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

D5.2 Guidelines and Curricula for Teacher Training

www.creative-little-scientists.eu

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

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D5.2 Guidelines and Curricula for Teacher Training

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0	Oct 2013	AUC	Development of the assignement and invitation for the online focus group
1	Oct – Nov 2013	AUC and EA	Development of the online focus group environment in Moodle
2	Nov 2013	All partners	Extensive feedback on the assignement, digital environment in London
3	Nov – Dec 2012	All partners	The online focus group in the different countries
4	Dec 2013	AUC	Development of the Excell sheet for analysis
5	Dec 2013	All partners	Feedback on the Excell sheet
6	Jan 2013	All partners	Analysis and translation of the focusgroups per country
7	Feb 2013	AUC	Analysis of all data
8	March 2013	AUC	Development of the internal report
9	April – June 2013	IoE, OU and EA	Feedback on the internal report
10	April – May 2013	AUC	Development of the assignement and Excel sheet for analysis of the face-to-face focusgroup
11	May – August 2013	All partners	The face-to-face focusgroup in the different countries
12	June – August 2013	All partners	Analysis and translation of the face-to-face focus group per country
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EXECUTIVE SUMMARY

Introduction

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

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

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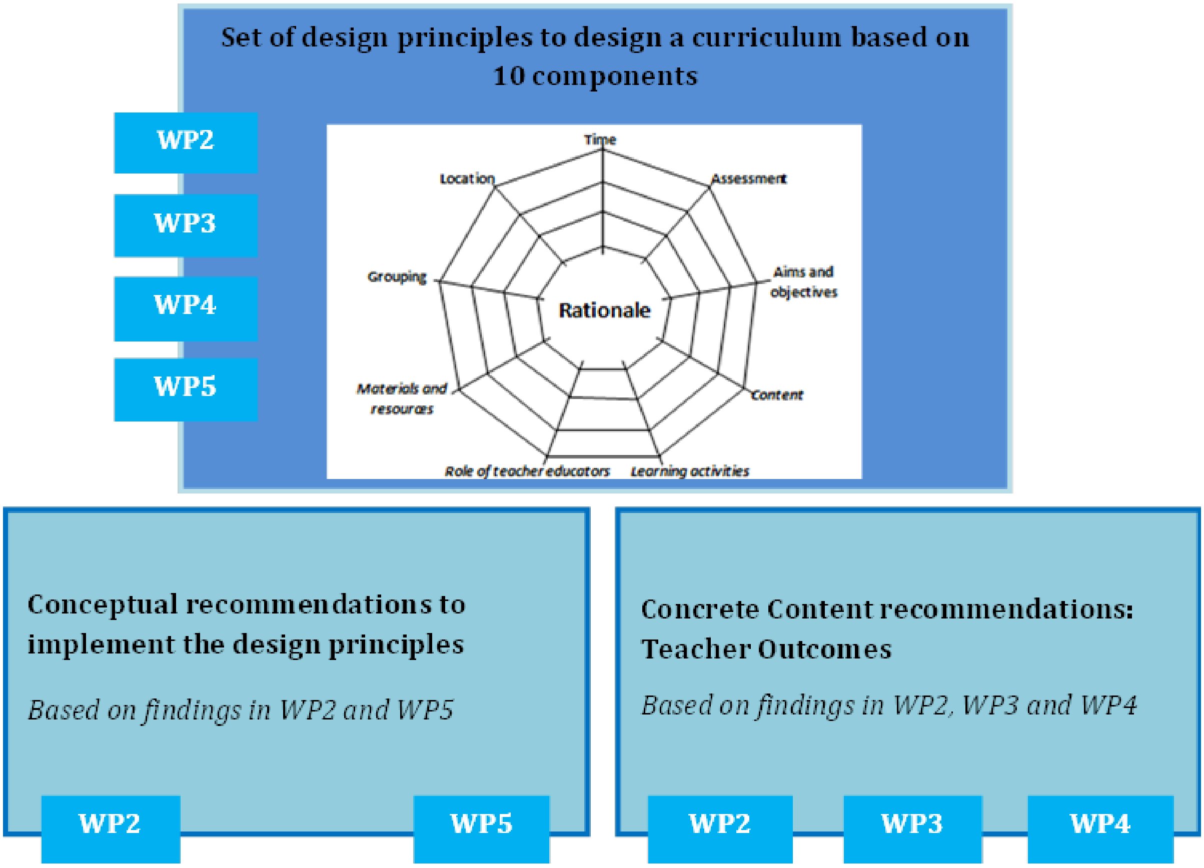

Methodology for developing the curricular principles

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

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

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

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

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

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

Teacher Education Curricula promoting Creativity in Early Years Science and Mathematics

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

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

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

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

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

Teacher Outcomes: a set of concrete guidelines

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

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

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A. INTRODUCTION

The importance of science and mathematics education for Europe is the main incentive in the *Creative Little Scientists* project. As creativity and innovation are seen as a vital priority in society, this angle of incidence is used to discover potential available in Europe. The potential to strengthen those two aspects in and through education is foregrounded by exploring the common ground that science and mathematics education in preschool and early primary school may share. By developing a set of teacher education curriculum design principles as concrete guidelines and accompanying illustrative teacher training materials, the project wants to facilitate the implementation and further development of creativity-based approaches to science and mathematics learning in preschool and the first years of primary education. The project's vision (or rationale) for teacher education in particular is the development of teachers who can foster creativity and inquiry-based approaches to science and mathematics learning in preschool and the first years of primary school.

Work Package 5 focuses on the development of this set of curriculum design principles and successive guidelines for teacher education, as well as on the proposition of exemplary teacher training materials. In order to do so, the methodology of curriculum design research is implemented.

In the first phase (Task 5.1), a set of 'prototypical' curriculum design principles for teacher education in preschool and primary science and mathematics education was developed by the project experts. These were subsequently refined during the second phase (Task 5.2 and Task 5.3) based on the findings of online focus groups and comparative research (Work Package 3). The refined 'prototypical' design principles and findings of the in-depth research (Work Package 4) have fed the development of a final set of curriculum principles as concrete teacher education guidelines in a third phase (Task 5.4 and Task 5.5). During the concluding phase (Task 5.6), exemplary teacher training materials will be developed drawing on examples of good school practice (identified in Work Package 4) in order to support the implementation of the proposed curricula principles and guidelines.

This document seeks to offer to policy makers and stakeholders of initial teacher education (ITE) and teacher continuous professional development (CPD) a description of this final set of curriculum design principles as a framework for the development of science and mathematics related curriculum formats, which will foster creative approaches to science and mathematics learning in preschool and first years of primary education. It also sets out the conceptual basis and methodology used to develop the curriculum design principles.

Furthermore this document seeks to offer teacher educators and teacher education institutions a set of concrete teacher outcomes to frame workshops, sessions and/or courses. These teacher outcomes are inherently linked with the proposed curriculum design principles and closely reflect the research findings in the project, derived themselves from the: literature review (Work Package 2), comparative studies (Work Package 3), in-depth fieldwork (Work Package 4) and curriculum design research (Work Package 5).

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In summary, the whole document - the set of curriculum design principles and related teacher outcomes – comprise concrete guidelines for European ITE and CPD programmes that will foster creative approaches to science and mathematics learning in preschool and the first years of primary education in the frame of inquiry-based educational environments.

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B. METHODOLOGICAL FRAMEWORK OF WORK PACKAGE 5

B1. Curriculum design research in *Creative Little Scientists*

In the framework of the *Creative Little Scientist*s project (Work Package 5), a set of curriculum design principles, expressed as concrete guidelines, for European ITE and CPD programmes were developed with the purpose of enhancing the use of creative approaches to learning in pre-school and first years of primary school science and mathematics education. To this end, the methodology of curriculum design research was used.

The curriculum design research model in Figure 1 (also in Deliverable D5.1 *Prototypical Guidelines and Curriculum Design Principles for Teacher Training*, p19) depicts the different phases – analytical, prototypical and assessment– of the design research process, as well as how the project's research work (Work Packages and Tasks) and findings have contributed to these. It should be noted that the assessment phase does not form part of the work assigned to the *Creative Little Scientist*s project, according to its Description of Work. The implementation and evaluation of the proposed curriculum design principles, guidelines and related teaching materials in teacher education settings with student teachers or in-service teachers will hopefully be the focus of future studies.

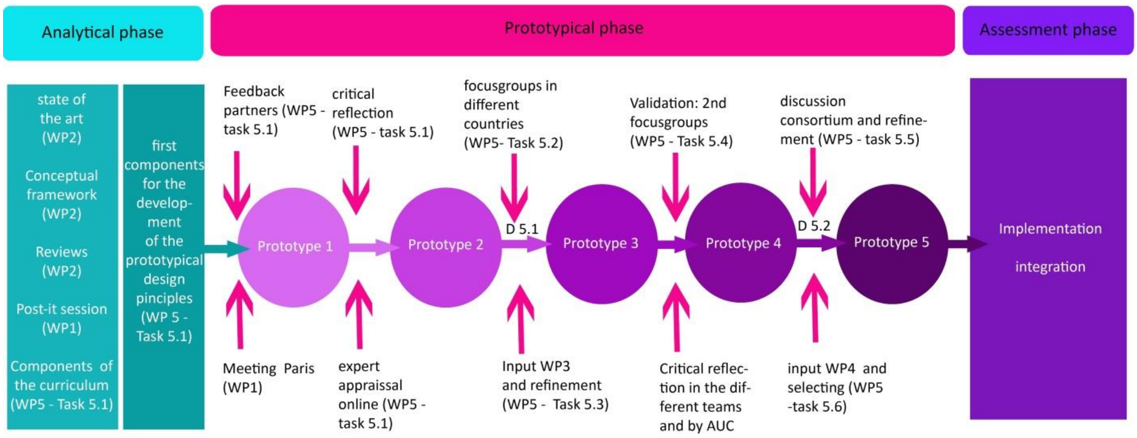

Figure 1: Curriculum design research model of *Creative Little Scientists*

The design principles and the successive guidelines were developed in collaboration with different relevant stakeholders in iterative cycles, represented by the gradually optimized and elaborated prototypes in Figure 1. During the analytical phase, the project's conceptual framework (Work Package 2, D2.2 *Conceptual Framework*) was developed, based on four literature reviews (*Addenda to D2.2 Conceptual Framework*) – 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. Additional a literature research was undertaken with a focus on curriculum design and curriculum design research (Work Package 5, Task 5.1).

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At the end of this phase, important issues from the *Conceptual Framework* and the reviews were combined with the corresponding viewpoints of the consortium partners (post-it exercise at the Kick-off Project Meeting, Work Package 1) and presented under the 10 curricular components (van den Akker, 2007). These were: Rationale; Aims and Objectives; Content; Learning Activities; Role of Teacher Educator; Materials and Resources; Grouping; Location; Time; Assessment, and are associated with 'the vulnerable spider web' (see section D1).

Following further elaboration and feedback by the consortium partners during and after the Second Project Meeting (Work Package 1), a draft version of the design principles (prototype 1) was prepared.

During the next phase, the prototypical phase, this draft version of design principles was evaluated and refined through iterative cycles with a view to developing curriculum guidelines for teacher education. In the first cycle, the draft version (prototype 1) 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 through negotiation and synthesis, and these results guided the development of prototype 2 of curriculum design principles (see D5.1, *Prototypical Guidelines and Curriculum Design Principles for Teacher Training*). In a following cycle, the draft prototypical design principles were evaluated in each of the partner countries by means of online focus groups for stakeholders (Task 5.2). Moreover, they were analysed and further adjusted according to feedback from the partners (Task 5.3). During the final cycle (Task 5.4 and Task 5.5), prototype 3 was developed into the final set of curriculu design principles for teacher education. This was achieved through the organisation of face-to-face focus groups with teacher educators. Each *Creative Little Scientists* partner provided context-specific examples of (best) practice, intended to clarify and illustrate the underlying messages of the final set of design principles. Additionally, the set of design principles was further refined based on the findings and implications from WP 2, 3, 4 and 5. These findings provided the teams with insights into the main focal issues that had to be addressed by teacher education in order to foster creativity in science and mathematics education in early years. Based on these issues, the design principles which referred to the content of the teacher education curriculum could be elaborated into a specific and concrete set of statements: the Teacher Outcomes. These teacher outcomes can be seen as important content recommendations for teacher educators to frame their courses.

Because of the importance of these teacher outcomes they are discussed separately in section E.

In the following sections, we report on the data collection and data analysis associated with Task 5.2, 5.3, 5.4 and 5.5. Both methodology and results are summarized.

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B2. Working towards prototypical design principles through online focus groups

B2.1 Testing prototypical curriculum design principles

The internal and external vision building sessions (cf. *Creative Little Scientists* project meetings in Paris and London, 2012) involved discussions on the work plan and on the methodology of curriculum design research. As discussed and decided in Paris, online focus groups rather than face-to-face groups were established for the first stage of iterative testing of the prototypical curriculum design principles. Although data collection audiences differed over time, from experts to stakeholders to teacher educators, the rationale for the development of a new teacher education curriculum did not change. Namely, that teachers (pre- and in-service) should be trained to foster creativity-based approaches to science and mathematics learning in the preschool and the first years of primary school.

Online focus group for Creative Little Scientists *partners (project experts). Prototype 1.*

For deliverable D5.1 *Prototypical Guidelines and Curriculum Design Principles for Teacher Training*, 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). 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). Consortium partners were invited to highlight possible comments, examples, and questions on 59 proposed curriculum design principles for teacher education (prototype 1) which were related appropriately to one of the aspects in the so-called curricular spider web: Aims and Objectives, Content, Learning Activities, Role of Teacher Educator, Materials and Resources, Grouping, Location, Time, and Assessment. Moreover, by participating in the online expert focus group, *Creative Little Scientists* partners were familiarised with the tasks of an e-moderator, a role adopted at that time by the Work Package 5 and Task leaders (AUC team), but at later stages (e.g. in the online focus group for stakeholders that followed) by the partners themselves.

169 contributions were counted in the web-based experts' appraisal panel. All 9 components were covered, from Aims and Objectives to Assessment. Most postings (i.e. comments, questions, examples) related to the proposed design principles concerning Learning Activities (33). The Task Leaders e-moderated the discussions on an almost-daily basis. As a result of the asynchronous discussion amongst *Creative Little Scientists* partners, this first draft of curriculum principles was amended, to take into account the expert group's written suggestions. Further clarifications were provided by the partners, some principles were rephrased and some new ones formulated. In Table 3 of D5.1 *Prototypical Guidelines and Curriculum Design Principles for Teacher Training* (Appendix A), the adjusted prototypical design principles (prototype 2) and corresponding examples of practice suggested by partners are presented. During following meetings, the AUC team extensively discussed how and why to include or exclude examples from the expert panel in relation to

specific prototypical design principles. In a number of cases, the example of practice merely highlighted one content aspect or specific word mentioned in the prototypical design principle. In other cases, the given example incorporated more than one design principle, referring rather to a wide-range of principles. Examples of practice could not therefore be considered as exhaustive; they were meant to help the reader clarify and consider prototype 2 within a specific teacher education context and/or school culture.

Online focus group for stakeholders. Prototype 2.

In Task 5.2, the project's Description of Work (DoW) specified the organisation of focus groups with teacher education stakeholders in different countries. Given the previous successful experience with the web-based expert focus group, the consortium decided once more to undertake these online and asynchronously, as this would allow more flexible participation of stakeholders from different parts of the country and over a longer and sustained period. Each partner had to recruit 6-8 stakeholders: three with the professional expertise as:

- A research and development consultant for educational policy;
- A teacher educator;
- An elementary school staff member – participant in classroom-based research (WP4);

and at least another three from the following categories:

- Coordinator of teacher education;
- Childhood education teacher;
- Student teacher;
- Expert in inquiry and/or creativity and/or science and/or mathematics education;
- Researcher in the field of educational sciences;
- Out-of-the box thinker.

To this purpose a special invitation letter was prepared and sent out to potential participants, with information about the project, the purpose of the focus group and their suggested involvement in it (see Appendix B). The latter consisted of commenting (in writing) on a selection of the 'prototype 2' draft design principles, and in particular the ones that addressed the four van den Akker's curriculum components: **(1) Aims and Objectives, (2) Role of Teacher Educator, (3) Learning Activities, and (4) Assessment**. The four core components to focus the discussion upon were agreed at the *Creative Little Scientists* 3rd project meeting in London. The focus groups ran for three weeks (November 29th to December 20th, 2012).

All content information was made available to focus group participants as before via a secure Moodle-based forum structured according to the four chosen components in the curricular spider web. 12 such fora were set up for groups of stakeholders from the 13 national educational systems represented in the consortium [English, Belgian (including Flemmish and Walloon stakeholders), Finnish, French, German, Greek, Maltese, Northern

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Irish, Portuguese, Romanian, Scottish, Welsh]. Overall 79 stakeholders were involved. Table 1 shows the composition of each focus group.

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STAKEHOLDERS	BE (AUC)	EN-UK (BG)	FI (UEF)	FR (UPJV)	GE (GUF)	GR (EA)	MA (UoM)	NI-UK (OU)	PT (UMinho)	RO (NILPRP)	SCO-UK (IoE)	WA-UK (BG)	TOTAL
Research and development consultant for educational policy	1	1	1	1	1	1	1	1	1	1	1	1	**12**
Teacher educator	1		1		1	1	1	1	1	1	1	1	**10**
Coordinator teacher education		1		1	1	1			1	1			**6**
Childhood education teacher	1	1	1	1	1	1	1		1	1			**9**
Student teacher	1	1	1	1	1				1		1		**7**
Elementary school staff member – participant of WP4	1	1	1		1	1	1	1	1	2	1	1	**12**
Expert in inquiry and/or creativity and/or science and/or mathematics education	1	1		1	1	1			1	1		1	**8**
Researcher in the field of educational sciences	1	1		1	1	1			1	2	1	1	**10**
Out-of-the box thinker		1	1	1					1		1		**5**
TOTAL	**7**	**8**	**6**	**7**	**8**	**7**	**4**	**3**	**9**	**9**	**6**	**5**	**79**

Table 1: Categories of stakeholders involved in national online focus groups

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CURRICULUM COMPONENT	BE (AUC)	EN-UK (BG)	FI (UEF)	FR (UPJV)	GE (GUF)	GR (EA)	MA (UoM)	NI-UK (OU)	PT (UMinho)	RO (NILPRP)	SCO-UK (IoE)	WA-UK (BG)	TOTAL
1. Aims and Objectives	49	7	14	7	24	33	4	1	5	15	7	12	**178**
2. Role of Teacher Educator	26	9	12	4	14	7	4	1	13	15	12	10	**127**
3. Learning Activities	31	9	16	2	12	23	4	5	16	19	16	11	**164**
4. Assessment	16	11	15	1	13	12	4	5	32	15	10	6	**140**
Other	0	0	7	0	6	16	0	0	0	0	9	4	**42**
Total Postings	**122**	**36**	**64**	**14**	**69**	**91**	**16**	**12**	**66**	**64**	**54**	**43**	**651**

Table 2: Numbers of postings per curriculum component and focus group

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To facilitate the stakeholders' access and enrolment in the fora, a video was prepared and uploaded on a dedicated page on the project's website (http://www.creative-little-scientists.eu/content/stakeholders), guiding them through the login process and the structure of the discussion forum. The stakeholders were asked to make at least one meaningful posting on each component per week, with the view to refine the corresponding design principles and contribute to the project's vision for teacher education, in other words the development of teachers who can foster creativity and inquiry-based approaches to science and mathematics learning in preschool and the first years of primary school (see instructions and explanatory information provided to stakeholders in Appendix C). Table 2 shows the number of postings per curriculum component and per forum. 651 postings were counted for the four curriculum components. The discussion took place either in English and/or in one of the national languages of the partner countries depending on the preference of the stakeholders. The partners, having the role of e-moderators in their respective forum, welcomed the participants, specified the 'ground rules' for the exchanges amongst them, kept the discussion focused on the purposes of the group assignment within each of the pre-identified curriculum foci, and facilitated the discussion by scaffolding social and cognitive processes. The latter meant that the e-moderator could introduce new content knowledge if s/he deemed this necessary, either directly or through questioning (see detailed instructions to e-moderators in Appendix D).

In particular, the role of the e-moderator in the stakeholders' discussion fora was informed by Salmon's (2000) five-step model of e-moderation, seen in Figure 2.

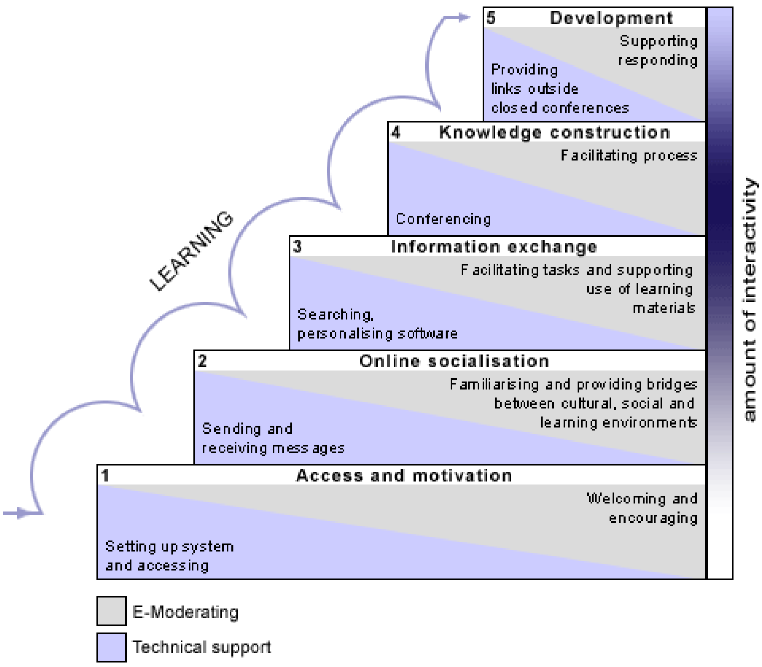

Figure 2: The five-step model of e-moderation (Salmon, 2000) (http://www.gillysalmon.com/five-stage-model.html)

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The model is taxonomical in structure. Each of the five steps highlights the role of the e-moderator and the nature of the technology involved, while considering the implications for online learning and interaction.

On the whole, the approach followed by the e-moderators over the three weeks of forum exchanges was informed by the following findings about online asynchronous discussions (Salmon, 2000; 2002; 2011):

- *E-moderation requires successively more complex e-moderating skills and focuses on intensifying the level of interaction between the e-moderator and group members.*
- *Social and emotional presence is of importance to foster cognitive processing.*
- *Knowledge construction is promoted through social negotiation, task-related engagement, sharing, common understanding, and argumentation.*

Ethical considerations

All participant stakeholders had to complete an informed consent form (see Appendix E) in which they were assured that all personal data provided by them would only be used for research purposes and would be handled in accordance with Data Protection Regulations and in compliance with the EC directive 95/46/EC. In addition, all data gathered were stored in password protected servers accessible only to the researchers. Finally, it was stipulated that in the ensuing research reports, no real names or personal details would be included to protect the identity of participants and the anonymity of their comments.

B2.2 Refinement of prototypical curriculum design principles

Qualitative data analysis was undertaken following the data collection. Prototype 3 is shown as the outcome for Task 5.3 (see Appendix F). Illuminating data on teacher education aims, pedagogy, learning activities and assessment were collected from the online stakeholder focus groups across the nine partner European countries. The instruments that were used for data analysis at both partner and consortium level are presented below. Again, the methodology was inspired by the work of Van den Akker (2007). The section underneath provides descriptive information summarising the process of developing prototype 3.

Excel file

Data analysis at *Creative Little Scientists* partner level started with each *Creative Little Scientists* partner completing an Excel file, which provided a framework for partners to report on their national (or regional) online focus group discussion. Comments for improvement on the instrument were welcomed. *Creative Little Scientists* partners participated in debate and information exchange as part of the data collection process in an appropriate manner that led to good quality data. Reflection among research partners generated a framework with feedback loops. This reflects much of the current education design research process. It also allowed for better identification of practical problems that may be encountered when applying prototypical design principles, a better formulation of curriculum tasks, and a closer examination of the connections with knowledge extracted from literature, comparative studies, and in-depth fieldwork.

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The Excel file consisted of three worksheets, two aiming for qualitative data collection and one aiming for quantitative data collection. All three worksheets were structured to reflect the four curricular components explored in the focus group assignment: (1) Aims and Objectives, (2) Role of Teacher Educator, (3) Learning Activities, and (4) Assessment. Worksheet 1 required partners to report on key issues discussed during week 1, 2, and 3. Worksheet 2 asked partners to report on stakeholders' comments, suggestions and examples of practice related to the prototypical design principles (prototype 2). In comparison with worksheet 1 which focused on key topics, worksheet 2 was chiefly meant to collect both context-specific and detailed information and/or quotes that would be useful for teacher education curriculum design purposes. A clear distinction was made between (a) authentic data (worksheet 2) coming from the stakeholders' negotiations in online focus groups and (2) reflections on this data (worksheet 1) coming from the e-moderator and/or the *Creative Little Scientists* partner preparing the Excel file. Finally in worksheet 2, *Creative Little Scientists* partners also reported on personal reflections with regard to workload, technical set-up, group dynamics, etc. Worksheet 3 differed from the previous ones as it incorporated quantitative data on participants' contributions over time. Both the number of postings per participant and per spider web component were asked for (see Table 2 above).

Quick sheets

Data analysis at a consortium-wide level also included the completion of quick sheets for each *Creative Little Scientists* partner (see Appendix G). The AUC team elaborated on the Excel files by reducing them to one written page per partner, a so-called 'quick sheet'. When considering the data collected via the online stakeholder focus groups, the first aim was to provide a brief overview on keywords and other context-specific evidence. The second aim was to provide a brief overview of the *Creative Little Scientists* stakeholder-related suggestions per partner country in order to co-construct and ameliorate prototype 2. With regard to the first aim, key issues or keywords (max. 5) were chosen in association with the four curricular components explored in the group assignment: (1) Aims and Objectives, (2) Role of Teacher Educator, (3) Learning Activities, and (4) Assessment. Other evidence was mostly reports on remarkable quotes, tensions, and useful comments for the field of science and mathematics teaching. With respect to the second aim, the A4-method was introduced. In the quick sheets, per *Creative Little Scientists* partner and per component, a matrix table shows which prototypical design principles in particular are to be Accepted, Adjusted, Rejected, and/or Added, according to stakeholders. The A4-method was developed by the AUC team in order to acknowledge the valuable contributions of stakeholders to the refinement of the prototype 2 set of curriculum design principles for teacher education.

In Appendix F, prototype 3 as proposed and adjusted during Task 5.3 is presented. Both Excel files and quick sheets underlie prototype 3. Moreover, they provide background information, for example on concerns and recommendations related to time, contents, and resources in teacher education. A range of issues were highlighted as implications for the implementation of the prototype. For example, the UK stakeholders suggested the use of

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case studies to show real examples of how creativity was achieved even within the perceived challenges mentioned in the design principles. Feedback from *Creative Little Scientists* partners on prototype 3 was uploaded on Dropbox and subsequently taken into account by the AUC team during design. *Creative Little Scientists* partners mainly searched for clusters of principles and improvements concerning word choice. Taking into account their detailed suggestions on the specific content of the document, a re-worked prototype was drafted as outcome for Task 5.3. Feedback resulted in 53 prototypical design principles related to the four components of teacher education curriculum: (1) Aims and Objectives, (2) Role of Teacher Educator, (3) Learning activities, and (4) Assessment. Prototype 3 should be read keeping in mind the underlying rationale for the proposed curriculum (Work Package 5, see section C1) and the data collected as depicted in the Excel files for analysis.

B2.3 Findings from the online focus groups with stakeholders

B2.3.1 Analysis of quick sheets: Similar and different emphases about teacher education requirements

79 stakeholder representatives participated in the online focus groups across European countries (see Table 1 above). Synthesis of all *Creative Little Scientists* partner information collected through online focus groups for stakeholders resulted in commonalities for (1) Aims and Objectives, (2) Role of Teacher Educator, (3) Learning activities, and (4) Assessment. The rationale was: “*Teachers (incl. student teachers) should foster creativity based approaches to science and mathematics learning in preschool and the first years of primary school*”. Stakeholder contributions were accepted as promising ideas in order to bring the rationale closer to actual teacher education practice (in ITE and CPD). By framing their experiences and opinions in their qualitative responses, the stakeholders provided useful input towards the formulation of guidelines for teacher education, the output cited for Work Package 5.

In summary, according to the data, (teaching for) creativity in the fields of science and mathematics for young children should be underpinned by four central purposes: developing and sustaining interaction; pursuing affective ends; promoting exploration and reflective practice. More particularly, the following key ideas were mentioned commonly (i.e. with at least three allusions to the advice) by stakeholders for each of the four sets of curriculum design principles across the 12 *Creative Little Scientists* online focus groups.

(1) **Aims and Objectives.** The aims of teacher education can be seen as twofold but intertwined; they should address the competences to be developed in (student) teachers as well as the educational process itself.

Desirable teacher competences, according to the stakeholders, include:

- The ability to appreciate and convey the wonder of science learning;
- The ability to pursue lifelong learning in their professional career, making use of globalised learning opportunites;
- The ability to join communities of practice and form partnerships;

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- The ability to think for oneself (self-regulation);
- The ability to observe and think through the reasons and consequences of one's actions (reflection).

The aims that refer to the education process in teacher education should address:

- The pursuit of subject knowledge and literacy in the fields of science and mathematics;
- The recognition of affective ends such as teacher confidence and self-efficacy beliefs;
- The process of establishing a teacher as a node in a broad network of distributed creativity;
- The elaboration of needs that go along with transitions, for example from preschool to primary education, from theory to practice, from ITE to CPD;
- The consideration of open teaching (physical and mental access to such practices);
- The recognition of practical constraints related to inquiry-based science education (IBSE), e.g. time, infrastructure, scaffolding skills

(2) **Role of Teacher Educator**. This is mainly seen as encouraging initiative and curiosity.

Stakeholders' suggestions are summarized as follows:

- Teacher educators' role is to mediate between scientific research and practice;
- Teacher educators' role evolves over time, e.g. from role-model to coach to consultant;
- Teacher educators should have pedagogical content knowledge in the field of science and mathematics;
- Teacher educators should create and disseminate knowledge about science and mathematics learning and instruction;
- Teacher educators should practice lifelong learning;
- Teacher educators should be actively engaged in relevant professional networks;
- Teacher educators should be able to integrate new media and e-learning in their teaching.

(3) **Learning Activities.** They should subscribe to Dewey's 'learning-by-doing' idea.

As to the stakeholders' views, the data indicate that they maintain that teachers (incl. student teachers) foster creativity based approaches to science and mathematics learning in preschool and the first years of primary school when they use learning activities which include:

- (Inter)activity;
- Cross curricular and/or integrative topics;
- Demonstrations;
- Thinking aloud protocols;
- Real-life contexts;

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- Video as learning tool.

(4) **Assessment.** Stakeholders' suggestions about assessment in teacher education mainly refer to the importance of formative assessment and ongoing feedback.

Common issues mentioned are:

- The assessment process is more important than the assessment product;
- Teamwork and support-giving in a safe learning environment are important elements of assessment practice;
- Individual needs and personal targets should be taken into account;
- Time-management is crucial in assessment.

In addition to the teacher education requirements, just mentioned, identified in common by stakeholders across the national online focus groups, country-specific differences in emphasis also emerged in terms of stakeholders' generic aspirations about teacher education in the fields of science, mathematics and creativity. For example, the focus groups in Portugal and Romania hoped for greater teacher autonomy and higher standards of teacher education. The focus group in Greece emphasised the high value of educational leadership and use of communities of practice for in-service teachers. The focus groups in the four countries of the United Kingdom raised concerns on teaching-to-the-test. Moreover, they talked about the importance of students in teacher education setting their own targets and reflecting on their learning. The focus group in Belgium indicated the strong influence of publishers of textbooks on teachers' lesson plans. The outcomes of the focus group in France underscored the advantages of pathways for instruction to help address insecurities that beginning teachers may experience. German stakeholders underpinned the use of IBSE when referring to experiences with "Haus der Kleinen Forscher" - the "Little Scientists' House" association encourages the enthusiasm of three-to-ten-year-old boys and girls in natural science and technological phenomena.

B2.3.2 Dilemmas and questions raised according to the findings

As previously mentioned, participants in the online focus groups were also asked to provide examples, comments, and questions in relation to the draft design principles presented to them. Consequently, the data indicated relevant dilemmas, tensions, dichotomies, 'questions for thought' to be explored in more detail. Underneath, some of the issues and 'questions for thought' raised by the stakeholders in the online forum discussions across the partner countries are listed, grouped under the curriculum component to which they seemed more pertinent. It should be acknowledged that the understanding of these concerns differs greatly across stakeholder representatives.

(1) **Aims and Objectives.**

- Teacher education should not offer a "one size fits all" curriculum.
- Are pedagogical skills and understanding necessary and enough conditions to ensure that learning takes place?

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- Is there an optimal point for teacher subject knowledge in science and mathematics?
- Shouldn't teacher education treat subject matters (such as science and mathematics) in larger ensembles and in a more integrated way, transcending the traditional subject borders?
- How do curriculum aims differ between ITE and CPD?
- Should teacher education help teachers also develop an awareness of the nature of their profession?

(2) **Learning Activities.**

- How should teacher education deal with teachers' misconceptions and/or alternative ideas in the fields of science and mathematics?
- Should teacher education provide teachers with ready lesson plans or scripts? Teachers are asking for more practical guidance; this might limit the scope of the proposed pedagogy, but it might also be necessary to provide a firm foundation on which to build the more diverse and open practice.

(3) **Role of Teacher Educator / Pedagogy.**

- Teacher educators should model desirable teacher behaviour and pedagogy in their teaching?
- IBSE and problem-based learning are not the only approaches to use in teacher education. There are also other effective pedagogical approaches such as cognitive apprenticeship, direct instruction modelling, etc.
- What implications does the use of IBSE have for classroom management? Are there any related practical arrangements and/or requirements that should be taken into consideration by teacher educators and teachers?
- How can open inquiry be defined?
- How is creativity relevant to the nature of science? Is the teaching of creativity an add-on, or is it an integral part of teaching about the nature of science?

(4) **Assessment.**

- What is the role of assessment in childhood education? Is it a standalone process or not? Should it be focusing on past or future performance?
- Should assessment focus on creativity as a product or on the process of being creative?
- What might assessment of creative teaching look like?
- Subject audits in teacher education seem to play an important part in developing individual student teacher profiles and areas for development.
- How might teacher education go about assessing teachers' attitudes in addition to their knowledge and/or skills?

(5) **Other.**

- What status should textbooks have in early years and primary education?

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- Will the project's examples of (good/best) practice reflect actual or potential practice?

B2.3.3 Reflections about methodological issues

The methodological choices made during Work Package 5 were informed by the relevant academic literature. Moreover, the instruments developed were selected as suitable for the particular purposes and audiences involved and the strengths and weaknesses of the planned methodology were identified. These are now considered.

One confusion which was identified in the discussions with stakeholders (and also sometimes amongst partners themselves), related to the focus of the design principles. Some perceived it was unclear if these referred to curricula for teacher education or to curricula for early childhood and primary education. As a consequence, the discussion often veered towards the latter. This was perhaps inevitable due to the composition of the stakeholder groups and with criteria for early and primary curricula delineated and well known in all countries

Additionally as Salmon (2002) also found, the online discussions needed a strong steer and as a consequence the group assignment was introduced in small steps, with visual support and background information. Initially partners were sceptical and stakeholders occasionally apprehensive about the organization of the online discussion, and their participation in the focus groups. However, these concerns soon abated and the technical and theoretical elements were well handled. Again, the spider web model (van den Akker, 2007) served as a helpful structuring tool for the discussion and the debriefing with e-moderators afforded them an opportunity to reflect upon and summarise their stakeholders' suggestions.

Unfortunately, the contribution from some of the stakeholder groups was lower than hoped. This may have been due to the proximity of the online focus group to the Christmas vacation and because some partners work in institutions which are not directly involved in teacher education. Nonetheless, 178 contributions were posted for the Aims and Objectives component, and 164 for the Learning Activities component (see Table 2).

Another commonly experienced challenge during both the data collection and the data analysis was distinguishing between general pedagogy and subject-related didactics in the fields of science and mathematics. It should be acknowledged that partner countries differ greatly in the space ascribed to subject-related didactics within their teacher education curricula.

B3. Working towards a final set of curriculum design principles through face-to-face focus groups

In Task 5.4, the tested and reformulated curriculum design principles (see prototype 3, Appendix F) were subjected to validation in a new round of face-to-face focus groups with 70 teacher educators from the 9 partner countries. In order to eliminate individual, interpersonal and environmental bias at this stage, interview protocols were scripted and

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participants were required to respond under supervision of a moderator to a pre-established list of questions (see Appendix H). Each partner's focus group was audio-recorded and stored, accompanied by annotated synthesis of the discussion in an Excel file. Data were reported to the Task Leaders in English and shared with all partners via Dropbox.

B3.1 Validation of the curriculum design principles - Teacher educators

This section summarises the process of validation of the curriculum design principles with the help of teacher educators participating in face-to-face focus groups. The instructions for the group assignment are available in Appendix I.

The core role of these focus groups (6-8 teacher educators per group), was to comment on the 85 prototypical design principles (prototype 3), clustered under van den Akker's (2007) nine curriculum components. The groups were convened in May 2013 and were planned to last up to 3 hours.

As it was planned, the groups' composition was homogeneous. All stakeholders in each group were experienced teacher educators from at least two different institutions. Moreover, they were chosen for their professional expertise in science and/or mathematics teaching in early years and/or primary ITE and/or teacher CPD. Partners again moderated the discussions, listening and encouraging open debate and the development of shared understanding.

B3.2 Refinement of the tested curriculum design principles - Acknowledging the valuable contributions of teacher educators

Qualitative data analysis followed the data collection. 49 refined curriculum design principles for teacher education were the outcome of this analysis. The steps taken in developing an Excel file, which helped greatly the data analysis, are now documented underneath.

Excel file

In a manner similar to that used for the analysis of the online focus groups, each *Creative Little Scientists* partner was asked to complete an Excel file, which provided a framework for reporting their national (or regional) face-to-face focus group discussion.

The Excel file consisted of five worksheets, each with its own focus for qualitative data analysis. More particularly:

Worskheet 1 contained details about the current job and within it role of focus group participants in relation to teacher training.

Worksheet 2 asked partners to provide a debriefing of the process and report on teacher educators' comments, suggestions and examples of practice under the headings (1) welcoming, (2) rationale for the EU-project *Creative Little Scientists*, (3) examples of current practice in teacher education, (4) review of prototypical design principles, (5) examples of practice which build upon the design principles, and (6) focus group conclusions. Under the

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same headings but separately, partners were asked to write their reflections from the point of view of moderator on the data reported.

Worksheet 3 included the 85 prototypical design principles and partners were asked to indicate which should be Accepted, Rejected, or Adapted according to the key messages from the focus group discussions. If a design principle needed to be adapted, the partners were asked to suggest an alternative. They were also asked to record whether each design principle was more pertinent to ITE and/or to teacher CPD, or was applicable to both.

In worksheet 4 the main focus was on examples of practice based on current teacher education curricula in Europe. Examples of practice were structured along the nine components of the curricular spider web. The purpose was to collect context-specific evidence from the field of science and mathematics teacher education for young children.

Worksheet 5 contributed to subsequent work (Tasks 5.5 and 5.6). It included partners' reflections and suggestions on how the examples of good practice witnessed in fieldwork (as part of WP4) and reported in D4.3 *Country Reports* and D4.4 *Report on Practices and their Implications* could be linked and related to the proposed teacher education curriculum principles and guidelines. These questions were crucial to ensure the curriculum design was sufficiently functional to implement in teacher education.

B3.3 Findings from the face-to-face focus groups with teacher educators

The purpose of these focus groups was to collect feedback from a range of different teacher educators on the content and potential usefulness of the prototypical design principles in European teacher education (ITE and CPD). The *Creative Little Scientists* partners acted as moderators of these focus groups and 'recorders' of this feedback.

The discussions ranged from face-to-face conversations within small homogeneous groups (AUC, Uminho, GUF, BG/IOE, EA, UPJV), to videoconferencing (UEF), and sending written comments by e-mail (NILPRP). As previously described, the partners were all using the same information collection tool. The inputs from the focus groups led to a final set of curriculum design principles being gathered and produced by the AUC research team. This document was given out to *Creative Little Scientists* partners for comments during the 4th project meeting in Crete. During this validation phase, an informal expert appraisal panel was organised.

The analysis of information from the eight face-to-face focus groups and the expert appraisal panel led to a final set of 49 curriculum design principles but also to core insights and examples of practice. With regard to teacher training in the fields of science, mathematics and creativity, the teacher educators called for guidelines and materials which address:

- Student teachers' starting profiles
  - E.g. Pre-course tasks, diagnostic assessment, and alternative learning trajectories
- Science and mathematics content/subject knowledge

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E.g. Concept maps, stories, and picture books

- Positive attitudes and confidence
  E.g. Value of various forms of learning such as free play and exploration
- Reflective practices
  E.g. Cross curricular learning activities and questioning
- IBSE in 'rich' learning environments
  E.g. Availabilitiy of a variety of human/material resources
- Physically, emotionally and cognitively engaging activities
  E.g. A maths trail at a local museum or cathedral
- Field observations and experiences
  E.g. Thematic activity, visual projects, games, riddles, biotope studies
- Networking and teacher collaboration
  E.g. Sharing the processes of lesson planning and timetabling
- Digital technologies and ICT resources
  E.g. Computer lab, "petit labo" in the fields of science, mathematics, and creativity
- Teacher scaffolding to support creativity, inquiry, problem solving
  E.g. Making a clown by asking what is a clown

The teacher educators responses and the examples of practice they suggested indicated their perceptions of the importance of cooperation, reflection, affective enagement, role modelling, experiental learning, the use of new media, and ongoing feedback. They also appeared to accept that teachers should elicit young children's questions and (pre)conceptions in the fields of science and mathematics, and take these seriously, and commonly noted that experienced classroom teachers could serve as mentors for student teachers during their internship in schools. With regard to implementing the design principles in teacher education, many voiced a concern regarding time constraints e.g. *"time is a constant conflict"*. They perceived science and mathematics education and creativity as equally important, and viewed their integrated strengthening as a vital priority. Whilst the educators, had a broad view of creativity and tended to align it with problem solving behaviour, their voices, noted below, serve to indicate the variety of conceptualisations of creativity within science and mathematics offered within and across the partner countries.

In Romania:

- Developing creativity in children cannot be regarded as a sporadic activity from time to time but should be a constant concern of the teacher.
- Developing creativity in children involves stimulating the courage to make assumptions.
- Game exercises develop in the child's mind a set of cognitive scenarios, which when activated generate ideas that help to solve the problem.

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In Portugal:

- Creativity is not something that can be taught but children should be helped towards creativity through providing opportunities.
- The teacher's role is as a facilitator.
- The curriculum could be a potential barrier to creativity.

In Greece:

- Teachers' creativity has to be unlocked in order for them to be able to promote children's creative learning.
- It is important for teachers to develop a creative culture through CPD opportunities.
- The development of children's creative dispositions has the potential to motivate teachers and support change in their beliefs about early years science and mathematics education which would subsequently allow them to change their practice.
- The national curriculum could be a potential barrier to creativity.

In France:

- Creative education might be linked to using different approaches for the same thing. Different approaches from literature, history, investigation can constitute creative approaches of the same topic.

In Belgium:

- A creative child is a child with an inquiring attitude, one who questions things, while using their imagination. This child also has to have persistence and opportunity to show his creativity during play.
- Dreaming, thinking, and daring to act are crucial for children. The teacher has to listen to the children in the most unprejudiced way as possible.

In Germany:

- Teaching for creativity is training student teachers in different ways of problem solving.
- Student teachers should receive different materials, freedom, and time to try new things.
- All kind of solutions should be allowed and appreciated.

In the United Kingdom:

- Creativity is about children coming up with their own ideas and making connections, it should be something that is engaging and engenders curiosity.
- Creativity should not be seen as prescriptive.
- Whilst creativity is something inherent in young children it does need to be nurtured and encouraged if it is to be meaningful.
- A restrictive curriculum in teacher training and too much focus on assessment could be a potential barrier to learning to teach for creativity.

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In Finland:

- Problem-based learning approaches, multidimensional approaches, informal learning environments, modelling, and flexibility are the appropriate approaches for increasing creativity.
- Process assessment, play-oriented activities and positive attitudes are also significant factors for the development of creativity.

B3.4 Reflections about methodological issues

Although the focus group discussions included considerable debate about the particular design principles, it was clear that the teacher educators in all of the partner countries were prepared to engage in this. All participants agreed on the nine components for curriculum design, with each component of the spider web being seen as interconnected and highly interdependent according to the rationale for educating young children within the areas of science, mathematics and creativity. As the focus group instructions for moderators (see Appendices I) shows, teacher educators became well informed on the iterative processes that are inherent to educational design research. It seemed that they valued the scripted and simultaneous use of feedback loops across the focus groups. Context-specific course structures and curriculum content were widely debated and many of the proposed revisions connected to the big issues behind enabling creativity in science and mathematics and to their practical application. In particular, common ground was found in the quest for (inter)activity and inquiry-based (science) education both within and beyond the school environment.

Over time, the *Creative Little Scientists* partners, acting as (e-) moderators, developed confidence and skill in both method and contents use. The richest discussions and reflections on the different curriculum design principles were sustained by *Creative Little Scientists* partners who were teacher educators themselves.

The number of design principles in prototype 3 created problems for some teacher educators, who were concerned, as one perceptively noted, that an 'overload of information can kill the information'. Some of the design principles were seen to be significant not only in terms of science, but also in relation to pedagogy more generally. Some related more exclusively to general pedaggy and these were either rejected or merged with others. Consequently, the output of Task 5.4 was a reduction of the curriculum design principles from 85 (prototype 3) to 49. Data analysis at the consortium level led to a further reduction in the set of curriculum design principles agreed upon by the project partners, this involved several rounds of internal appraisal panels.

The final set of design principles (see section D1) provides information about how diverse features of teacher education should foster creativity- and inquiry-based approaches to science and mathematics learning in preschool and the first years of primary school. As previously mentioned, these design principles include: the aims, learning activities, assessment strategies, grouping, time, location, role of teacher educator, resources and

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content. However, how these curriculum components should be implemented within different context-specific programmes for ITE and CPD was not specified. Teacher educators found it difficult to distinguish between ITE and CPD. Prototype 3 was mainly related to ITE but it was noted that in-service education programmes could also be informed and inspired by the prototypical design principles.

Based on the findings in Work Packages 3 and 4, the curriculum design principles were further refined, in particular those that focused on 'content'. The total set was, in a last cycle, discussed with the consortium partners, resulting in the final set of curriculum design principles (see section D).

B4. Working towards Teacher Outcomes

In order to ascertain the lessons learned and take into consideration the implications for teacher education from the research undertaken in WP3 and WP4 an in-depth screening was undertaken of previous relevant research-based deliverables D3.2, D3.3 and D4.4. The implications identified were all put together and refined into a set of statements about what a teacher should know and be able to do in order to foster inquiry and creativity in science and mathematics learning in preschool and the first years of primary school. These were mapped on to the Content component of the curriculum design principles and called Teacher Outcomes. These Teacher Outcomes are the learning outcomes the (student) teachers should achieve as a result of a training programme designed following the proposed curriculum design principles. It is however also possible to frame and plan shorter courses which address a subset of these teacher outcomes.

In section E a grid can be found in which the origin of these teacher outcomes is indicated.

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C. CONCEPTUAL BASIS FOR THE CURRICULAR DESIGN PRINCIPLES

During the *Creative Little Scientists* project the curriculum design principles and recommendations were developed and refined based on the findings of the theoretical work (Work Package 2), comparative review (Work Package 3), and in-depth field research (Work Package 4), as well as on the insights gained through involvement with stakeholder communities, both online and in face-to-face focus groups. The methodology and results of the focus groups was discussed in section B. Here we focus on the conceptual basis for the curriculum design principles, originating from work undertaken within Work Package 2, namely the literature review of Teacher Education (Addendum to Deliverable D2.2 – 3 of 4)

Several important issues emerged from this review in relation to teaching science and mathematics creatively, including: the development of professional identity and positive attitudes; the integration of different courses, disciplines and knowledge; the interaction between theory and practice; school-based versus university-based teacher education; the teacher educator's role and the importance of a repertoire of approaches and resources. Each of these is now revisited briefly to contextualize the later recommendations and guidelines.

- The development of professional identity and positive attitudes to science, mathematics and creativity.

The development of professional identity is seen to be linked to self regulation, ownership, lifelong learning, systematic reflection (the teacher as reflective practitioner), and the teacher as a researcher and innovator (Bitan-Friedlander, Dreyfus, and Milgram 2004). Additionally, the beliefs, conceptions and attitudes towards science and mathematics of pre-service teachers play an important role in the development of teachers' pedagogic practice (Downing and Filer, 1999; Yilmaz-Tuzin, 2007; Zacharos et al., 2007), as well as student teachers understanding of knowledge related to science and mathematics (Gago et al., 2004; European Commission, 2011a, 2011b). It is argued that successful teacher education programmes do not merely change, but build upon student teachers' belief making use of systematic support and guidance of teacher educators and of cooperating teachers during teaching practice periods (Wideen et al. 1998). This is confirmed by Schepens et al. (2009).

Aspects of teacher education programmes which have a positive impact on student teachers' pedagogical knowledge and beliefs include: strategies such as case studies and teaching portfolios; learning by doing; and collaborative arrangements between university programmes and local school districts (Cochran-Smith and Zeichner, 2005). Structured teaching formats, where instructional methods are demonstrated by teacher educators followed by guided and mentored practice are also widely claimed as providing supportive trajectories toward classroom application (Clift and Brady, 2005; Risko et al., 2008; Zeichner, 2010).

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Student teachers with positive attitudes towards science, inquiry and inquiry based science teaching, appear to have additional dispositions that support teaching of inquiry based science (Eick and Stewart, 2010). These supportive dispositions include curiosity and questioning, investigating first-hand, learning together, and active learning. However, Newton and Newton (2011) identified that primary pre-service teachers' conceptions of creativity in science lessons are narrow and include many misconceptions. They appear to conceive of creativity in science as mainly related to practical yet factual investigations and see creativity as centred more on the arts. As a consequence they fail to recognise or plan for creativity involving, for example, the imaginative processing of scientific information and the construction and testing of explanations. Newton and Newton (2011) also noticed that pre-service teachers have limited conceptions of engaging children in science lessons. The pedagogical aims tended to focus upon achieving willing and attentive participation in science lessons, and using hands-on experiences. However, such approaches are not always appropriate or effective. Relying on a single instructional format in the classroom or in teacher education is inadvisable as it fails to respond to diversity and does not recognize the need for individualized instruction. Bleicher (2009) advises teacher educators to develop different instructional interventions to prepare pre-service teachers, including those who are fearful or uncomfortable with working creatively in these domains.

It is important therefore to understand student teachers' beliefs, conceptions, attitudes and understandings and to build upon and extend these in teacher education, and widen their repertoire of teaching behaviours (Newton and Newton, 2011). Additionally, conceptions of creativity in science and mathematic teaching need to be addressed and developed directly during pre-service teacher education (Bolden et al., 2010).

- The integration of different courses, disciplines and knowledge

Combining content and methods courses is seen to be effective (Palmer, 2008);although science content courses focusing on disciplinary knowledge appear to be successful in improving student teachers' content knowledge, they do not, research indicates impact upon their attitudes (Schoon and Boone, 1998). This is supported by Hechter (2011) who advises collaboration between education and science departments to develop more holistic approaches in science content courses, prior to science methods courses. A relationship between secure subject knowledge and effective planning and teaching is noted by Goulding, Rowland, and Barber (2002) who also stress the importance of pedagogical knowledge in teaching mathematics.

Few studies of teacher education examine the integration of science and mathematics. Jones et al. (2003), however, present sound reasons for integrating science and mathematics methods classes in early childhood teacher preparation programmes. These scholars stress the fundamental goal in early childhood education is to deliver a curriculum in developmentally appropriate ways and thus they seek to encompass attention to both subject and pedagogical knowledge and suggest, for example, developing joint assignments, such as integrated science and mathematics lesson plans and reflective journals which

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consider teaching and learning in these contexts. Some studies have also shown the advantages of making links between the arts and science/mathematics courses in teacher education (Palmer,2009)

- The interaction between theory and practice

Connected to this, strong arguments are made for teacher education programmes that are characterized by the integration of practical experiences and theoretical study (Brouwer and Korthagen, 2005; Schepens et al. 2009).Korthagen et al.'s (2001) 'realistic and holistic approach' to teacher education starts from concrete practical problems and concerns experienced by student teachers in real contexts. It aims to promote systematic reflection both by student teachers and their pupils' and foregrounds the consideration of desires, feelings, thoughts and actions as well as the role of the context, and the relationships between these. Others scholars also highlight the teacher as a reflective practitioner constantly constructing and reconstructing their working theories through action and research (Bell, 2004).

It is argued that more field experiences might increase pre-service teachers' confidence in handling the issues examined in their courses (Yilmaz-Tuzun, 2007), so science method courses need to provide opportunities to learn about different methods through involvement in the field as observers and as reflective pedagogues.

- School -based versus university-based teacher education

Hybrid spaces in pre-service education programmes are reccommended as, it is claimed, they bring together academic knowledge and school and university-based teacher educators and practitioners in new ways, that have the potential to enhance the learning of all involved (Zeichner, 2010). It is thus suggested that schools and teacher education partnerships should not only focus on the education of student teachers, but on the professional development of the school staff, and on curriculum innovation and on shared research. (Snoek, Uzerli and Schratz, 2008; Bezzina, Lorist and van Velzen, 2006).

- The role of the teacher educator

In European literature, whilst teacher educators are seen to be a heterogeneous group (ETUCE, 2008) they are widely recognized to be central to effective initial teacher education. Nonethless, few of the studies reviewed, describe, document or analyse this role in any depth. Although Howitt 's (2007) research reaveals that teacher educators are a 'powerful influence' on pre-service teachers' confidence towards science and the teaching of science and Bleicher's (2006) work confirms these findings, he describes the positive effect of intensive guidance on student teachers' confidence in learning science.

Teacher educators are variously perceived as: instructors who scaffold student teachers' learning (Davis, 2006), mentors that support science planning (Jarvis, McKeon, Coates, and Vause, 2001)and supportive partners in field experiences (Kenny, 2009).

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- Importance of the development of a repertoire

A number of studies focus on particular interventions in order to support student teachers in developing a repertoire of approaches, ensuring they are able to make use of a range of resources and develop classroom contexts conducive to learning about science and fostering inquiry based science learning. Schwarz (2007) indicates that pre-service primary teachers are most likely to develop their scientific knowledge and practice within a coherent approach that focuses on a core scientific practice such as modelling-centred inquiry. He argues this provides opportunities to discuss and unpack reform-based instructional frameworks, and addresses the student teachers perceived problems in relation to practice.

Other studies also indicate that involving studnt teachers in inquiry based work supported the development of understandings of science and scientific inquiry (Weld and Funk, 2005; Haefner and Zemba-Saul, 2004). Etherington (2011) designed a problem-based learning approach, as a pedagogical mode of learning open inquiry science, and found a positive impact on pre-service teachers' motivation to teach science ideas within a real world context. He argues that this open inquiry approach can be seen as a method of teaching and practicing science wherein curiosity and the desire to understand the world are nurtured and talents, interests, creativity and skills are fostered. Varma, Volkmann, and Hanuscin (2009) found that when multiple inquiry-based experiences, from guided to open, are integrated into a science course, pre-service teachers develop not only an understanding of inquiry-based science instruction, but also an appreciation for the benefits of teaching and learning science in a constructivist environment.

Additional elements within the repertoire of approaches documented include other constructivist approaches, including blended learning and small group work focused on learning by doing, as well as the use of ICT tools such as video games which can support student teachers' scientific understanding (Anderson and Barnett, 2011). Whilst endorsing the view that a variety of learning opportunities are needed to develop student teachers' confidence as science educators, Luera and Otto (2005), amongst others, note the time constraints within teacher education courses.

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D. TEACHER EDUCATION CURRICULA PROMOTING CREATIVITY IN EARLY YEARS SCIENCE AND MATHEMATICS

D1. Components and curriculum design principles

As previously discussed, ten components, based on the curriculum concept of van den Akker (2007), were identified as the basis for the set of curriculum design principles. Figure 3 shows van den Akker's preferred visualization of these 10 components, as a spider web. The rationale in the middle of the spider web refers to the central mission of the curriculum. It 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 (van den Akker, 2007, p41).

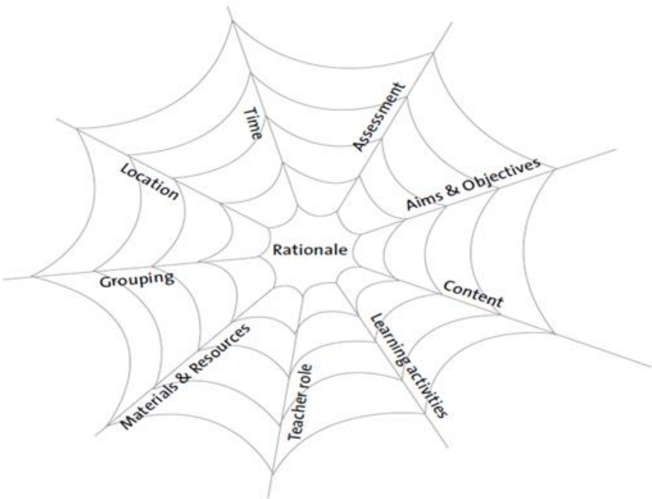

Figure 3: Curricular Spider Web (van den Akker, 2007, p. 41)

Moreover, van der Akker has associated these curriculum components with key questions about aspects of learning in schools. In adjusting these components for use as the basis for the curriculum design principles for teacher education, these associated key questions were adjusted and in some cases expanded accordingly and as follows:

- Rationale: *Why are teachers learning?*
- Aims and objectives: *Toward which goals are teachers learning?*
- Role of Teacher Educator: *How is the teacher educator facilitating learning?*
- Learning activities: *How are teachers learning?*
- Assessment: *How to measure how far teachers' learning has progressed? How is assessment information used to inform planning and develop practice?*
- Content: *What are teachers learning?*
- Materials and resources: *With what are teachers learning?*

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- Grouping: *With whom are teachers learning? How are they allocated to various learning trajectories? Are they learning individually, in small groups, or whole-class?*
- Location: *Where are teachers learning? Are they learning in class, in the library, at home or elsewhere? What are the social/physical characteristics of the learning environment?*
- 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?*

In the following sections, the components (and associated questions) are presented along with the associated curriculum design principles. It is important to note that while the components and design principles are presented in a list, the components are not in any hierarchical order and should not be viewed in isolation as they are all closely interconnected and highly interdependent. All of the design principles are meant to be seen as equally important and a foundation for different curricula development routes in Europe. They also represent the starting point for discussions with various groups of stakeholders, amongst them teacher education policy makers and teacher educators in training institutions. Recommendations incorporating this set of curriculum design principles are given in section D2.

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<table>
<tr><td colspan="2">

Rationale

Why are teachers learning?

Teachers (incl. student teachers) should foster inquiry and creativity in science and mathematics learning[1] in preschool and the first years of primary school.

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Aims and Objectives

Towards which goals are teachers learning?

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Competences for teachers

In teacher education teachers should:

1.1 Acquire secure content knowledge of science and mathematics ideas and processes, as well as the skills and competences to carry out inquiries.

1.2 Acquire the pedagogical content knowledge to foster inquiry and creativity in early years science and mathematics, including the use of inquiry approaches.

1.3 Become confident and develop positive attitudes towards learning and teaching science, mathematics using inquiry and creativity based approaches.

1.4 Acquire the skills to act as researchers and reflective practitioners in learning and teaching science and mathematics, and should become able to discern and reflect on innovative ideas.

1.5 Acquire the knowledge and skills to support the diverse interests and needs of young children in engaging creatively within the fields of science and mathematics.

Foci of teacher education

Teacher education should:

1.6 Emphasise the importance of science and mathematics education for personal and society development by advocating its role in the preparation of scientific and mathematic literate citizens as well as the role of creativity in these domains and in human development.

1.7 Emphasise the pedagogical synergies between IBSE and creative approaches in both science and mathematics learning and teaching.

1.8 Foster teacher learning outcomes aligned with creative science and mathematics teaching strategies and assessment methods.

1.9 Foster teachers' creativity and their potential to be creative in science and mathematics.

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

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Rationale

Why are teachers learning?

Teachers (incl. student teachers) should foster inquiry and creativity in science and mathematics learning[1] in preschool and the first years of primary school.

Role of teacher educator

How is the teacher educator facilitating learning?

Teacher educator profile

Teacher educators of science and mathematics education should:

2.1 Combine content knowledge, pedagogical content knowledge, and teaching practice of science and mathematics.

2.2 Be reflective practitioners who promote creative approaches in their practice, including inquiry and problem solving.

2.3 Be willing to try new things and be open to taking risks in their practice, so they can bring in (new) effective pedagogy and approaches in the fields of science and mathematics.

2.4 Have the skills to build partnerships (e.g. communities) with different science and mathematics education stakeholders such as schools, science research centers, science museums, scientific and mathematics associations at national and local level, etc.

2.5 Be encouraged to be actively involved in research and discussion networks about science and mathematics education pedagogy.

Teacher educator role

Teacher educators should:

2.6 Take into consideration teachers' prior knowledge, skills, attitudes, beliefs, fears, preconceptions (incl. stereotypical images), learning styles and experiences associated with learning and teaching science, mathematics, and creativity, and organize appropriate learning activities.

2.7 Make explicit connections among content knowledge, pedagogical content knowledge and teaching practice of science and mathematics, as well as between these and the development of creativity.

2.8 Practically demonstrate a variety of roles in their interactions with teachers e.g. facilitator, supporter, coordinator, leader, motivator, role model.

2.9 Model inquiry- and creativity-based learning, teaching and assessment practices, by for example encouraging teachers' decision making during inquiry processes, and sharing, evaluating and reflecting on outcomes.

2.10 Model how teachers should select science and mathematics materials and resources for fostering creativity in mathematics and science.

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Rationale *Why are teachers learning?* **Teachers (incl. student teachers) should foster inquiry and creativity in science and mathematics learning[1] in preschool and the first years of primary school.**	
Learning activities *How are teachers learning?*	Teacher education should provide learning activities in science and mathematics which: 3.1 Are inquiry-based, addressing all essential features of inquiry (questioning, designing or planning investigations, gathering evidence, making connections, explaining evidence, communicating and reflecting on explanations), and their various purposes and degrees of structure and guidance (including open, guided and structured inquiries). 3.2 Bring out the synergies between inquiry-based science and mathematics and approaches directed at developing learner creativity. 3.3 Are interactive, within a rich, motivating context, and should encompass a range of formal and informal learning approaches and strategies. Examples of such activities include lesson planning, discussions focused on fostering creativity; demonstrations of good practice; outdoor learning; field trips; project work. 3.4 Integrate science and mathematics learning, making use of real life, meaningful and interactive contexts, and illustrating the potential of such interdisciplinary approaches for inquiry and creativity. 3.5 Provide teachers with opportunities to recognize and better understand both young children's learning of science and mathematics and the role of creativity within this, through for example classroom observations, collection and analysis of evidence, talking to children. 3.6 Attend to teachers' different approaches to their own learning and encourage their expression and representation of scientific and mathematics ideas in various modes. 3.7 Help teachers reflect on their own prior knowledge, (mis)conceptions (incl. stereotypical images) beliefs and attitudes about science, mathematics and creativity, using a variety of approaches, such as microteaching, peer-observations, learning journals. 3.8 Support teachers' learning, by providing them with illustrative examples of diverse practices for them to critically examine opportunities for creativity and inquiry in learning, teaching and assessment. 3.9 Are a variety of individual and collaborative to promote teachers' creative thinking skills and dispositions.

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Rationale

Why are teachers learning?

Teachers (incl. student teachers) should foster inquiry and creativity in science and mathematics learning[1] in preschool and the first years of primary school.

Assessment

How to measure how far teachers' learning has progressed? How is assessment information used to inform planning and develop practice?

Focus of assessment

In teacher education:

4.1 Teachers' acquisition and development of science/mathematics content and pedagogical content knowledge, skills and attitudes should be assessed.

4.2 The development of teachers' inquiry and creativity-based teaching and assessment approaches should be assessed.

4.3 Teachers' acquisition and development of understanding about what it is to foster children's creativity in science and mathematics should be assessed.

4.4 The development of teachers' abilities to plan for, foster, reflect upon and assess children's creativity in science and mathematics education should be assessed.

Process of assessment

Teacher education should:

4.5 Promote teachers' independence and responsibility in identifying their own progress and areas for development both in the fields of science and mathematics education and in the fostering of creativity within these fields.

4.6 Use different assessment strategies in order to assess holistically cognitive, social and affective aspects of science and mathematics learning, as well as tap into the potential for peer and self-assessment.

4.7 Use different forms of evidence (e.g. portfolios, teacher diary, observation lists, tests, essays, project work, teaching practice) for assessment purposes.

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Rationale *Why are teachers learning?* **Teachers (incl. student teachers) should foster inquiry and creativity in science and mathematics learning[2] in preschool and the first years of primary school.**	
Content *What are teachers learning?*	Teacher education should: 5.1 Provide content knowledge about science and mathematics, including interesting and current topics, to be used in activities linked with everyday life. 5.2 Provide teachers with skills and competences to carry out practical investigations of science and mathematics in the classroom. 5.3 Advance teachers' understandings about the nature of science and how scientists work, confronting stereotypical images of science and scientists. 5.4 Promote understandings about the nature and framings of creativity, characteristics of creative teaching and learning, and how creativity is manifest in early years science and mathematics. 5.5 Provide knowledge about how children's creativity development could be enhanced and assessed within science and mathematics education. 5.6 Provide pedagogical content knowledge to stimulate inquiry and problem solving in science and mathematics education. 5.7 Familiarise teachers with a range of formal and informal inquiry- and creativity-based learning, teaching and assessment approaches and strategies and their use in relation to authentic problems within the areas of science and mathematics. 5.8 Enable teachers to design and assess creativity-enabling inquiry-based activities which are child-friendly and include both guided and open inquiries. 5.9 Enable teachers to make best use of and assess the various modes of expression and representation of science and mathematics learning to support inquiry and the development of creativity. 5.10 Enable teachers to recognize and build on children's questionings, ideas, theories and interests for the teaching of science and mathematics. 5.11 Enable teachers to use questioning effectively and encourage children's questions in order to foster creativity and inquiry. 5.12 Provide knowledge about early child development, the purposes and aims of science and mathematics education, and their place in the early years curriculum.

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

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Rationale *Why are teachers learning?* **Teachers (incl. student teachers) should foster inquiry and creativity in science and mathematics learning[3] in preschool and the first years of primary school.**	
Content (cont.) *What are teachers learning?*	5.13 Provide teachers with knowledge about the relevant education policy guidelines and documents for science, and mathematics education (and the role of creativity in them) at national level, as well as about the corresponding policy trends at European level. 5.14 Equip teachers with knowledge and skills to use a range of formal, non-formal and informal learning environments, including the outdoor environment, both the school grounds and the wider environment beyond the school, in their teaching of science and mathematics. 5.15 Promote teachers' use of group work to support children's inquiry processes and creative learning. 5.16 Provide teachers with knowledge of approaches to timetabling and organizing cross-curricular project work. 5.17 Address with teachers issues in ensuring rich provision, planning and use of resources (including digital resources) in and out of the classroom to support children's inquiry and creativity. 5.18 Encourage and assess the development of teachers' literacy, numeracy and digital literacy skills through science and mathematics.
Materials and resources *With what are teachers learning?*	Teacher education should: 6.1 Provide ICT infrastructure and logistical support to teachers to access diverse learning materials and resources, which may include web-based resources, social media, videogames, online academic journals and databases, as well as other digital technologies, such as cameras, tablets, and other digital devices. 6.2 Facilitate and promote access to a variety of early years science and mathematics curriculum materials and resources fostering inquiry and creativity. These should be both for indoor and outdoor use and include everyday materials, picture and story books, building blocks, equipment for hands-on exploration. 6.3 Facilitate and promote access to materials and resources (including everyday materials) fostering inquiry and creativity in early years science and mathematics.

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

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Rationale *Why are teachers learning?* **Teachers (incl. student teachers) should foster inquiry and creativity in science and mathematics learning[4] in preschool and the first years of primary school.**	
Grouping *With whom are teachers learning? How are they allocated to various learning trajectories? Are they learning individually, in small groups, or whole-class?*	Teacher education should: 7.1 Provide a range of learning trajectories to teachers to choose from according to their needs and preferences. 7.2 Promote collaborative learning practices, including peer learning, in science and mathematics education in order to foster creativity and inquiry. 7.3 Promote team teaching and working in the fields of science and mathematics education. 7.4 Support teacher collaboration, including at a distance through digital media and other ICT tools that make this possible. 7.5 Provide interaction and interdisciplinary collaboration opportunities amongst student teachers, in-service teachers, science experts, research scientists, teacher educators, children, and educational establishments and organizations.
Location *Where are teachers learning? Are they learning in class, in the library, at home or elsewhere? What are the social/physical characteristics of the learning environment?*	Teacher education should: 8.1 Take place in a variety of learning environments (formal, non-formal and informal, indoor and outdoor), including e.g. science museums, science research centers, natural habitats, etc., modelling their subsequent use for inquiry and creativity in the classroom. 8.2 Facilitate access to industries and research centres of science and mathematics to promote collaboration, sharing, visiting, and networking of teachers. 8.3 Provide opportunities for place-independent and collaborative learning, i.e. flexibility and variety of teaching locations.

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

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Rationale

Why are teachers learning?

Teachers (incl. student teachers) should foster inquiry and creativity in science and mathematics learning[5] in preschool and the first years of primary school.

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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?

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Teacher education should:

9.1 Provide time for teachers to interact with colleagues: e.g. collegial consultation/reflection, teamwork, mind mapping, vision-building.

9.2 Allow sufficient time for teachers to explore opportunities for creativity in learning and teaching in early science and mathematics and to gain confidence through the process.

9.3 Provide opportunities for time-independent (distance) learning.

9.4 Model different approaches to timetabling science and mathematics education, encouraging interdisciplinary and project work.

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

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D2. Recommendations for teacher education policy makers and institutions to apply the set of curriculum design principles

The intention of the final set of curriculum design principles is to present a document that could be employed as a stimulus for debate, design and evaluation and as a means to promote creativity in science and mathematics education for young children. The document is intended for policy makers and practitioners to modify for their own use in response to different purposes and audiences.

In order to use the set of design principles appropriately, some specific aspects need to be taken in consideration by a teacher educator, working alone or in a team, and by teacher education institutions. These are:

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

These aspects are discussed in the following sections and are relevant to the recommendations for teacher education policy makers and institutions.

As mentioned above, the proposed set of curriculum design principles can also be used as an evaluation tool for existing European ITE and CPD programmes for early years teachers in the domains of science and mathematics. Marking criteria per component might be differentiated into 5 levels of achievement. By evaluating programmes using the proposed design principles, additions and alterations to courses and new short term goals can be encompassed. A digitalized version made by the AUC partner is visualised in Figures 4 and 5.

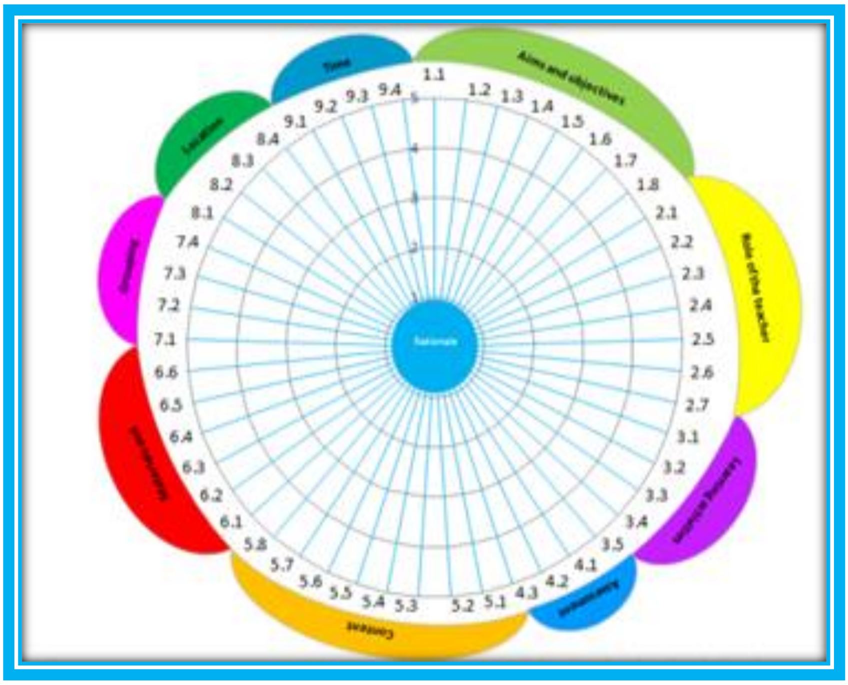

Figure 4: A visualisation of the evaluation tool

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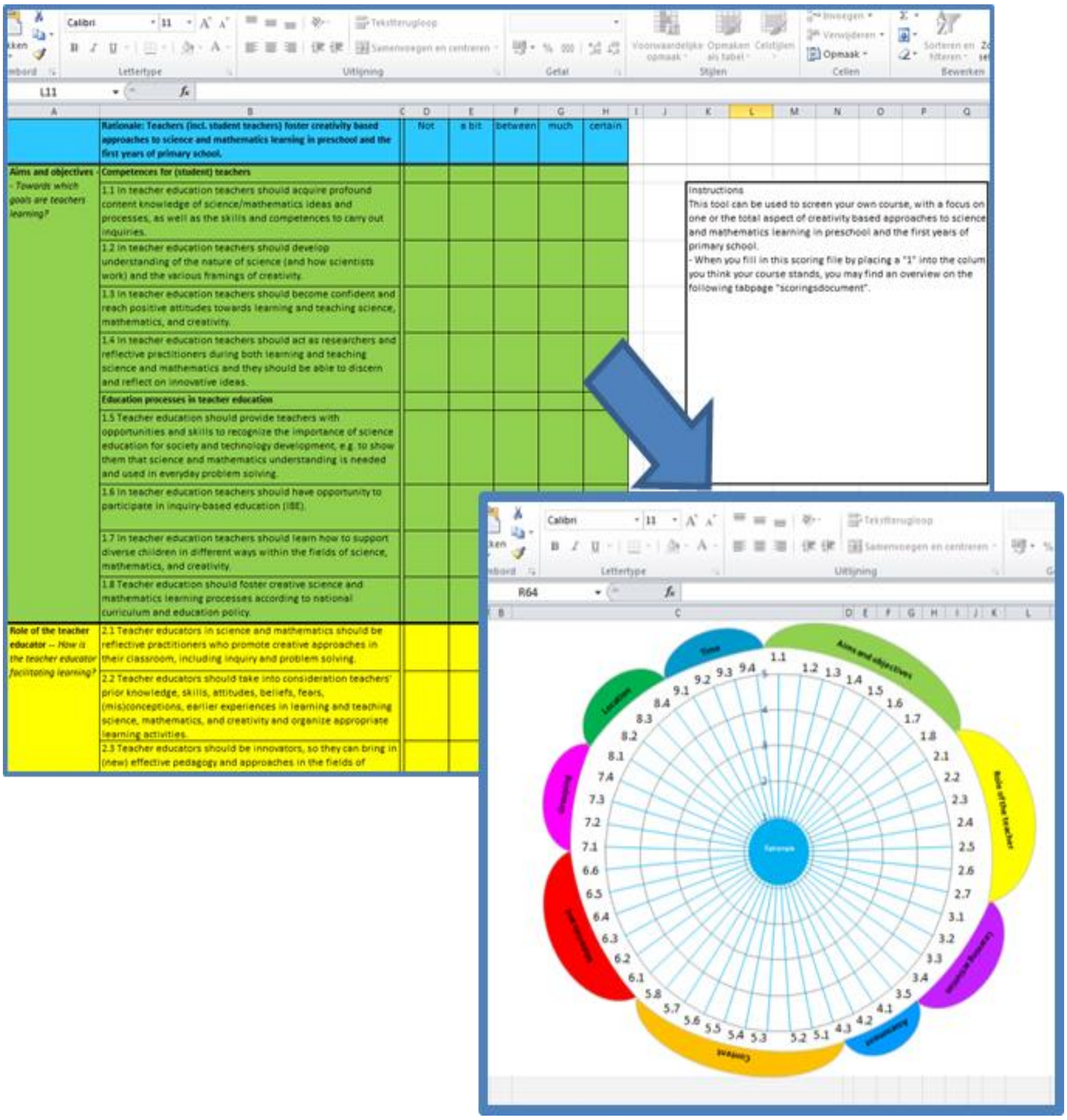

Figure 5: A visualisation of how the proposed curriculum principles could be used for the evaluation of the existing ITE and CPD programmes

D2.1 Concept of the spider web

In designing a curriculum van den Akker (2007) argues that attention needs to be paid to several components, as described in section D1 (Figure 3). The middle of the spider web refers to the central mission of the plan (curriculum or programme) and should not, he asserts, be viewed in isolation from its multiple interconnected and highly interdependent components. For example, if the designers of a teacher education curriculum focus only on promoting inquiry approaches through learning activities, and pay no attention to the related time and materials, it will be hard to achieve the desired aim that teachers: *"[…] acquire profound content knowledge of science/mathematics ideas and processes, as well as the skills and competences to carry out inquiries"* (Design principle 1.1). The interconnection

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between the components of the curriculum design principles was considered by the participants of the online focus groups. They perceived that the availability of materials and tools, the space to work, and sufficient time for discussion and alternative solutions could greatly enhance learning activities with inquiry potentials. Therefore, the learning activity component should be considered together with the components of time, content, role of teacher educator, materials and resources, location, and grouping. Furthermore, the stakeholders considered (student) teacher confidence as a prerequisite to meaningful science/mathematics learning. They saw it as related to children's engagement and thus the role of teacher educator in fostering teachers' confidence is crucial.

As discussed, when building a programme for teacher education it is necessary to take into account all the curriculum components together with the accompanying design principles. There will be differences between ITE programs and CPD programs. In CPD programs it is possible to focus on a specific teacher outcome (see section E) while in ITE it is necessary to focus on all the important outcomes in order to prepare student teachers to foster creative approaches in science and mathematics education in early years.

According to Thijs and van den Akker, curriculum design or innovation can start with any component on the spider web,but most often starts with the learning content (2009; pp. 12-13):

> *"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* [system, national] *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* [institution] *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."*

Through the research undertaken in the *Creative Little Scientists* project, particular issues were identified as important in order to foster creativity in science and mathematics education in the early years classroom. These were conceptualised as desirable Teacher Outcomes and were linked to the Content component of the curriculum design principles. These Teacher Outcomes are the learning outcomes the (student) teachers should achieve as a result of a training programme designed following the proposed curriculum design principles.

D2.2 Starting situation of (student) teachers

The starting situation – competences, expectations, beliefs, attitudes towards science and mathematics, prior experiences and prior knowledge –of student teachers and in-service

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teachers are important factors to be taken into account when designing a curriculum. Consequently, it is necessary to identify these starting points which will also be influenced by cultural and gender issues. For example, in a CPD context, teachers who experienced inquiry-focused science education in their ITE will have different needs to those who simply had basic training in science principles.

Based on the findings of the review of policy documentation (D3.2) it is clear that in Europe most of the preschool and primary school teachers have at least a Bachelor's (or equivalent level) degree. This was confirmed by the data of the survey (D3.3). However, more primary than preschool teachers have a higher education qualification than a Bachelor's (or equivalent) and have studied science and mathematics at a higher level of formal education. Nevertheless, the majority of the teachers in the quantitative part of the research (D3.3) reported only receivng an overview of or introduction to Mathematics, Science, Environmental/Earth Sciences and ICT as part of their post-compulsory education and ITE. These teachers, whilst they reported feeling confident in their general pedagogic knowledge, expressed the least confidence in their knowledge/understanding of science (ideas, processes and nature) and their competencies to carry out scientific inquiry. The teachers also reported feeling more confident in their mathematics teaching, assessment and pedagogic knowledge, than in their science teaching, assessment and pedagogic knowledge.

These findings give an indication about the starting point of average European teachers, although there will be individual and cultural differences. As such, in the development of a CPD programme it will be important to take in account the starting point of the teachers and to select the teacher outcomes, which are prioritised in that particular country or local context. Furthermore, teachers may, based on their own needs select appropriate CPD programmes. An evaluation tool for teachers to judge their own levels of competences in science and mathematics and their ability to enhance opportunities for inquiry and creativity would be valuable. During the fieldwork phase of *Creative Little Scientists* a framework was used to analyse the data originating from the observations in the classrooms. This could be used as basis for such an evaluation tool.

As for ITE, student teachers would benefit from a flexible curriculum based on their own needs and starting points, rather than a fixed curriculum. This was a recurrent message from the country stakeholders in both the online focus groups and the face-to-face focus groups. Further research and evidence is needed on the potential for individualised learning plans and student incentives in the fields of science and mathematics.

D2.3 Initial Teacher Education versus Continuous Professional Development

As mentioned before in initial teacher education student teachers are educated and enabled to work as teachers of the future. Based on this and on discussions in the different focus groups it became clear that ITE curricula should encompass all the curriculum design principles and related teacher outcomes.

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In line with Jan Figel (European Commission, 2007), the various stakeholders in the focus groups agreed that lifelong learning has become a necessity for all citizens. *"We need to develop our skills and competences throughout our lives, not only for our personal fulfilment and our ability to actively engage with the society in which we live, but for our ability to be successful in a constantly changing world of work"* (p.1). In light of this, the project argues that CPD opportunities for teachers, should not be viewed as additional extras or favours, but as an integral part of the education profession. For example, in the curriculum design principle 1.3: "*In teacher education teachers should become confident and develop positive attitudes towards learning and teaching science, mathematics using inquiry and creativity based approaches*", confidence is viewed as a competence to be exercised and developed over time, beyond the remit of ITE.

As noted in D3.2 (policy review) and confirmed in D3.3 (teacher survey), there should be a professional entitlement to CPD to support new initiatives and approaches related to inquiry-based and creative approaches to teaching, for example CPD with a focus on strategies for developing children's curiosity and agency as creative young scientific thinkers

As such, CPD differs from ITE. In initial teacher programmes sufficient attention has to be paid to the nature of science, whereas in CPD gaps have to be bridged and a climate for ongoing improvement, interaction, and sharing developed. Based on the data in D3.3 it is clear that teachers in Europe would benefit from professional development opportunities in science and mathematics which for example, demonstrate the potential of outdoor learning activities; focus on the evaluation and generation of ideas of children; demonstrate the creative potential of questioning as a teaching tool; and the use and potential of digital technologies and ICT resources for creativity development. The related teacher outcomes can be found in section E.

Nonetheless, there are cultural differences, such as national policy issues and differences in ITE programmes, which may influence the topics or teacher outcomes chosen for CPD programmes.

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E. TEACHER OUTCOMES AS CONCRETE CONTENT RECOMMENDATIONS FOR TEACHER EDUCATION

The comparative research (policy review and teacher survey) and in particular the in-depth fieldwork of *Creative Little Scientists* provided insights into a number of issues that need to be tackled in teacher education in order to foster creativity in science and mathematics education in the early years. Based on these, the Content design principles were elaborated into concrete and specific teacher learning outcomes. In the table below these Teacher Outcomes can be seen, alongside the deliverables containing the research evidence on which they were based. The Teacher Outcomes, which are not shown as linked to a particular research-based deliverable, i.e. D3.2, D3.3, D4.4, are derived either from the project's Conceptual Framework (D2.2) and/or are refinements of the corresponding curriculum design principles, which themselves have been the product of the curriculum design research carried out in WP5

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

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Curriculum Design Principles about Content and linked Teacher Outcomes	Comparitive policy review (D 3.2)	Comparitive teacher survey (D 3.3)	In-depth field research (D 4.4)
5.1 Teacher education should provide content knowledge about science and mathematics, including interesting and current topics, to be used in activities linked with everyday life.			
5.1.1 Teachers should be able to pursue the social and affective objectives of children's science and mathematics learning, in synergy with the corresponding cognitive ones.	X		
5.1.2 Teachers should be able to make children aware of connections between science and mathematics learning and their everyday lives, in order to engage their motivation, interest and enjoyment in science and mathematics and foster curiosity and creativity.			
5.2 Teacher education should provide teachers with skills and competences to carry out practical investigations of science and mathematics in the classroom.			
5.2.1 Teachers should be able to instigate and involve children in the design and conduct of practical investigations of science and mathematics in the classroom, as such activities can contribute to the development of children's creativity.		X	
5.2.2 Teachers should have detailed knowledge about the nature of inquiry and investigations in early years science and mathematics in order to be able to recognise the opportunities they offer both for creative learning and developing children's creativity.	X		
5.3 Teacher education should advance teachers' understandings about the nature of science and how scientists work, confronting stereotypical images of science and scientists.			
5.3.1 Teachers should be able to advance children's understanding about the nature of science and how scientists work, confronting stereotypical images of science and scientists.		X	

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5.3.2 Teachers should be able to recognize young children's capabilities to engage with processes associated with the evaluation as well as generation of ideas in science and mathematics, since these processes are also important for the development of learner creativity.	X	X	
5.3.3 Teachers should be able to foster the processes of imagination, reflection and consideration of alternative ideas in supporting children's understanding of scientific ideas and procedures and development of creativity	X		
5.4 Teacher education should promote understandings about the nature and framings of creativity, characteristics of creative teaching and learning, and how creativity is manifest in early years science and mathematics.			
5.4.1 Teachers should be able to recognize how creativity is manifest in early years science and mathematics and have knowledge of distinctions between features of creative teaching and creative learning.			X
5.5 Teacher education should provide knowledge about how children's creativity development could be enhanced and assessed within science and mathematics education.			
5.5.1 Teachers should have detailed knowledge about the synergies between inquiry and creativity, such as play and exploration, motivation and affect, dialogue and collaboration, problem solving and agency, questioning and curiosity, reflection and reasoning; and teacher scaffolding and involvement, to support children's creative learning and advance their creativity within science and mathematics education		X	
5.6 Teacher education should provide pedagogical content knowledge to stimulate inquiry and problem solving in science and mathematics education.			
5.6.1 Teachers should have knowledge of all essential features of inquiry and problem solving (questioning, designing or planning investigations, gathering evidence, making connections, explaining evidence, communicating and reflecting on explanations), their different purposes, degrees of structure and guidance (including open, guided and structured inquiries), and varied opportunities they offer for creativity.		X	X
5.6.2 Teachers should be able to open up everyday learning activities to allow greater opportunities for inquiry, problem solving and scope for creativity.			X

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5.6.3 Teachers should be able to recognise the key roles of children's questioning and existing ideas (both implicit and explicit) of science and mathematics.			X
5.6.4 Teachers should be able to use a variety of strategies for eliciting and building on children's questions and ideas during inquiry processes (before, during and after explorations and investigations).			X
5.6.5 Teachers should be able to foster opportunities for children's agency and creativity in learning in inquiry and problem solving – in particular the importance of children making their own decisions during inquiry processes, making their own connections between questions, planning and evaluating evidence, and reflecting on outcomes.			X
5.7 Teacher education should familiarise teachers with a range of formal and informal inquiry- and creativity-based learning, teaching and assessment approaches and strategies and their use in relation to authentic problems within the areas of science and mathematics.			
5.7.1 Teachers should have knowledge of a range of formal, non-formal and informal learning, teaching and assessment approaches and strategies to promote creativity in their early years science and mathematics classroom.			
5.7.2 Teacher should be able to use a range of strategies both formal and informal for supporting children's extended engagement with an area of study and progression in learning in science and mathematics.			X
5.7.3 Teachers should be able to recognize and exploit the value of play and exploration in science and mathematics for fostering and extending inquiry and creativity, by for example prompting questions, eliciting ideas, providing opportunities for consideration of alternative strategies during children's familiarisation with phenomena and events.			X
5.7.4 Teacher should be able both to build in new and to make the most of existing opportunities for child-initiated play, recognising and capitalising on the potential of children's explorations beyond the teacher's original intentions.			X
5.7.5 Teachers should be able to use a range of creative contexts and approaches for provoking children's interest, motivation and enjoyment in science and mathematics, such as stories, poems, songs, drama, puppets and games.		X	X
5.7.6 Teachers should be able to use strategies for making and building on science and mathematics real life connections and applications for engaging creatively young children in science and mathematics learning.			X

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5.7.7 Teachers should be able to assume a variety of roles in their interactions with the children e.g. allower, leader, afforder, coordinator, supporter, tutor, motivator and facilitator, to support children's creativity and inquiry in science and mathematics.			
5.7.8 Teacher should be able to use a variety of scaffolding techniques to promote creativity in science and mathematics, from standing back in order to observe, listen and build from the children's interests, to intervening with appropriate questioning to support and extend inquiries.			X
5.7.9 Teachers should be able to use different assessment approaches and strategies and in particular those that involve children in the assessment processes, such as peer and self assessment, dialogue and feedback on progress, in the early years science and mathematics classroom.			X
5.7.10 Teachers should value and be able to make use of varied forms of assessment evidence (including children's portfolios, individual or group records of activities), both to promote creative learning, through reflection and discussion in science and mathematics, and explicitly to inform teaching and longer term planning.			X
5.8 Teacher education should enable teachers to design and assess creativity-enabling inquiry-based activities which are child-friendly and include both guided and open inquiries.			
5.8.1 Teachers should be able to design and assess open-ended learning activities.			
5.9 Teacher education should enable teachers to make best use of and assess the various modes of expression and representation of science and mathematics learning to support inquiry and the development of creativity.			
5.9.1 Teachers should be able to recognize and value children's various forms of expression and representation of their ideas and learning in science and mathematics.			X
5.9.2 Teachers should be able to make best use of children's preferred forms of expression and representation of their science and mathematics ideas to support inquiry and their creativity development.			X
5.9.3 Teachers should be able to select and use different approaches for and forms of recording children's ideas and learning in science and mathematics at different stages of the learning process and for various purposes, including to support children's reflection and reasoning processes.			X
5.9.4 Teachers should be able to use the various modes of children's expression and representation of science and mathematics	X	X	

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ideas (e.g. pictures, graphs, gestures, physical activities) for assessment purposes.			
5.10 Teacher education should enable teachers to recognize and build on children's ideas, theories and interests for the teaching of science and mathematics.			
5.10.1 Teachers should be able to use a range of strategies for picking up on children's ideas, theories and interests.			X
5.10.2 Teachers should be able to build flexibility into planning to take advantage of unexpected events, children's interests and questions.			X
5.11 Teacher education should enable teachers to use questioning effectively and encourage children's questions in order to foster creativity and inquiry			
5.11.1 Teacher should be able to use different forms of questioning at appropriate points to scaffold creative learning outcomes in science and mathematics, and in particular to encourage children's reflections and explanations, foster their independence and extend their inquiry.			X
5.11.2 Teachers should value and be able to build on the potential of children's own questions to foster their curiosity in science and mathematics, and support their generation and follow up, including those that are investigable.		X	X
5.12 Teacher education should provide knowledge about early child development, the purposes and aims of science and mathematics education, and their place in the early years curriculum.			
5.12.1 Teachers should have knowledge of the various purposes and aims of science and mathematics education in compulsory schooling.			X
5.12.2 Teachers should have knowledge of the prevailing academic rationale for the place of science and mathematics in the early years curriculum.			X
5.12.3 Teachers should have knowledge of the role of creativity in child development and in the fields of science and mathematics.			
5.12.4 Teachers should be able to contribute towards the goal of preparing creative citizens, who have scientific and mathematic literacy.			
5.12.5 Teacher should be able to align the aims and rationale for early years science and mathematics education with their teaching and assessment approaches and priorities.			
5.12.6 Teachers should be able to support the diverse interests and needs of young children in engaging creatively within the fields of science and mathematics.			

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5.13 Teacher education should provide teachers with knowledge about the relevant education policy guidelines and documents for science, and mathematics education (and the role of creativity in them) at national level, as well as about the corresponding policy trends at European level.			
5.13.1 Teachers should have knowledge about the relevant education policy guidelines and documents for science and mathematics education (and the role of creativity in them) at national level, as well as about the corresponding policy trends at European level.			
5.14 Teacher education should equip teachers with knowledge and skills to use a range of formal, non-formal and informal learning environments, including the outdoor environment, both the school grounds and the wider environment beyond the school, in their teaching of science and mathematics.			
5.14.1 Teachers should be able to make use of varied settings for science and mathematics learning, including flexible use of the environment both indoors and out.			X
5.14.2 Teachers should be able to recognise and build on opportunities for informal learning in science and mathematics within the school environment, for example within day to day routines or child-initiated games and other activities in school classrooms or outdoor play areas.		X	X
5.14.3 Teachers should be able to elicit and build on children's informal learning of science and mathematics outside school, at home or in the wider environment.		X	X
5.14.4 Teachers should be able to manage visits with children to the outdoor and wider environment beyond the school, addressing issues of health and safety, liaison with parents, building progression in experience inside the classroom.			X
5.15 Teacher education should promote teachers' use of group work to support children's inquiry processes and creative learning.			
5.15.1 Teachers should have knowledge of the value of collaboration for inquiry and creative thinking and learning.			X
5.15.2 Teachers should be able to purposefully use a variety of patterns of collaboration, shifting between individual and collaborative activity over time, to support children's inquiry processes and creative learning.			X
5.15.3 Teachers should be able to organize group work, aligning ways of grouping children, task design, teaching and assessment strategies in different ways to promote collaboration amongst children in science and mathematics.			X
5.15.4 Teachers should be able to use resources and teacher intervention appropriately to foster collaboration in science			X

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

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5.18 Teacher education should encourage and assess the development of teachers' literacy, numeracy and digital literacy skills through science and mathematics.			
5.18.1 Teachers should develop their literacy, numeracy and digital literacy skills through science and mathematics.			

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F. FINAL CONCLUSIONS

The central focus of D5.2 was on prototyping curriculum design principles relevant to teacher education fostering creative approaches in science and mathematics education for young children. The process has been complex, interactive, iterative and situated. In the following a number of observations and implications are summarised and future directions for research are suggested.

Observations and Implications

- Any extensive teacher-training programme should pay attention to the **multidimensional nature of curriculum design**, involving a range of components built around a rationale or mission.
- The application of Van den Akker's (2007) 'spider web' model has proved valuable and should be recommended to policy makers responsible for curricula design. However, a gap was noticed within it, namely that it pays no attention to the **starting situation of pre- or in-service teachers- their competences, expectations, beliefs, attitudes towards science and mathematics, prior experiences and prior knowledge**. This is critical to take into account when designing a curriculum, and some conceptual recommendations were developed in this regard.
- **Approaching curriculum design research collaboratively and iteratively in order to prototype the curriculum design principles has been advantageous, enabling in-depth discussion of different stakeholders views and concerns.** This was evident in the online and face-to-face focus group discussions in several of the participating countries. The collaboration and vision-building with multiple stakeholders allowed the project team to design and validate a relevant curriculum framework. It facilitated the process of rejecting, accepting, adapting, and/or adding to the prototypical design principles for *Creative Little Scientists.*
- The **developed design principles and teacher outcomes reveal that a broad and deep approach to enabling early years teachers to foster creativity in science and mathematics education is needed**. The research affirms that creativity is socially situated and that teachers need to make time to listen to children's questions and observe their engagement, and to give the young learners time and space to explore, and inquire. In this respect, the importance of providing a safe, non-threatening learning environment for exploration and debate in teacher education is emphasized. In tune with Benammar's (2006) work, the project suggests that in order to enhance teacher confidence in fostering creativity in science and mathematics education, increased time needs to be afforded in ITE and CPD to address this.
- In order to teach for creativity in science and mathematics, teachers need to **experience the process first-hand and to reflect upon the processes involved**. Through building communities of practice, they may be enabled to consider their own teaching behaviour, and share concerns and experiences related to teaching particular content

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creatively. The project suggests that through working alongside young children in authentic settings, (student) teachers will have increased opportunities to encounter children's questions and through close observation their creative thinking and behaviour. It is also acknowledged that teachers need to be supported as they learn to foster creativity in science and mathematics education in the early years.

Future directions for research

- The implementation and evaluation of the curriculum design principles, teacher outcomes and the exemplary teaching materials in teacher education settings with teachers does not form part of the *Creative Little Scientists* project. However it would be valuable to follow up any ITE and CPD programs in Europe which decide to employ the design principles and teacher outcomes. Such findings would benefit all European teacher education institutions and CPD providers.
- More research is needed regarding the factors which contribute to teachers' self-confidence and efficacy beliefs. Crippen and Earl (2007) assert that in ITE the inclusion of examples from the classroom can help to increase self-efficacy and confidence. *Creative Little Scientists* will provide *Exemplary Teacher Training Materials* (D5.3) which are based on examples of good practice observed and analysed during the fieldwork phase of the research (WP4).
- Future studies of teacher educators should pay attention to the concept of job shadowing and triggers for creativity in ITE and CPD. Negotiation of meaning on these and other multiperspective issues such as current barriers to IBSE would be valuable.

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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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APPENDIX A: The draft curriculum design principles (prototype 2, task 5.2)

Teachers (incl. student teachers) foster creativity based approaches to science and mathematics learning in preschool and the first years of primary school.

1. Aims and objectives

1.1 Teacher education should provide teachers with opportunities and skills to recognize 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.

1.2 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.

1.3 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.

1.4 In teacher education teachers should acquire positive attitudes towards learning and teaching science, mathematics, and creativity.

1.5 In teacher education teachers become confident to teach science and mathematics fostering inquiry and creativity.

1.6 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.

1.7 In teacher education teachers should participate in inquiry-based science learning.

1.8 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.

1.9 In teacher education teachers should act as innovators, researchers and reflective practitioners during both learning and teaching.

1.10 In teacher education teachers should be encouraged to become self-regulated learners.

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1.11 Through teacher education teachers should commit themselves to promoting equity and inclusion in their teaching and to recognize and capitalize on diversity.

1.12 Through teacher education teachers should commit themselves to engage in partnerships with others (other teachers, parents, professional associations, experts, etc).

1.13 Through teacher education teachers should commit themselves to engage in lifelong learning.

1.14 In teacher education teachers should acquire skills in perspective-taking.

1.15 Curriculum developers of teacher education should organize 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.

2. The role of the teacher educator

2.1 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.

2.2 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.

2.3 Teacher education should provide teacher educators who can build partnerships (for example communities) with different stakeholders such as school staff, outside agencies, science research centers, etc.

2.4 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.

2.5 In teacher education teacher educator's qualifications should be in the field of content knowledge, pedagogical content knowledge and teaching of science and mathematics.

2.6 In teacher education teacher educators should make explicit connections between content knowledge and pedagogical content knowledge of science and mathematics in their teaching.

2.7 Teacher education should provide teacher educators who are inquirers/researchers; e.g. they provide access to research-based teaching.

2.8 Teacher education should provide teacher educators who are reflective practitioners.

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2.9 Teacher education should encourage teacher educators to contribute to and foster dynamic relationships between research, policy, and practice.

2.10 Teacher educators should be lifelong learners and be able to demonstrate this to teachers.

3. Learning activities

Focus on (inter)active learning

3.1 Teacher education should involve project work related to science and/or mathematics and creativity for young children.

3.2 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.

3.3 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.

3.4 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.

3.5 Teacher education should offer a dynamic platform for exploration and activity. As an example, together with teachers, teacher education could trial and verify varied approaches for children's expression and representation of (scientific) ideas.

3.6 Teacher education should promote the integration of ICT in science and mathematics teaching and learning.

3.7 Teacher education should provide time and space for microteaching, lesson plan discussions, demonstration of good practice, and experimental learning.

3.8 Teacher education should organize learning activities that follow a participative modeling 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)

3.9 In teacher education, inquiry-based science activities should be experienced by teachers under various levels of guidance/self-direction.

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3.10 Teacher education should get teachers to design multiple inquiry-based activities that are child-friendly and evolve from guided to open inquiries.

3.11 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.

3.12 Teacher education should provide learning activities that challenge inquiry-oriented and information-seeking skills, and attitudes of teachers.

3.13 Teacher education should refer to and elaborate on specific science research processes and research outcomes during learning activities.

Focus on reflective skills

3.14 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.

3.15 Teacher education should provide learning activities that promote reflective practices. Teachers need to be trained in critical thinking skills.

3.16 Teacher education should provide learning activities that vary the degree of self-regulated learning opportunities of one or more students at a certain moment.

3.17 In teacher education assessment could be perceived as a separate component, but as a learning activity too.

Focus on (pedagogical) content knowledge

3.18 Teacher education should include learning activities that encourage and evaluate the development of scientific literacy.

3.19 In teacher education science and mathematics content knowledge should be applied as concrete and stimulating as possible.

3.20 Teacher education should strengthen the pedagogical content knowledge construction of all teachers in the fields of science, technology, and mathematics.

3.21 Teacher education should provide learning activities which integrate science and mathematics content and pedagogical content knowledge in order to improve knowledge transfer.

4. Assessment

4.1 Teacher education (depending on its aims and objectives) should use different assessment strategies.

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The assessment strategies implemented in teacher education, and in particular with relation to science and mathematics, should ensure that there is:

4.2 - a balanced use of summative and formative assessment;

4.3 - a balanced use of process and product evaluation;

4.4 - a balanced use of self-, peer-, tutor-, group- and audience assessment;

4.5 - a balanced use of verbal and non-verbal tools for assessment;

4.6 - a balanced use of competence-based and talent-oriented assessment.

4.7 In teacher education, the acquisition and development of science/mathematics knowledge, skills and attitudes should equally be assessed.

4.8 Teacher education should value its assessment strategies as best examples of practice that may be transferred to teaching practice.

4.9 Teacher education should foster teacher independence and responsibility in identifying their own progress and areas for development.

4.10 Teacher education should provide assessment useful for learning, as a learning activity.

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APPENDIX B: Invitation letter to online focus group participants

Dear …,

We believe you have valuable expertise in early science education in country and so, we would like to invite you to participate in an online focus group.

This focus group will aim to draw upon varied expertise to debate curriculum design principles for the Creative Little Scientist project. These principles aim to inform initial teacher education as well as continuous professional development, as part of the *Creative Little Scientists* (CLS) project.

The *Creative Little Scientists* project is a European research project exploring the potential available on the common ground that science and mathematics education in pre-school and early primary school (up to age of eight) can share with creativity. The project brings together academics and researchers from 9 European countries (Belgium, Finland, France, Germany, Greece, Malta, Portugal, Romania, and the UK) and comprises expertise of the highest level and quality in the areas of science and mathematics education in early childhood, creativity in education, cognitive psychology, comparative educational studies, and teacher training. More information about the project can be found on the project website, www.creative-little-scientists.eu.

One of the key objectives of the project is the proposition of **a set of curriculum design principles** as concrete guidelines for European initial teacher education (ITE) and continuous professional development (CPD). These design principles enable teachers to 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.**

As a part of the research, we wish to evaluate the viability of these principles using online focus groups in the different partner countries. Hence our letter to you, where we feel your knowledge and experience would be very valuable.

Each **online focus group** will compose of experts with different experience, working at different levels in education – from research and policy to everyday practice. Each focus group will consist of around 6 to 8 participants. The running period of the online focus group is from the **30th of November until the 21th of December**. During these 3 weeks, we would like to request each participant at least one hour a week to provide written comments, questions and specific examples of practice from a context which they are familiar with. Login passwords, detailed information on the group assignment, and technical support will be introduced by an e-moderator, name, who can be contacted on email and accessible through the project's website. It is their responsibility to ensure everything is as clear and easy as possible.

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The collected data will be used to adjust the design principles, so no names will be mentioned. The examples will be used to clarify these design principles. Because of the influence of the context, the country will be mentioned in the examples.

As mentioned above, we would like to invite you to engage in the online focus group for *the country/Community*. We think your expertise and opinions will be of enormous value in the refinement of the prototypical design principles for teacher education.

As a small token of our appreciation, all participants will receive:

- A certificate of participation in the EC-funded research project *Creative Little Scientists.*
- All educational and scientific material generated by the project in English.

Thank you very much,

…… (Name of a partner member/country)

Members of the *Creative Little Scientists* consortium

e-mail

link website

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APPENDIX C: Instructions and explanatory information provided to stakeholders

This online focus group serves as an asynchronous discussion space in which participants add either new ideas or react to the input of others. The implementation of online focus groups is based on the social constructivist notion that social dialogue is important to trigger knowledge construction. Participants in an asynchronous collaborative environment are free from temporal and spatial constraints, enabling discussionn over time and space with special opportunity for reflection.

The text-based online group assignment contributes to work carried out by the Creative Little Scientists European project consortium towards the development of curriculum guidelines and design principles **for European initial teacher education (ITE) and continuous professional development (CPD) programs, which foster creativity and inquiry-based approaches to science and mathematics learning in preschool and the first years of primary education**. In the first phase the consortium developed a draft version of design principles which are strongly associated with the aforementioned rationale. In order to improve these we kindly ask for your views, opinions, and critical reflections through discussions in an online forum. Moreover, it is hoped that the discussion will enable the gathering of examples which could be helpful for teacher education.

The draft design principles as prepared for and so far presented in the online focus group are developed in order to feed into teacher education (initial teacher education and continuing professional development). They have been developed using the spider web model of Jan van den Akker (2007), a Netherlands-based expert in curriculum design. 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. Associated with each component are specific principles of curriculum design.

The online focus group has been established so as to comment on only 4 of these components (and related curriculum design principles): **(1) aims and objectives, (2) teacher educator, (3) learning activities, and (4) assessment**. The running period for providing written feedback is three weeks starting from November 29th 2012. All content information is made available in a secure Moodle-based website and the enrolled 6-8 participants should work together time- and place-independently. During participation, it will become clear that the online forum is structured according to the components in the curricular spider web. It is hoped that each person participating in the online focus group will make **at least one meaningful posting on each component per week**. These postings should contribute towards the project's vision for teacher education, in other words **the development of teachers who can foster creativity and inquiry-based approaches to science and mathematics learning in preschool and the first years of primary school**. The e-moderator takes responsability for this issue by means of (re)questioning (see examples in assignment). The e-moderator will also stipulate the 'groundrules'.

Note: If you choose to comment on specific principles, please make sure to refer also to their numbers.

Personal data provided by participants will only be used for research purposes and are protected according to the EC directive 95/46/EC. All data gathered during the project will be stored in a secure location accessible only to the researchers. In the final research reports no real names or information will be included that can identify comments of particular participants.

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APPENDIX D: Detailed instructions to e-moderators

Invitation letter/ Informed consent

See separate document

Privacy

Personal data provided by participants will only be used for research purposes and are protected according to the EC directive 95/46/EC. All data gathered during the project will be stored in a secure location accessible only to the researchers. In the final research reports no real names or information will be included that can identify comments of particular participants.

Group assignment

The text-based online group assignment contributes to work carried out by the *Creative Little Scientists* European project consortium towards the development of curriculum guidelines and design principles **for European initial teacher education (ITE) and continuous professional development (CPD) programs, which foster creativity and inquiry-based approaches to science and mathematics learning in preschool and the first years of primary education**. In the first phase the consortium developed a draft version of design principles which are strongly associated with the aforementioned rationale. In order to improve these we are asking for your views, opinions, and critical reflections through discussions in an online forum. Moreover, we are aiming to capture examples from your own first-hand experience which could be helpful for teacher education.

At this point draft design principles for teacher education have been developed and presented in the online focus group. These were based on the spider web model of Jan van den Akker (2007), an expert in curriculum design. 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.

The key expectations for the online focus group will be to comment on 4 of these components (and related curriculum design principles): **(1) aims and objectives, (2) teacher educator, (3) learning activities, and (4) assessment**. The focus groups will run for a three week period beginning on November, 29. From commencement all content information will be made available in an online platform 'Moodle' which all enrolled participants will be able to access independently at a time and place convenient to them. During participation, it will become clear that the online forum is structured according to the components in the aforementioned curricular spider web. Each person participating in the online focus group should make at least **one meaningful posting on each component per week**. These postings will contribute towards the project's vision (or rationale) for teacher education which is **the**

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development of teachers who can foster creativity and inquiry-based approaches to science and mathematics learning in preschool and the first years of primary school.

The main purpose of the group assignment will be **to provide broad feedback on the curriculum design principles within each of the 4 components: (1) aims, (2) teacher educator, (3) learning activities, and (4) assessment.** It is important to remember that all contributions will help to provide answers to the following questions, so it would be helpful if participants aim to address them explicitly from their personal viewpoint of **the role they play** in science and mathematics (teacher) education (e.g. student teacher, in-service teacher, teacher educator, curriculum designer, policy maker, researcher, etc.):

1. **Are there any design principles missing? What are these gaps?**
2. **Is there an overlap?**
3. **Are the proposed curriculum design principles clear and consistent?**
4. **Are there any good examples which show how the specific design principle can help to promote inquiry and creativity in science and mathematics learning? What are these?**
5. **Are you aware of any kind of advice regarding the implementation of these curriculum design principles?**
6. **What are implications of these curriculum design principles for teacher education more generally?**
7. **What are implications of these curriculum design principles for learning and teaching science and mathematics specifically?**
8. **Are there any design principles which are (not) relevant for continuous professional development? What are these?**

Note: If you choose to comment on specific principles, please make sure to refer also to their numbers.

Asynchronous discussion group

Each online focus group serves as an asynchronous discussion group in which participants add either new ideas or reactions on the input of others. The implementation of asynchronous discussion groups is based on the social constructivist notion that social dialogue is important to trigger knowledge construction. As the participants in an asynchronous collaborative environment are free from temporal and spatial constraints, numerous implications of the time- and place-independent nature of computer-supported discussions are indicated in educational research.

E-moderator role

Each online focus group works under supervision of an e-moderator who is an active member/partner of the *Creative Little Scientists* project. The main task of the e-moderator is to keep the group discussion going and focuses on the purposes of the group assignment

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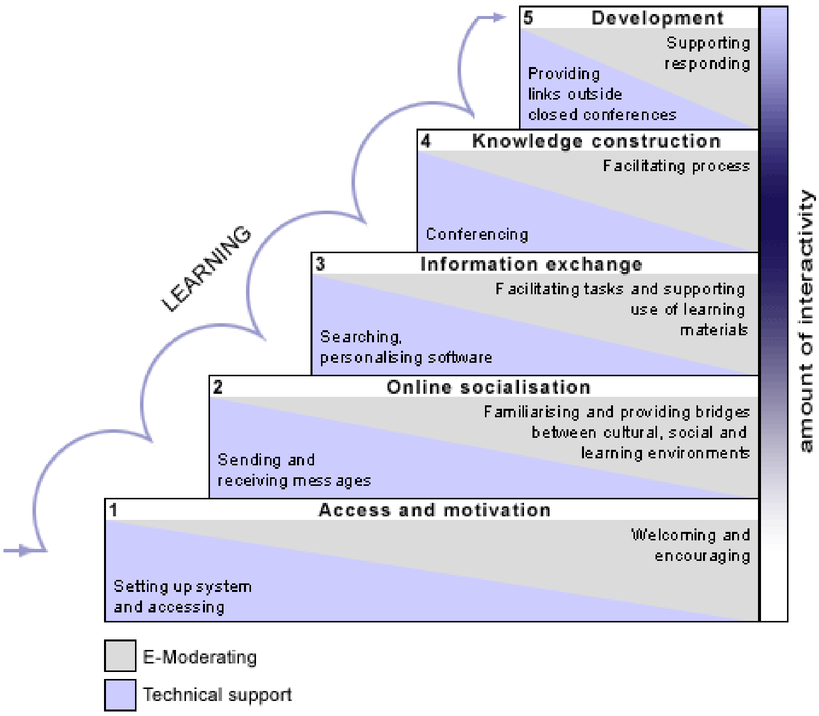
and on the project's identified focus areas, i.e. inquiry and creativity in science and mathematics early years education. (S)he is expected to welcome participants and to provide assistance within the asynchronous discussion group by scaffolding **social and cognitive processes**. This means that the e-moderator may introduce new content knowledge too, either directly or through questioning.

From the **five-step model on e-moderating** as seen below (Salmon, 2002), we learn how to provide assistance within computer-supported learning environments. The model is taxonomical in structure. Over time:

(1) Social and emotional presence is of importance to foster cognitive processing, more complex e-moderating skills. The project aims to achieve these objectives by allowing all participants **time** for welcoming and giving reading time during week 1 of the online focus group. Regular online appearance of the e-moderator is of importance for making progress over time.

(2) Intensifying the level of **interaction** between the e-moderator and the group members. In this framework the e-moderator scaffolds and guides by playing the devil's advocate. In addition, knowledge construction keeps focus on social negotiation and task-related engagement, sharing, common understanding, and argumentation.



The main role of the e-moderator is to facilitate negotiation on the draft design principles and to highlight directions for improving them. Facilitating means taking into account:

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1. Postings have to contribute towards the project's vision (or rationale) for teacher education which is **the development of teachers who can foster creativity and inquiry-based approaches to science and mathematics learning in preschool and the first years of primary school.**

2. Keeping the main **focus** on (1) curriculum aims, (2) teacher educator pedagogy, (3) learning activities, and (4) assessment related to **teacher education contexts**. In addition, it is aimed to elaborate on **implications** for issues associated with time, location, grouping, learning contents, materials and resources.

Listed below are some other inspirational questions that the e-moderator could ask to either the group or individuals :

1. Could you please provide an example based on your experience of teacher education of how a specific design principle can help to promote inquiry and/or creativity in science and/or mathematics learning for young children?
2. Would you call this input an example of 'good' practice?
3. Does every participant agree with the viewpoint of participant X? Why (not)?
4. Are there any related benefits or shortcomings, in your opinion?
5. Thank you for your contribution, could you please specify your vision of learning and/or teaching that this corresponds to?
6. Does this topic have implications for assessment?
7. Does this topic have time- and/or place-dependent implications?
8. What about requirements on group size and/or group composition?
9. Do you think that your expressed ideas can be implemented in initial teacher education?
10. Do you think that your expressed ideas could fit into continuous professional development?
11. How would young children react to this suggestion in your opinion?
12. Are there any (pre)conditions that would make the implementation of these ideas more likely to succeed in your opinion?
13. What is your personal definition of ... ?
14. Is there anyone who might not be happy with this viewpoint?
15. Do you see any other issues that have not been covered?
16. So, have we reached a consensus on this issue?
17. What other initiatives do you have in mind?
18. What are the essential resources associated with this goal?
19. So, is this how reality looks, in your opinion?
20. Could we summarize these points ... ? What are the 'big' ideas up until now?
21. What role if any does creativity play in these?
22. How can this example or comment inform development of practice in teacher education?

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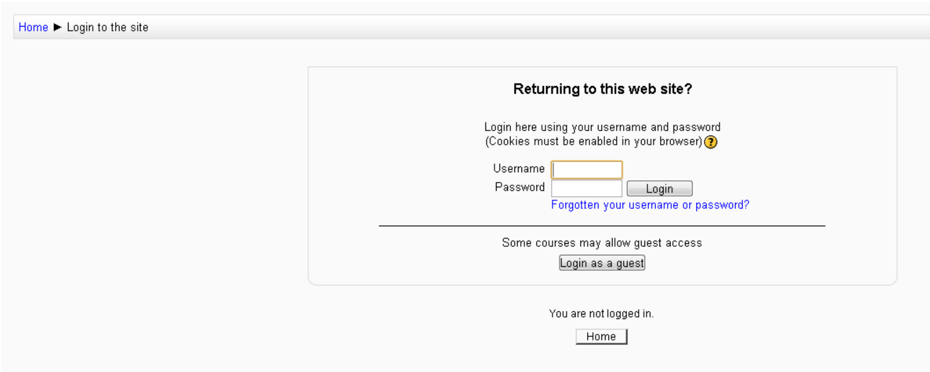
23. How does this approach foster pre/in-service teachers' interest and motivation in science and mathematics?

Group formation

Group composition is heterogeneous. All stakeholders have an interest in teacher education. Contributions are expected from teacher education practitioners, researchers, and developers.

Working with Moodle

Each online focus group will convene through a forum using the Moodle platform. Each participant will receive a log-in and password in order to participate in the online forum. Therefore, e-mail addresses are needed.



Login code + password

Pathway

See movie on how to log-in

Further reading

Draft design principles related to 4 components of curriculum design: aims, learning activities, teacher educator, and assessment.

Salmon, G (2002). *E-tivities: The key to active online learning*, Kogan Page, London.

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

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APPENDIX E: Informed consent

Personal data provided by participants will only be used for research purposes and are protected according to the EC directive 95/46/EC. All data gathered during the project will be stored in a secure location accessible only to the researchers. In reports of the research no real names or information will be included that can identify comments of particular participants.

If you are willing to be involved, please could you sign the consent form attached and return it to Name and e-mail

Do get in touch if you require any further information about the focus groups or the project more generally.

Creative Little Scientists

Focus Groups: Testing Curriculum Design Principles

When you are willing to participate in this research project, we kindly ask you to fill in following form.

I **am/am not willing** to participate in the focus groups **(Delete as appropriate)**	
Name	
Organisation	
Contact details	
Signed	
Date	

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APPENDIX F: The draft curriculum design principles (prototype 3, task 5.3)

RATIONALE WP5 focusing on curriculum design for teacher education:

Teachers (incl. student teachers as learners) foster creativity based approaches to science and mathematics learning in preschool and the first years of primary school.

1. Aims and objectives

Competences for (student) teachers

1.1 In teacher education teachers should acquire a good understanding of science/mathematics ideas and processes, as well as the skills and competences to carry out inquiries.

1.2 In teacher education teachers should achieve a good understanding of the nature of science (and how science and scientists work), of child development, and the various framings of creativity.

1.3 In teacher education teachers should reach positive attitudes towards learning and teaching science, mathematics, and creativity.

1.4 In teacher education teachers become confident to teach science and mathematics.

1.5 In teacher education teachers should be able to discern and reflect on innovative ideas and act as researchers and reflective practitioners during both learning and teaching.

1.6 Through teacher education teachers should commit themselves to engage in dialogue (e.g. with other teachers, parents, professional associations, experts, internship stakeholders, etc).

1.7 Through teacher education teachers should commit themselves to engage in professional development.

Education processes in teacher education

1.8 Teacher education should foster science and mathematics learning processes according to national curriculum and education policy.

1.9 Teacher education should provide teachers with opportunities and skills to recognize the importance of science education for society and technology development, e.g. to show them that science understanding is needed and used in everyday problem solving.

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1.10 In teacher education teachers should be encouraged to realize a positive impact on the ongoing science/mathematics learning processes and outcomes of children.

1.11 In teacher education teachers should have opportunity to participate in inquiry-based science learning.

1.12 In teacher education teachers should learn how to respect diversity in children but also how to respond, facilitate, and support them in different ways within the fields of science, mathematics and creativity.

1.13 In teacher education teachers should be encouraged to become self-regulated learners in the area of science of mathematics.

1.14 In teacher education teachers should be taught strategies in perspective-taking towards science and mathematics assignments.

1.15 Curriculum developers of teacher education should organize vision-building sessions on dealing in a profound way with ethics and teacher safety guidelines, for example with regard to teacher practice in schools and external school visits.

1.16 In teacher education teachers should develop awareness of the specific nature of the teacher profession, by focusing their efforts on the improvement of their ability to enhance students' learning specifically related to the fields of science and mathematics.

1.17 Teacher education should provide teachers with confidence and resilience to connect emotionally with children.

2. The role of the teacher educator

2.1 Teacher educators should take into consideration teachers' prior knowledge, skills, attitudes, beliefs, fears, misconceptions, earlier experiences in learning and teaching science and mathematics.

2.2 Teacher educators should manage it to organize learning activities taking into account what to add to the learner's profile in the fields of science and mathematics.

2.3 Teacher educators should be innovators, so they can bring in (new) effective pedagogy and approaches in the fields of science and mathematics.

2.4 Teacher educators should build partnerships (for example communities) with different stakeholders such as school staff, outside agencies, science research centers, scientific associations at a local level, etc.

2.5 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.

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2.6 Teacher educators' complementary qualifications should be in the field of content knowledge, pedagogical content knowledge, and teaching of science and mathematics.

2.7 Teacher educators should make in their teaching explicit connections between content knowledge and pedagogical content knowledge of science and mathematics.

2.8 Teacher educators should be supportive towards the needs of teachers, meaningful activity planners rooted in research/inquiry.

2.9 Teacher educators should be reflective practitioners who promote creative approaches in their classroom.

2.10 Teacher educators should contribute to and foster dynamic interrelationships between research-based teaching, policy, and actual practice.

2.11 Teacher educators should be lifelong learners and be encouraged to disseminate and discuss their work in a variety of ways.

3. Learning activities

Focus on (inter)active learning

3.1 Teacher education should involve project work related to science and/or mathematics and creativity for young children.

3.2 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.

3.3 Teacher education should build upon real-world activities and nearby field experiences.

3.4 In teacher education teachers should be confronted with evidence-based learning activities and materials next to experiencing what children experience when faced with scientific issues.

3.5 Teacher education should offer a dynamic platform for dialogue, exploration, play, and hands-on activity. As an example, together with teachers, teacher education should trial and verify a range of modes for children's expression and representation of (scientific) ideas.

3.6 Teacher education should promote the integration of multimedia in science and mathematics teaching and learning.

3.7 Students in teacher education should be confronted with a variation of interesting and current topics on science, mathematics, and technology on which additional knowledge has to be built.

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3.8 Teacher education should provide time and space for microteaching, lesson plan discussions, demonstration of good practice, and experimental learning which are including characteristics such as belonging, sharing, communicating, inspiring, and peer learning.

Focus on problem- and/or inquiry-based education

3.9 Teacher education should enable teachers to design multiple inquiry-based activities which are child-friendly and include both guided and open inquiries.

3.10 In teacher education teachers should learn to build on children's questions, theories, ideas, interests and answers, and use them, together with children, in the fields of science and mathematics.

3.11 Teacher education should provide learning activities that challenge inquiry-oriented and information-seeking skills and attitudes of teachers.

3.12 Teacher education should refer to and elaborate on specific science research processes and outcomes during learning activities.

Focus on reflective skills

3.13 In the design and implementation of learning activities, teacher education should pay attention to and confront teachers with their own prior knowledge, learning styles, misconceptions and stereotypical images of science, mathematics, and creativity.

3.14 Teacher education should provide learning activities that promote reflective practices. Teachers should be trained in critical thinking skills.

3.15 Teacher education should provide learning activities that vary the degree of self-regulated learning opportunities of one or more students at a certain moment.

3.16 In teacher education assessment should be perceived both separately and as a learning activity dependent on the situation.

Focus on (pedagogical) content knowledge

3.17 Teacher education should include learning activities that encourage and evaluate the development of scientific literacy.

3.18 In teacher education science and mathematics content knowledge should be applied as concrete and stimulating as possible.

3.19 Teacher education should strengthen the pedagogical content knowledge construction of teachers in the fields of science, technology, and mathematics.

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3.20 Teacher education should provide learning activities which integrate science and mathematics content and pedagogical content knowledge in order to improve knowledge transfer.

3.21 Teacher education should experience with cross curricular and integrative learning activities.

4. Assessment

4.1 Teacher education should use different assessment strategies as appropriate to the situation.

4.2 In teacher education, the acquisition and development of science/mathematics knowledge, skills, and attitudes should be assessed.

4.3 Teacher education should value its assessment strategies as best examples of practice that may be transferred to teaching practice.

4.4 Teacher education should foster teacher independence and responsibility in identifying their own progress and areas for development concerning science and mathematics.

5. Content

5.1 Teacher education should provide basic knowledge about science and mathematics to be used in activities linked with everyday life.

5.2 Teacher education should provide teachers with basic skills and competences to conduct basic practical investigations in science and mathematics.

5.3 Teacher education should provide knowledge about educating children creatively.

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

5.5 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.

6. Materials and Resources

6.1 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.

6.2 Teacher education should give access to the science and mathematics materials and resources in the nearby environment in which teaching and learning occurs.

6.3 Teacher education should give access to creative science and mathematics picture books and story books.

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6.4 Teacher education should give access to tools for the evaluation of learning and teaching materials.

6.5 Teacher education should give access to science and mathematics curriculum materials such as textbooks, national policy documents, etc.

6.6 Teacher education should give access to materials and resources fostering inquiry-based learning and exploration of science and mathematics.

6.7 Teacher education should give access to scientific educational journals, books, online and other databases, etc.

6.8 Teacher education should model how teachers should select science and mathematics materials and resources based on criteria linked with curriculum aims and objectives.

6.9 Teacher education should be pro-active in finding about and investing in new learning materials and resources.

6.10 Teacher education should provide infrastructure and logistic support to teachers to access diverse learning materials and resources.

7. Grouping

7.1 Teacher education should provide 'intervision' and/or 'supervision' sessions.

7.2 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.

7.3 Teacher education should provide the possibility for collaboration at a distance through digital or other ICT tools that make this possible.

7.4 Teacher education should define group size and/or group composition depending on course activity aims and objectives, and teachers' needs.

7.5 Teacher education should value peer learning.

7.6 Teacher education should value team teaching.

8. Location

8.1 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.

8.2 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.

8.3 Teacher education should provide students the possibility to practice science and mathematics teaching in real classroom settings.

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8.4 Viewing education as a dynamic social barometer, teacher education should recognize both formal and informal learning processes.

8.5 Teacher education should provide real-life learning and teaching opportunities from the viewpoints of where science is experienced on a daily evidence-base.

8.6 Teacher education should create an atmosphere in which there is tolerance of diversity.

8.7 Teacher education should provide opportunities for place-independent learning.

9. Time

9.1 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.

9.2 Teacher education should provide time for teachers to interact with colleagues: e.g. collegial consultation, teamwork, brainstorming, vision-building.

9.3 Teacher education should allow time for teachers to accomplish the curriculum aims in a quality way.

9.4 Teacher education should provide opportunities for time-independent learning.

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APPENDIX G: Quick sheets per *Creative Little Scientists* partner (12)

See underneath.

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Quick sheet online focus group BG - Wales

Number of participants:	5
Number of postings over time:	43
Keywords *aims and objectives*:	Understanding learning and child development; Observations; Child-led learning; Reflection; Confidence
Keywords *teacher educator*:	Role model; Teaching qualifications and experience; Innovation; Apprenticeship approach
Keywords *learning activities*:	Hands-on activities; Demonstration; Skills
Keywords *assessment*:	Learning theory; Enthusiasm
Other evidence:	Mathematics gets forgotten. Education is not one size fits all. Relevance of supplying fixed lesson plans, science schemes to teachers? Both academic and teaching qualifications are of importance for teacher educators. Balance content and pedagogy? Teaching to the test in Wales: focus on literacy and numeracy. Consequences for internships. Talking with children is key to unfold their thinking. Learning process being seen as ongoing. Time issue for transfer theory and practice in ITT.

Prototypical design principles	Accept	Adjust	Reject	Add
1. Aims and objectives	1.3; 1.8	1.12 & 1.14 in 1.9; 1.6	(1.6)	
2. Teacher educator	2.6	Clusters: - 2.1; 2.4; 2.8 - 2.5; 2.7; 2.10 2.3 & 2.9 CPD		
3. Learning activities	3.11	3.4		
4. Assessment	4.1			Assessment of teaching practice

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Quick sheet online focus group BG - England

Number of participants:	8
Number of postings over time:	36
Keywords *aims and objectives*:	Specific education needs; Reflection; Self-regulation; Time; Lifelong learning
Keywords *teacher educator*:	Demonstration; Pedagogical content knowledge; Research; Confidence
Keywords *learning activities*:	Cross curricular learning; First hand experiences; Real life
Keywords *assessment*:	Formative assessment; Personal targets; Traditional thinking
Other evidence:	Subject audits seem to play an important part in developing individual student profiles and areas for development. Is there enough emphasis on seeking cross curricular opportunities for science and mathematics? Building in time for evaluation, reflection, and dissemination (1.10 & 1.13). Is there a saturation point when we can be confident that subject knowledge is optimized? It is the pedagogical skill and understanding that is crucial to ensure that learning takes place? Can we make assumptions about the standards and capabilities of ITT students (cfr. GCSE qualifications) or does more need to be done in the early stages of the course? Pro's of poor subject knowledge and initial anxiety students?

Prototypical design principles	Accept	Adjust	Reject	Add
1. Aims and objectives	1.9; 1.10; 1.13			Time issue
2. Teacher educator	2.1; 2.4; 2.5; 2.9; 2.10			Validation latest research and effective practice
3. Learning activities	3.3; 3.11; 3.15			
4. Assessment	4.2; 4.3; 4.7			

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Quick sheet online focus group UEF – Finland

Number of participants:	6
Number of postings over time:	64
Keywords *aims and objectives*:	Self regulation; Nature of Science; Play; Practice; Partnerships
Keywords *teacher educator*:	Lifelong learning; Innovation; Research-based; Concept of learning
Keywords *learning activities*:	Integrative approach; Everyday activities
Keywords *assessment*:	Process evaluation; Diversity in assessment and activities
Other evidence:	Statements could be expressed more 'softer', there are too many, very demanding, too detailed and fragmented. Most relevant issues discussed are considered from the viewpoint of ITT. Assessment in/of/for/as learning? Time-management in teacher education. Priorities? Seeing matters in larger ensembles and going over the subject borders (cfr. Dewey). Problem-based learning is not like only truth.

Prototypical design principles	Accept	Adjust	Reject	Add
1. Aims and objectives	1.3; 1.4; 1.10; 1.12; 1.13	1.15		
2. Teacher educator	2.2; 2.4; 2.7; 2.8; 2.9; 2.10	2.5		
3. Learning activities	3.3; 3.5; 3.17	3.2; 3.4; 3.6	(3.1)	
4. Assessment	4.1; 4.9	4.2 - 4.5; 4.7	4.6	

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Quick sheet online focus group UPJV – France

Number of participants:	7
Number of postings over time:	14
Keywords *aims and objectives*:	Real life; Video demonstration; Pathways; Partnerships
Keywords *teacher educator*:	New media; Lifelong learning; Research; Partnerships
Keywords *learning activities*:	Video; Epistemic obstacles; Transfer; Protocols for science
Keywords *assessment*:	Relevance; Observation
Other evidence:	Design principles appear to be too general and too ambitious. Dropout focus group. Role of assessment in childhood education? Video as learning tool. E-moderator: time/space for welcoming.

Prototypical design principles	Accept	Adjust	Reject	Add
1. Aims and objectives	All			
2. Teacher educator	2.9; 2.10			
3. Learning activities	3.1; 3.8	3.9; 3.13; 3.18 - 3.21		Video
4. Assessment	4.10			

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Quick sheet online focus group UMinho – Portugal

Number of participants:	9
Number of postings over time:	66
Keywords *aims and objectives*:	Focus on learning; Lifelong learning; Teacher autonomy; Flexible curriculum
Keywords *teacher educator*:	Lack of motivation at this moment, non-effective ITT at University (cfr. pre-primary)
Keywords *learning activities*:	Cooperation; Open questioning; Student-centered learning; Hands-on activities
Keywords *assessment*:	Peer assessment; Interdisciplinary teams
Other evidence:	IBSE in relation to class management (noise). Barriers? Young children are creative in essence. Tensions creativity: time constraints, rigid syllabus. Need for scientific professionalism in CPD, e.g. research. In teacher education teachers should develop awareness of the specific nature of the teacher profession, by focusing their efforts on the improvement of their ability to bring about students' learning, including learning specifically related to the fields of science and mathematics.

Prototypical design principles	Accept	Adjust	Reject	Add
1. Aims and objectives		1.1; (1.6)		
2. Teacher educator				
3. Learning activities				
4. Assessment				

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Quick sheet online focus group UoM – Malta

Number of participants:	4
Number of postings over time:	16
Keywords *aims and objectives*:	Practice instead of theory; Origins of Science, IBSE, Key ideas is ECE, Key ideas in science and mathematics, Link between science and everyday activities.
Keywords *teacher educator*:	Role Models, Different Roles, Lifelong Learners, Reflection, and Partnership.
Keywords *learning activities*:	Inquiry Based Science Experiments, Time; Positive Attitudes, Authentic Investigation, Student Teachers' Commitment.
Keywords *assessment*:	Outcomes, Documentation, Combine Formative & Summative, Correlation between TE and ECE assessment, and Transferring assessments.
Other evidence:	Most design principles were discussed from the viewpoint of ITT. Only design principles dealing with teacher educators involved CPD. Most design principles were discussed with regards to science neglecting issues surrounding mathematics. Concern over time when practicing IBE with a consequence of integrating different subjects to make space for inquiry. IBE plays an important role in facilitating positive attitudes and beliefs towards science both with student teachers and children.

Prototypical design principles	Accept	Adjust	Reject	Add
1. Aims and objectives	1.1; 1.2; 1.4; 1.7	1.3		
2. Teacher educator	2.4; 2.8; 2.10	2.2		
3. Learning activities	3.2; 3.3; 3.4; 3.9			Time and IBE
4. Assessment	4.2; 4.3; 4.4; 4.5 4.6; 4.9; 4.10	4.8		

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Quick sheet online focus group OU – Northern Ireland

Number of participants: 3

Number of postings over time: 12

Unfortunately, the number of postings were not sufficient to derive any useful results from this online focus group.

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Quick sheet online focus group GUF – Germany

Number of participants:	8
Number of postings over time:	69
Keywords *aims and objectives*:	Teacher as facilitator; Activity; Strengths; Lifelong learning
Keywords *teacher educator*:	Fellow scientist; Partnerships; Feedback; Effective pedagogy
Keywords *learning activities*:	Extra-curricular education; Active participation; Experiencing
Keywords *assessment*:	Reflection; Discussion; Getting to know new methods
Other evidence:	IBSE into practice would involve a fundamental change of the teacher educator's thinking patterns. Definition of creativity in connection with nature of science? Haus der kleinen Forscher: e.g. experimental and creative handling of material, without providing any specific aim. The concrete field experience is often neglected. Open inquiry needs to be distinguished from the general term 'research'. CPD: do not take prior knowledge for granted. Attitudes must not be rated with equal weight as knowledge and skills.

Prototypical design principles	Accept	Adjust	Reject	Add
1. Aims and objectives	1.1; 1.4; 1.8	1.2; 1.14; Clusters: 1.1; 1.2; 1.3 (NoS) 1.4; 1.8-1.14 (attitudes) 1.2; 1.3; 1.5; 1.6 (methods)		Transition preschool to primary, partnerships with parents, methodological learning competences
2. Teacher educator	2.4	2.2; 2.3 & 2.9; 2.7; 2.8	(2.10)	Self-evaluation, feedback

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3. Learning activities	3.4; 3.6; 3.17; 3.18	3.3; 3.12; 3.8 in 3.7; 3.10; 3.11		Help of experts
4. Assessment	4.10	4.7		

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Quick sheet online focus group IoE – Scotland

Number of participants:	6
Number of postings over time:	54
Keywords *aims and objectives*:	Wonder; Imagination; Professional Learning Networks; Confidence; Lifelong learning
Keywords *teacher educator*:	Experience of early years; Observation; Networking; Dissemination
Keywords *learning activities*:	Risk taking; Classroom examples; Modelling; Supportive/safe learning environment; Children's reflections
Keywords *assessment*:	Agency; Ownership; Creativity versus conceptual understanding; Creativity versus curriculum requirements
Other evidence:	Teacher education should provide teachers with confidence and resilience to connect emotionally with children (1.0). Creativity within, not separate or as add on (e.g. maths). Key in teacher education is developing confidence and knowledge of resources and contacts to support continuing development (cfr. teach meets, mentoring). Science has a negative connotation nowadays. Innovation is ? Creativity relates to variety of experiences, range of modes of representation. Assess creativity or the process of being creative, or both or neither? What measures can be taken to help student teachers who fail to demonstrate sufficient level of creativity? Need for creative teachers to encourage learners/children to enjoy free thinking, wonder and play?

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Prototypical design principles	Accept	Adjust	Reject	Add
1. Aims and objectives	1.4; 1.5; 1.9; 1.10; 1.12; 1.13			Resilience with young children
2. Teacher educator	2.10	2.2 in 2.9		What can teachers learn from children?
3. Learning activities	3.3; 3.4; 3.5; 3.7; 3.8; 3.11	3.15		
4. Assessment	4.2; 4.4; 4.9			Ongoing feedback

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Quick sheet online focus group EA – Greece

Number of participants:	7
Number of postings over time:	91
Keywords *aims and objectives*:	Practice; Partnerships; History and philosophy of science; Peer collaboration; Educational leadership
Keywords *teacher educator*:	Web 2.0 tools; Trust; Networks; Reflection
Keywords *learning activities*:	Examples of practice; Mixed method approach; Skills
Keywords *assessment*:	Strategies; Trust; Formative assessment; Individual needs
Other evidence:	Teachers shouldn't just be convinced about the importance of science in their everyday lives but cultivate their beliefs that scientific reasoning and inquiry about the world around them, concepts from mathematics and technology, involve skills and competences relevant to children. Deprivatization of teaching practice. Teacher educators should be supportive towards the needs of teachers, meaningful activity planners rooted in research/inquiry elements, reflective practitioners who promote creative approaches in their classroom (2.7). Make the principles relevant to practitioners - provide them with more of a practical approach. Time issue in CPD/ITT. Assessment cannot be treated as a standalone process (micro/meso).

Prototypical design principles	Accept	Adjust	Reject	Add
1. Aims and objectives	1.1; 1.3; 1.5; 1.7; 1.12	1.9		Philosophy of science; Leadership
2. Teacher educator		2.7; 2.8		Duration CPD in relation to trust and transfer
3. Learning activities		3.11		Mixed-method
4. Assessment		4.8		Integrative

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Quick sheet online focus group NILPRP – Romania

Number of participants:	9
Number of postings over time:	64
Keywords *aims and objectives*:	Introspection; CPD and lifelong learning; IBSE (-) implications; Scientific investigation; Skills
Keywords *teacher educator*:	Flexible curriculum; Authentic activities; Consult; Wide competences; Reform
Keywords *learning activities*:	Stories; Integrated; Interdisciplinary; Hands-on; Experiment
Keywords *assessment*:	Process; Video; Observation; Transfer; Experience/age
Other evidence:	Courses should enable teachers to develop logical reasoning to help them in the process of inquiry-based method. The preschool teacher needs permanent formation in the fields such as science and mathematics in order to be able to work on interdisciplinary activities and to transmit to the children correct and clear information. It is true that inquiry-based activities require substantial preparation time and also the development of personalized learning materials for each subject and class. Animosity? The resonance between the teacher and the teacher educator is essential. Teachers' education in universities does not refer to IBSE. How do I apply what I learned in class? Accumulated knowledge (cfr. assessment, competence-related curriculum).

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Prototypical design principles	Accept	Adjust	Reject	Add
1. Aims and objectives	1.10	1.2		Parent involvement Motivation for CPD
2. Teacher educator	2.1	2.4	2.7 for CPD?	
3. Learning activities	3.1; 3.4; 3.5; 3.7; 3.8			
4. Assessment	4.1			Personalized Learning styles and MI

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Quick sheet online focus group AUC – Belgium

Number of participants:	7
Number of postings over time:	122
Keywords *aims and objectives*:	Partnerships; Bottom-up teaching; Observation; Creativity concept; (Pedagogical) content knowledge issue (tensions)
Keywords *teacher educator*:	Job coaching; Intermediate research/practice; New media; Demonstration time; Scientific literacy
Keywords *learning activities*:	Authentic problems; Positive attitudes; ICT-integration; Curiosity in IBSE; Reflection skills
Keywords *assessment*:	Growing; Curriculum differentiation; Error-making time
Other evidence:	My experience in primary teacher education is that once students are at schools, they forget what they have been taught and they are copying the handbooks of the school. Why? Mostly because they feel insecure about their own teaching or because teachers tell them to do so. Following handbooks is 'safe'. Textbook status? Quality control? It is very important that teachers have access to evidence-based teaching strategies. Teach what you preach. Students in teacher education should be confronted with a variation of interesting and current topics on science, mathematics, and technology. Concrete - Schematic - Abstract principle (cfr. mathematics). Assessment should also be a moment to look forward, for the future and its possibilities. Plea for lifelong learning (cfr. CPD). Transition from preschool to primary occurs abruptly. IBSE requests decisions on time management.

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Prototypical design principles	Accept	Adjust	Reject	Add
1. Aims and objectives	1.1; 1.4; 1.5; 1.8; 1.9; 1.12; 1.13			Misconceptions
2. Teacher educator	2.2; 2.4; 2.6; 2.9; 2.10	2.7		Train the trainer
3. Learning activities	3.1; 3.3; 3.6	3.18		Transfer
4. Assessment	4.7; 4.8			Handbooks assessment

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APPENDIX H: Script for Face-to-Face Focus Groups

THEME	CREATIVE LITTLE SCIENTISTS – TASK 5.4 STAKEHOLDER APPRAISAL PANEL: TEACHER EDUCATORS TOGETHER FROM PROTOTYPICAL DESIGN PRINCIPLES TO GUIDELINES
Research aims	Per *Creative Little Scientists* partner: 1. Teacher educators actively participate in the method of curriculum design. 2. Teacher educators negotiate on given prototypical design principles in a face-to-face focus group. 3. Teacher educators formulate their personal opinion and participate in debate on how to improve creativity in science and mathematics education for young children. 4. Teacher educators share examples of (good) practices related to their experiences and personal thoughts with regard to science/mathematics education. 5. Teacher educators share examples of (good) practices related to components of curriculum design and/or design principles. 6. Teacher educators comment on given prototypical design principles from the viewpoint of initial teacher training (ITT) and continuous professional development (CPD). 7. Teacher educators set priorities for teacher education and its curriculum decisions with regard to science/mathematics learning/teaching in early childhood education. 8. Teacher educators engage in educational design, they make suggestions for going from prototypical design principles to guidelines.
Prior knowledge participants and moderator	Prototype 3 is output from the online focus groups with stakeholders (Task 5.3). *Creative Little Scientists* partners have experience with acting in the role of (e)moderator (Task 5.2). *Creative Little Scientists* partners subscribe to the method of curriculum/educational design (WP5). Pre-announcement on Task 5.4 by AUC on March, 15th.
Resources	Bloor, M. et al. (2001). Focus Groups in Social Research: London: Sage. van den Akker, J. (2007). *Curriculum design research*. In: Plomp, T. and Nieveen, N. (Eds). An introduction to Educational Design Research. Enschede, The Netherlands: SLO.

See underneath. This script for running a face-to-face focus group has been distributed to *Creative Little Scientists* partners in Spring 2013 (Task 5.4). The AUC team has developed the instrument.

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SCRIPT

1. Welcoming		
10’	/	
	Registration of data collection. Informed consent.	

Instructions

Moderator thanks participants for coming and opens up the meeting by giving some information on his/her actual role in *Creative Little Scientists*.

In order to getting to know each other, please introduce yourself to the group.

Organisation

Participants are sitting around a table. Each teacher educator introduces him/herself.

Questioning

Allowance for audio registration of your input?

Teacher educator in the field of … ? Name and institution you are working for?

2. Rationale for the EU-project on Creative Little Scientists		
15’	3	
	Creative Little Scientists partners chose how far to go on providing information on EU-project history.	

Instructions

Moderator provides information on the 8 research aims and planning of the focus group.

Moderator explains the rationale for WP5, namely (student) teachers foster creativity-based approaches to science and mathematics learning in preschool and the first years of primary school.

A personal opinion on the rationale is requested/expected from participants. Time for responding is restricted.

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Organisation

Participants are sitting around a table. A compulsory three minutes talk per participant on the opening question follows.

Questioning

Creativity in science/mathematics education for young children, up to you it is what (not)? This question also involves divergent thinking.

3. Examples of practice in actual teacher education		
15'	4	
	Facts > potentials.	

Instructions

Examples of practice on the rationale is requested from participants. Facts and reality are asked for.

Organisation

Participants are sitting around a table. Interaction is of importance.

Questioning

Creativity in science/mathematics education for young children has to be initiated/learned/taught in teacher education, could you give an example which is currently demonstrated in teacher education in your country and/or at your institution?

Why do you find the example you give a 'good' example of practice?

Your example of practice could be related to learning activities, assessment, resources, etc. Explain to us.

If you do not find an example, what type of support is missing in your team?

4. Prototypical design principles to be reviewed		
50'	1, 2, 3, 6, 7	Prototype 3 delivered on paper per participant.
	Guidance of moderator is crucial to keep discussion ongoing.	

Instructions

Moderator distributes prototype 3.

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Moderator aims for information-exchange, vision-building and co-construction of knowledge on given prototypical design principles.

Moderator focuses on teacher education contexts anno 2013, in both initial teacher training and continuous professional development.

Moderator asks for ranking design principles per component.

Moderator looks for issues on which there is group consensus.

Organisation

Participants are sitting around a table and read single design principles. Afterwards, they negotiate on contents as written down in prototype 3.

Questioning

Please, set three priorities for teacher education practice based on the prototypical design principles per component (e.g. aims, teacher educator, learning activities, assessment).

Which design principle per component is less meaningful for teacher education?

Which design principles are chiefly related to initial teacher training?

Which design principles are chiefly related to continuous professional development?

Which design principles are chiefly related to childhood education?

Which design principles do not enhance aspects of creativity?

Implications to be mentioned?

5. Examples of practice building on the design principles		
30’	5	Prototype 3.
	Control common understanding on examples.	

Instructions

Prototypical design principles could inspire participants to make them more definite by giving examples of practice which are evidence-based.

Organisation

Participants are sitting around a table and silently read single design principles per component. Afterwards, they are invited to share experiences and examples of (good) practice. Practical details are mainly welcomed.

Questioning

Example: fact or wishful thinking?

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Implications for practice?

Teacher educator concerns?

6. Group conclusions		
15’	2, 3	
	Mindmapping, concept drawing, … is an option.	

Instructions

Moderator summarizes discussions. Participants could help by adding, reformulating, … issues.

Moderator consults teacher educators on ideas for how to transform design principles to promising guidelines.

Thank you.

Organisation

Participants are sitting around a table and co-construct conclusions.

Questioning

Items which should not be forgotten? Priorities according to the focus group?

In order to improve science/mathematics courses in teacher education, financial means and/or educational support are needed for … ?

From prototypical design principles to guidelines, suggestions, how accomplishing this task for structuring output?

- Needs concerning lay-out?
- Examples you know from policy? References?
- How combining guidelines and particular examples of (good) practice?
- How convincing readers?

Final questions or evaluations?

THANK YOU !!

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APPENDIX I: Detailed instructions to moderators for the face-to-face focus groups

Invitation letter

See separate document.

Informed consent

See separate document.

Privacy

Personal data provided by participants will only be used for research purposes and are protected according to the EC directive 95/46/EC. All data gathered during the project will be stored in a secure location accessible only to the researchers. In the final research reports no real names or information will be included that can identify comments of particular participants.

Group formation

Group composition is rather homogeneous. All 6-8 stakeholders are teacher educators working in at least 2 different institutions. So participants to be selected soon for Task 5.4 are teacher educators who have professional resilience with science and/or mathematics teaching in initial teacher training (ITT) and/or continuous professional development (CPD). Teacher education they are currently working for enroll (student) teachers who will or are working with young children.

Group assignment

The group assignment contributes to work carried out by the *Creative Little Scientists* European project consortium towards the development of curriculum guidelines and design principles **for European initial teacher education (ITE) and continuous professional development (CPD) programs, which foster creativity and inquiry-based approaches to science and mathematics learning in preschool and the first years of primary education**. Previously, the consortium developed prototypes of design principles which are strongly associated with the aforementioned rationale. In order to improve these we are asking now teacher educators for their views, opinions, and critical reflections through a time-dependent discussion. We do prefer a face-to-face focus group but also a Skype meeting with stakeholders could be arranged by CLS partners. In the focus group with 6-8 teacher educators as stakeholders we are aiming to capture examples from first-hand experience which could be helpful for teacher education.

At this point prototypical design principles for teacher education have been developed and presented in the focus group. These were based on the spider web model of Jan van den Akker (2007), an expert in curriculum design. This model consists of 10 components: the

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rationale or vision of the curriculum, aims and objectives, content, learning activities, teacher role, materials and resources, grouping, location, time, and assessment.

The key expectations for the focus group will be to comment on these 10 components (and related prototypical design principles). The focus group will last maximum 3 hours on a day in May chosen by partners themselves.

Moderator role

Progress and aims of the face-to-face focus group are nearly scripted, see underneath. Participants actively engage in the iterative process of curriculum design. We make a plea for open ongoing argumentative knowledge construction and active listening. Time-keeping and paraphrasing are important moderator skills. Preparations for CLS partners involve intensive reading of prototype 3. Background information on this key document could be found in the internal report related to Task 5.3, distributed to partners on March, 31st.

Output per CLS partner

Data is required to be reported in English language. Documents relevant to data analysis should be distributed by the end of April.

Deadline partner report is June, 15th.

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