D2.2 EFFECTIVE CREATIVE SCIENCE TEACHER PROFILE

EFFECTIVE CREATIVE SCIENCE TEACHER PROFILE

Project Reference:	539818-LLP-1-2013-1-NO-COMENIUS-CMP	**Editing:**	Greenwood, M. Black, A. Hennessy, S. Slade, C. Craft, A. Chappell, K.
Code:	D 2.2	**Approved by:**	
Version & Date:	**1.0 10.5.2014**	**Process Owner:**	UNIVERSITY OF EXETER

Short Description: This document reports on three research activities that aim to build a definition of the 'Effective Creative Science Teacher Profile'. These were an online survey; interviews and classroom observations and all three forms of data collection were carried out in the period January-April 2014. Data were gathered from teachers and other kinds of science educators in all the countries represented by the Consortium.

It summarizes the profile of the effective creative science teacher based on the findings thus far.

List of Recipients:

- All partners

The CREAT-IT project has been funded with support from the European Commission under grant agreement 2013 – 3637 / 001 - 001

Table of Contents

Executive Summary 4

1. Survey methodology and design 6

1.1 How the literature review informed the survey design 6
1.2 Survey design 7
1.3 Data collection 8
1.4 Data analysis procedures 8
1.5 Survey Synthesis 9
1.6 The creative science teacher is: 9
1.7 The creative science teacher uses the strategies of: 13
1.8 Teaching FOR creativity 18
1.9 Educating teacher trainees to be creative science teachers 22
1.10 What barriers need to be dealt with? 23
1.11 Current teachers' levels of knowledge/skills/confidence in creative science teaching .. 28
1.12 Creativity at a country/policy level 28

2. Interviews and observation findings 31

2.1 Interviews 31
2.2 Interview analysis 31
2.3 Examples of creative teaching 31
2.4 Reasons for choosing the example 33
2.5 Teaching for creativity 33
2.6 The value of creative teaching 34
2.7 Challenges or barriers to teaching creatively 35
2.8 Characteristics of the creative teacher 35
2.9 In summary 36
2.10 Observations 37
2.11 Summary 42
2.12 The CREAT-IT Creative Science Teacher characteristics and role 43

3. Reference List 45

4. Appendices 46

A.1 Full results from online survey 46
A.2 Ethical permissions 98
Information for Teachers and Headteachers 99
Consent form for Headteachers 100
Consent form for Teachers 101
Informed Consent Form: PARENTS 102
A.3 Example of semi structured interview questions for science teachers 103

Lifelong Learning Programme

The CREAT-IT project has been funded with support from the European Commission under grant agreement 2013 – 3637 / 001 - 001

List of figures and tables

Table 1 Barriers to creative science teaching ranked from MOST selected to LEAST selected..... 24

Figure 1 Pupils' alternative suggestion 41

Figure 2 Pupils' correct suggestion 41

Acknowledgements

We are grateful to all those who completed the survey, who participated in interviews and teachers and students whose classroom practice was observed, and to other members of the consortium for their feedback on earlier drafts of this document.

The CREAT-IT project has been funded with support from the European Commission under grant agreement 2013 – 3637 / 001 - 001

Executive Summary

Overall the CREAT-IT project intends to create a workable methodology for designing, communicating and representing creative Science Education approaches for late primary and early secondary schools in Europe. The foundation for this project is presented within Work Package 2 in the three deliverables D2.1 (Pedagogical Framework), D2.2 (Effective Creative Science Teacher Profile) and D2.3 (CREAT-IT Training Scheme and Implementation Scenarios).

This deliverable, D2.2, comprises a report that determines the main aspects of the creative science teacher role. It is based on an online survey sent to participating teachers, researchers, scientists and curriculum developers teachers in England, Norway, Serbia, Italy and Greece, which sought to create an overall picture of the way stakeholders see the creative science teacher's profile. Analysis has been based on the CREAT-IT project's aims to establish a new role or positioning of the creative science teacher. Design and analysis of the survey has been informed by the literature review (D2.1), which has been integrated into the report where relevant. The report has also been influenced by qualitative analysis of a small sample of teachers identified through the survey, who were interviewed and observed in each of the participating countries.

The report reports the survey methodology and design and how the literature review (D2.1) informed them. It reports data analysis procedures and survey synthesis, with a specific focus on determining the aspects of the creative scientific teacher role, establishing that new role and positioning of the creative science teacher. There is a discussion of survey outcomes in relation to the small sample of interview and observations and the literature review. Finally, it summarizes the T creative science teacher based on the findings thus far as:

- constantly developing – endeavouring to reflect, build principles and explore practice
- pupil focused and led – co-construction, pupil agency and high expectations
- emotionally connected – to the pupils and the work
- motivated through prioritising and facilitating creative teaching
- collaborating with peers and pupils - in idea generation, support, high level outcomes
- seeking experience, including in the arts – both professionally and personally
- confident to take risks
- playful and flexibile
- independent

The creative science teacher adopts many roles in the course of their teaching:

- Instructor and demonstrator
- Guide and advisor
- Knowledgeable expert

The CREAT-IT project has been funded with support from the European Commission under grant agreement 2013 – 3637 / 001 - 001

- Observer
- Co-constructor
- Collaborator
- Researcher
- Resource manager
- Assessor, critic.

Through the theoretical framework provided by D2.1 and the small scale research exercises undertaken for D2.2 it is clear there is a broad consensus about the importance of creativity in science education and what makes a creative science teacher. National differences are most significant in relation to policy, the culture of schooling and economic constraints. In developing the programme of training activities for this project, it is important to have a good understanding of the contexts in which teachers work, their concerns and aspirations. Professional development for teachers, although recognised as important in all the consortium countries, is provided and managed differently in each. The project's training workshops will need to be designed to be relevant to local conditions whilst also modelling creative teaching.

The CREAT-IT project has been funded with support from the European Commission under grant agreement 2013 – 3637 / 001 - 001

1. Survey methodology and design

1.1 How the literature review informed the survey design

In designing the survey, questions were formed from the following discussions in the literature:

- current research, practice and policy within Europe across the domains of creativity, education and science
- creative pedagogies currently being used in primary and secondary schools
- current policy and curriculum constraints of science education in Europe
- good practice already happening
- emerging tensions and dilemmas
- the CREAT-IT definition for creativity in science education.

The case studies offer examples of existing good practice (that promote teaching science creatively and teaching for creativity in science) and could be used as choices for the participants to identify with or reject. The definitions[1] of creativity and creative science teaching as described in the literature review were included to find out to what extent participants agreed with these.

In particular, the survey draws upon the concepts of:

- possibility thinking
- the four p's (pluralities, playfulness, participation and possibilities)
- living dialogic space
- wise humanising creativity

Within these concepts, issues such as the ethical consequences of scientific creativity; developing oneself as part of the creative process; and creative learning conversations that engage all participants in the process, contributed to how questions were framed and the kind of options that participants could choose.

The literature review recognises that digital environments are inherently creative but also acknowledges critical discourses highlighting the following:

[1] The definition for creative science education adopted by CREAT-IT was developed by the FP7 Creative Little Scientists project. After the survey was administered, the Creative Little Scientists group adjusted this definition, following robust debate at the project's final event held in March 2014 in Greece. The new definition, which CREAT-IT has now adopted, foregrounds the evaluation of evidence: "Generating **ideas and strategies** as an individual or community, **reasoning critically between these** and **producing plausible explanations and strategies consistent with the available evidence.** " As before this definition of scientific creativity is seen as fuelled by 'little c' creativity, i.e. **purposive and imaginative activity generating outcomes that are original and valuable in relation to the learner**.

Lifelong Learning Programme

The CREAT-IT project has been funded with support from the European Commission under grant agreement 2013 – 3637 / 001 - 001

- they may deny more embodied ways of engaging with the world
- can lack domain knowledge and focus too strongly on communication per se
- competitive elements of digital environments may stifle creativity
- there may be questionable ethical practices in unmonitored areas of online digital networks

Due to the fine balance to be negotiated between digital and real-world interaction within teaching and learning, the survey did not point in a particular direction regarding digital environments, but made space for participants to raise digital use where relevant. Instead, digital use was explored more through classroom observations, discussed later in this deliverable.

1.2 Survey design

To meet the aims of this deliverable we sought to survey a number of people with varying levels of experience of creative science teaching. Of all the survey tools available a semi-structured survey in the form of an electronic questionnaire was selected as the most appropriate tool as it could be distributed to, and self-administered by a wide range of international participants in a short time frame. The LimeSurvey™ tool was used for questionnaire design and the online hosting of the questionnaire, as well as data capture.
For purposes of data triangulation, illumination of themes and statistical data analysis, the survey included a variety of question types. These included:

- Likert-type rating scales (such as 'to what extent do you think current national level strategies promote creativity in science education' with 11 point scale ranging from 'strongly prevents creativity in science' to 'strongly encourages creativity in science')
- Selection from pre-determined lists (such as 'which of these do you see as creative science teaching')
- Open questions (such as 'how do you think we can educate trainee teachers to be creative science teachers') in addition to "please explain your selection" after a quantitative response.

To develop descriptions of frequency of mentions and to obtain accurate comparisons between stakeholder groups quantitative questions were also asked. The open-endedness of qualitative approaches allowed themes to emerge that may not have been anticipated in advance of the fieldwork.

The questionnaire was in 6 sections. The first two sections asked the same questions of all respondents, the remaining sections used a branching structure to enable general teachers, consortium members, curriculum developers, scientists and teachers who have experience of a specific creative approach to respond to tailored questions. The first section simply asked

Lifelong Learning Programme

The CREAT-IT project has been funded with support from the European Commission under grant agreement 2013 – 3637 / 001 - 001

for the respondent to select their role and country. Dependent on which role they selected, survey logic was set up that automatically directed them to questions pertinent to their role in the following sections.

1.3 Data collection

Opportunistic/snowball sampling was used; the LimeSurvey™ questionnaire link was passed via email to each consortium member, who forwarded it electronically to:

- Primary and secondary teachers
- Curriculum developers
- Scientists
- Teachers with experience of a specific approach
- It was also completed by the consortium members themselves.

The questionnaire was completed anonymously with a final question inviting respondents to give their email address if they were willing to be interviewed. In the reporting of the survey no respondent is identified.

The LimeSurvey™ tool was set up with the possibility of consortium members creating versions in their own language. A survey was set up in Greek, as well as the existing English one. Nine responses were completed in a language other than English (3 Italian, 3 Serbian, 2 Greek, 1 Belgian Dutch). These were copied and pasted onto an excel file for each language and sent to the relevant consortium members for translation of the qualitative responses.
The survey was live from 31st January to 21st February 2014.

1.4 Data analysis procedures

The on-line LimeSurvey™ tool was used to collate and store the data. Data were transferred from the LimeSurvey™ database to an Excel™ spreadsheet and “cleaned” (those who only completed the first question were removed, as were blank entries for entire survey). Qualitative and quantitative responses were separated for ease of analysis.

The quantitative data underwent descriptive and inferential numeric analysis and comparisons; the data from the Excel™ spreadsheet was entered on to SPSS™ which was used to calculate mean ratings, standard deviation, modal values and frequencies. In order to establish if any variation could be explained by country, cross-tabulations were run using a multi-variable chi-squared test (or Fisher’s Exact Probability where parametric assumptions are broken) where appropriate. For the qualitative analysis, responses were grouped thematically to illustrate various characteristics of the creative teacher.

Lifelong Learning Programme

The CREAT-IT project has been funded with support from the European Commission under grant agreement 2013 – 3637 / 001 - 001

The results are reported on in two ways: a survey synthesis and a summary report of responses question by question. The summary of responses to each question asked in the questionnaire, with the addition of statistical tests where relevant can be found in the appendix. The survey synthesis which is reported in the main body of this deliverable meets the aims of the deliverable:

- 'determining the aspects of the Creative Scientific Teacher role'
- creating an overall picture of the way stakeholders see the new teacher's profile
- establishing a new role or positioning of the creative science teacher who will integrate creative aspects in science activities

In order to achieve this, various headings were identified and the answers to the questions from the questionnaire that illuminated these headings were synthesised to produce a description of each heading.

- The creative science teacher is...
- The creative science teacher uses the strategies of...
- Teaching FOR creativity
- Educating teacher trainees to be creative science teachers...
- What barriers need to be dealt with?
- Current teachers' levels of knowledge/skills/confidence in creative science teaching
- Creativity at a country/policy level

1.5 Survey Synthesis

130 valid questionaires were received. The UK had the greatest number of participants, accounting for a third of the total. Respondents in Italy and Norway each accounted for a fifth of the participants, and Greece and Norway accounted for 10% apiece. Four responses were received from Belgium.

The majority of respondents have some experience of teaching: 84% of those surveyed are or have been teachers. 34% are scientists, 15 % are curriculum developers and 12% are members of the CREAT-IT Consortium. Only 7% selected that they have had experience of a specific creative science approach.[2]

The responses from the survey indicate that:

1.6 The creative science teacher is:

Constantly developing

[2] For full details see Table 1, p 43.(Appendix A.1)

Lifelong Learning Programme

The CREAT-IT project has been funded with support from the European Commission under grant agreement 2013 – 3637 / 001 - 001

The creative teacher is aware they are never the finished product: “this is a perpetual procedure of helping yourself be better and better. Teaching skills have no end. You can always be more sufficient than you used to be before” (general teacher, Greece). Even when you have a large amount of skills and knowledge there is still a notion of further learning “I feel I always have new elements to learn myself” (general teacher, UK); “I know a lot and I have certain skills, but I think I need to develop more” (teacher with experience of a specific creative project, Serbia). Part of this process involves “the freedom to make mistakes and learn from them, both as a teacher and as a pupil learning” (general teacher, UK). A general teacher from the UK states how “I could always improve my knowledge & skill; there are always new things to learn and practice. I don't think I'll ever be confident enough to rate my knowledge & skill as any higher”.
The word “endeavour”, used by a general teacher from the UK implies a constant searching and developing of ideas: “I endeavour to find creative ways of teaching science and inquiry skills within the creative curriculum”.

This approach is reflected in Craft’s (1998) study of creative teaching, which highlights critical reflection on teaching and adaptability of practice as appropriate. It also aligns with wise humanising creativity (Chappell & Craft, 2011; Chappell et al., 2011), which argues that creators need to think about the ethical consequences of their creations as well as acknowledge their own embodied identity development as part of the creative process.

Pupil focused and led

The creative teacher focuses the process and outcomes on the needs of the pupils. This can be to interest students and increase their knowledge: “I am always trying to make my lesson an interesting experience that makes my students wiser” (general teacher, Greece). It is related to the differentiation of sessions “I know how to manage children, how to … adapt to the ages/needs of the children” (curriculum developer/teacher, UK). The creative science teacher is a facilitator of learning: “Creative science enables children to use their own starting points not going over things they already know. The teacher's role is then to facilitate children taking their learning forward.” (curriculum developer/teacher, UK). Outcomes are dependant on the child: “Finding the best way to get the result I want is not always a reflection of what I know, but depends largely on child's involvement and readiness” (Curriculum developer/teacher, Serbia).

One of the key approaches to creative science teaching was seen to be encouraging children to try out their own ideas in investigations (51% of 83 respondants selected this). It was the approach with the most selections from the UK and Greece, the second most selected item by Belgium, Italy and Serbia, and the third most selected item by Norway. Another key approach was children asking questions for the purposes of problem finding (selected by 43%).

Lifelong Learning Programme

The CREAT-IT project has been funded with support from the European Commission under grant agreement 2013 – 3637 / 001 - 001

When reporting on a creative science lesson they had seen, one respondent commented that the lesson was creative as "all students could participate in it, express themselves [and their curiosity] and felt that they where smart in their own way" (scientist/teacher, Greece). A scientist/teacher from Norway cited a lesson in which the focus was on exploring a phenomenon of the students' own choice.

When asked to comment on the most important thing they had learned about creative science teaching through a specific creative project/approach, the majority of responses focused on the student. Three teachers noted how these approaches promote students' interest in science, one continuing this thought by adding "[when] pupils are more interested on subject, they collaborate and learn without tension and math anxiety" (teacher, Serbia). The pupils who take part "learn something in a new, efficent way" (teacher, Italy) and "the more alternative ways you use to teach a subject, the most students you manage to approach" (teacher, Greece).

Being pupil focused and led is also found in Craft et al (2013), who discuss three key characteristic features of creative pedagogies: co-construction, children's control/agency/ownership and high expectations in skills of creative engagement.

Emotionally connected

It is the love of science teaching "I love teaching science and will try anything" (scientist/teacher, UK) and care for the pupils "I really care about [my pupils] and they feel that and they don't hesitate to express their thoughts and the difficulties" (general teacher, Greece) that motivates teachers to pursue creative teaching. There are also personal rewards: "Creativity in teaching makes me very happy. I know when I am really creative and I very much enjoy it - the whole process, from finding an idea, to making it happen in the classroom" (General teacher, Greece). The emotional connection helps foster students' creativity, a scientist/teacher from Norway commented on a lesson they had seen that "encouraged creative exploration in a manner where there was no wrong answer [that is] it was 'safe' to be unconventional".

This emotional connection links to 'Quiet Revolutions' (Chappell et al, 2011) which argues that change towards different educational futures could be made to happen in small but potent ways, and encourages teaching and learning which builds shared solutions from the 'bottom up' – amongst teachers who are passionate about what they do and why they do it.

Trained

Training is seen as a key element of the development of a creative science teacher. It is the "knowledge of pedagogies and approaches that promote creativity" that increases the teacher's ability(general teacher, Greece). This knowledge is gained through training (scientist/teacher, Italy) and studies (general teacher, Greece). It is on-going and current (scientist/teacher, Italy).

Lifelong Learning Programme

The CREAT-IT project has been funded with support from the European Commission under grant agreement 2013 – 3637 / 001 - 001

An element of training can come from the teacher participating in a specific creative approach. A teacher from Norway who had taken part in *Write a Science Opera* commented how they learnt something more about the "theme we where artistically working on".

Motivated through prioritising creative teaching as a pedagogical approach

Teachers who feel skilled and confident in delivering science creatively 'are motivated educators' (general teacher, Greece). They prioritise creativity: "since I have started teaching I have always considered creativity a matter of the utmost importance" (scientist/teacher, Italy); this can be based on a perception, what should be: "I have the perception science should be taught with a more effective approach" (scientist/teacher, Italy). They encourage different ways of recording and expressing ideas (two fifths of 83 respondents selected this as an approach to creative science teaching). They foster imagination (more than a third of 83 participants select this as a creative teaching approach) and act as a facilitator rather than a 'top to bottom' (i.e. 'top down' approach (Curriculum developer/teacher, Greece).

Collaborative

There was a perceived need for collaboration for the purposes of exchanging of ideas; support; and achieving high level outcomes. "I think that for creative education you need constant cooperation and exchange of experience among schools, students and professors" (general teacher, Serbia). Collaboration occurs between the creative science teacher and their pupils - "we [the creative teacher and their pupils] are a team that we are collaborating and trying for the best" (general teacher, Greece), "we worked together" (general teacher, Greece); their mentors - "my support network at the school, [my] mentors etc, are phenomenal…I have much to inspire me here. The team…give you all the support you need to get creative in the classroom" (scientist/teacher, UK).

Seeks experience, often in the arts

There is some evidence that the creative science teacher is experienced, but the experience can be related to a wide variety of fields, not necessarily science related. Experiences mentioned are vast and varied; from degree level study in science, to regular leading of science festivals; from the teacher who is not a trained scientist but has "much experience in the field of creativity in science education"; from the "outstanding" science teacher to the active painter/musician. A teacher with experience of a specific creative project from Greece reports that "apart from Science, I possess high-level skills in electronics, informatics and the arts." A consortium member from Greece reports that although "my knowledge in Science can be considered limited, I do have a strong interest in Acoustics and its relation to the construction of the modern flute. I do feel confident when it comes to making strong points on the relation between Music and Acoustics".

Lifelong Learning Programme

The CREAT-IT project has been funded with support from the European Commission under grant agreement 2013 – 3637 / 001 - 001

1.7 The creative science teacher uses the strategies of:

- *Inquiry based learning (76% of 130 respondents selected this as an example of good practice)*

This item was selected as good practice by more than 60% of participants in 5 countries (only Belgium had less than 60% of participants selecting it, this could be due to Belgium's extremely low participant number).*

Practices related to inquiry based learning, such as 'using questioning as a tool'; 'encouraging observations and making connections'; 'encouraging reflective, reasoned conclusions based on evidence'; 'encouraging problem solving' and 'problem finding' were all used quite often or very often by science teachers (between 71-87% of 109 respondents selected these elements as teaching approaches they used often)[3]. Many of them were rated as the items with the highest means when broken down by country (see appendix y). 'Using questioning as a tool' and 'encouraging reflective, reasoned conclusions based on evidence' are both quite interesting as analysis shows that some of the variation in their use can be explained by country. Using questioning as a tool is the UK's highest mean (2.71), Serbia's 3rd highest mean (2.36), Norway's 5th highest mean (2.17), Greece and Italy's 7th highest mean (2.56 & 2.39 respectively). It is one of Belgium's lowest means (1.50) but Belgium's small sample size should be remembered. 14% of variation in this item can be explained by country. Less of the variation of the item 'encouraging reflective, reasoned conclusions based on evidence' can be explained by country (10%), nonetheless this can still be seen as significant. It is Italy's second highest mean (2.35), Norway and Greece's 4th highest mean (2.33 and 2.25 respectively), the UK's fifth highest mean (2.46) and Serbia's 7th highest 2.07. Again, it is one of Belgium's lowest means (1.50).

Trying out ideas in investigations, problem finding, observation and making connections, and problem solving were all rated highly as approaches to creative science teaching (more than a third of respondents selected these),

Scientific inquiry was an element of the definition of creative science. When people responded to the definition, elements of inquiry based learning were touched upon. When teachers "create new, alternative ways for their students to 'see' and perceive the science" pupils "learn how to observe and interact with everyday phenomena in nature and science". (teacher with experience of a creative science projects, Greece). A scientist/teacher from Norway noted that using inquiry as a teaching method does generate alternative ideas and a curriculum developer/teacher from Serbia commented that scientific inquiry as an innovative teaching strategy should be the basis for education in the future.

When asked to rate their knowledge, skill and confidence in the creative teaching of science a scientist/teacher from Norway responded that "science education research has for several

[3] The exact results can be seen on page --- of Appendix A.1 (p53)

Lifelong Learning Programme

The CREAT-IT project has been funded with support from the European Commission under grant agreement 2013 – 3637 / 001 - 001

decades focussed on inquiry approaches to learning science. And from the definition of creative teaching in science above many inquiry approaches would most likely qualify as creative approaches. Consequently, inquiry approaches should be well known to most researchers as well as educators in the field who are well oriented in science education research." However, a scientist/teacher from Norway critiqued the definition of creative science based on its use of the word inquiry, which they argue, has various definitions and connotations.

It was pointed out that the definition could be developed by taking account of the need to base development on "critical scientific tests of the ideas behind" the development, in addition to thinking creatively (scientist, Norway). This was reiterated by a general teacher from Italy who argued that "to develop a true scientific thought it is necessary to evaluate different hypotheses and test them where possible". A curriculum developer/teacher from Italy felt that the definition omitted consideration of "the experimental field of the body and of the materials, which are essential to every human creative process".

When respondents reflected on the given definition of everyday/'little c' creativity, further links to inquiry based learning were made. A general teacher from the UK stated that "working creatively helps to provide context which aids understanding of concepts and enquiry skills by exploring and manipulating the world around them". It enables pupils to explore and experience science in a non-threatening way and is not teacher or adult directed (UK general teacher).

Inquiry based learning is also seen as a strategy for educating trainee teachers to be creative science teachers. A CREAT-IT consortium member from Italy suggested trainee teachers should be encouraged to undertake research, a consortium member from Serbia write that inquiry-based teaching methods should be used when training teachers. A UK curriculum developer/teacher stresses that trainee teachers should be taught to create a creative classroom through "pupil-led investigations" and a UK scientist/teacher gave more detail on what this might look like: "Encourage collaborative planning with students from an open question generated by the students".

- *Learning which is connected to the real world (70% of 130 respondents selected this as an example of good practice, 96% of 109 respondents selected it as a teaching approach they use quite often/very often)*

This was selected as good practice by more than 60% of participants, in three countries - the UK, Italy and Serbia. (Selected by 50% of participants from Greece and Belgium, 33% from Norway).* When asked how often specific teaching approaches were used in their science teaching all countries except Belgium had the highest mean for the item 'relating science to everyday life'. It was one of Belgium's second highest means.

Lifelong Learning Programme

The CREAT-IT project has been funded with support from the European Commission under grant agreement 2013 – 3637 / 001 - 001

Creative science teaching was seen through approaches which related science to everyday life (almost half of 83 respondents selected this as an approach to creative science teaching).
Other teaching/learning approaches linked to this include: 'encouraging observations and making connections', reported as being used very often/quite often by 93% of 109 teachers; and 'building on children's prior experiences', used quite often/very often by 88% of the teachers. An interesting finding related to this latter point is that 15% of the variation can be explained by country. This item was recorded as Greece's third highest mean (2.33), the UK's 4th highest mean (2.49), Serbia's 6th highest mean (2.08), Norway's 7th highest mean (1.83) and Italy's 12th highest mean (1.71). Although it is one of Belgium's third highest means, Belgium only had 4 respondents. Its mean for this item was relatively low, 1.75.

When respondents were asked to comment on the definition of everyday/ 'little c' creativity, reference to connection to the real world was made by five participants. It is through 'little c' creativity that pupils understand how science is applied in the real world (teacher with experience of creative projects, Greece); pupils begin to make sense of the world themselves (scientist/teacher, UK). If the explorations are connected with "everyday phenomena and processes", "children can [more] easily grasp and understand the things that surround them" (curriculum developer/teacher, Serbia). There is an imperative for creativity to be expressive of or expressed by everyday life (scientist/teacher, Greece). In addition, "science should relate to everyday life and children should see and be able to match up experiences in real life with learning" (curriculum developer/teacher, UK). A general teacher from the UK noted that science has to be relevant to the child and fall within their zone of experience.

One curriculum developer/teacher form the UK disagreed with the definition of 'little c' creativity, saying that if outcomes are original they may be out of context, highlighting the importance of context and real world links.

The notion of connection to the real world also comes out when questions are asked about educating trainee teachers to be creative science teachers, for example, giving trainee teacher the chance "take science outside the classroom to the real world, matching with real opportunities" (Belgium, scientist/teacher). This can be done through introducing the trainee teachers to professional scientists and encouraging interaction between these groups (Italy, scientist/ teacher). Also linked to this is the imperative to show teachers "the practical and useful aspects about their studies" (Italy, scientist/teacher), linking to the practical application of knowledge (Serbia scientist/teacher).

- *Individual, collaborative and communal learning (62% of 130 respondents selected this as an example of good practice)*

Lifelong Learning Programme

The CREAT-IT project has been funded with support from the European Commission under grant agreement 2013 – 3637 / 001 - 001

These approaches are selected as good practice by more than 60% of participants in 4 countries (Serbia had 48% of respondents selecting it as good practice, Italy had 43%).[4]

Collaboration was a feature of the definition of creative science that respondent commented on. A general teacher from the UK agreed that "science should engage children in possibilities whilst broadening their experience and understanding of scientific concepts through collaborative exploration". "Person to person" relations were seen as a good practice in terms of creativity in science education by a curriculum developer/teacher from Greece. A general teacher from Italy describes how peer discussion can result in the "consideration of ideas different from [the individuals] own". When asked to select approaches that were creative science teaching, over a third of 83 partcipants selected 'fostering classroom discussion and evaluation of alternative ideas'.

A lesson which gave pupils autonomy and the ability to collaborate freely was seen by a curriculum developer/teacher from Greece as a creative science lesson. A lesson that encouraged pupils to engage in discussion was seen as a creative lesson by a scientist/teacher from Italy and a cuuriculum developer/teacher from the UK.

The sense of an impact on the individual was made by a general teacher from Italy, who stated that 'little c' creativity "move[s] your brain and your personality", it gives self-awareness (general teacher, Norway). Another general teacher from Italy notes how the definition relies on individual curiosity. Topics should be related to children's individual interests (scientist/teacher, Greece), "personal engagement with subject matter" is another element of good practice (general teacher, Norway).

Working in small groups was a strategy used quite often/very often by 93% of 109 participating teachers. 'Fostering classroom discussion and the evaluation of alternative ideas' was a learning approach used quite often/very often by 81%. However, 'fostering students' own agency' was used much less frequently, less than half of the participants (44% selected this as a learning approach that was used quite often/ very often. (8 respondents stated they never used this approach).

Again, these processes can be modelled in teacher training. A scientist/teacher from Greece noted that trainee teachers should be trained in groups and collaborate as they are asked to do with their pupils. A consortium member from Serbia suggests that teaching methods that "emphasise classroom collaboration" should be used with the trainee teachers. A scientist from Norway suggests that the trainees be given the opportunity to try out methods and techniques "in collaboration with other teachers and advisors". The need for experiences to be exchanged is highlighted by a scientist/teacher from Serbia, perhaps through the creation

[4] When a cross-tabulation is run, to show if there is a significant relationship between COUNTRY and selected GOOD PRACTICE, these items demonstrated some association. Please see Appendix A .1 pp 47-48 for more details

Lifelong Learning Programme

The CREAT-IT project has been funded with support from the European Commission under grant agreement 2013 – 3637 / 001 - 001

and maintenance of "science teaching blogs for sharing ideas" (curriculum developer/teacher, Serbia).

- *Cross-curricular learning (62% of 130 respondents selected this as an example of good practice, 69% of 109 respondents selected it as a teaching approach they use quite often/very often).*

This aspect of good practice was selected by more than 60% of participants in 3 of the countries - in the UK, Belgium and Greece. (It was selected by 50% of Greek participants, 48% of Serbian participants and 46% of Italian participants).

70% of teachers in the survey reported 'using history or geography to teach science' on a regular basis. Less frequently used was the approach of 'teaching science from or through stories'. Just over a third of participants (36%) reported using these strategies quite often/very often. Drama was the least used teaching approach used in science lessons. Only 14% reported that they used it quite often/very often, but the majority of respondents (44%) never used Drama. All countries with the exception of Belgium had the lowest mean for the use of Drama as a frequently used teaching approach.

Cross-curricular learning was seen as an important part of teacher training. Interdisciplinary training, including the provision of opportunities for "social science teachers and art teachers to learn about natural sciences phenomena or laws they can use in their work" (CREAT-IT Consortium member, Serbia) A scientist/teacher from Italy suggested that the approach of *Content and Language Integrated Learning*[5] would be a key way of educating teacher trainees to be creative science teachers. Another cross-curricular link suggested was that of *Ludopedagogy* or 'game training' in the field of Information Communication Technology.

A concrete example was given by a curriculum developer/teacher from the UK who described a creative science lesson linked to English. Using a range of artistic materials and electrical equipment "children worked in pairs, first to create a circuit to light the bulb then use this knowledge to make a torch for a story character".

- *Using the Arts to shed new light on scientific concepts (60% of 130 respondents selected this as an example of good practice)*

Using the Arts was selected by more than 60% of participants in 4 countries, only Serbia (48%) and the UK (51%) selected it less frequently. Aspects of using the Arts may include

[5] This is a dual-focused educational approach, in which an additional language is used for the teaching of a subject such as science and the teaching of a language (see Coyle, D, Hood, P & Marsh, D (2010) *Content and Language Integrated Learning* Cambridge: Cambridge University Press)

Lifelong Learning Programme

The CREAT-IT project has been funded with support from the European Commission under grant agreement 2013 – 3637 / 001 - 001

'encouraging different ways of recording and expressing ideas', 'the physical exploration of materials' and 'fostering imagination'. The first of these was selected by 82% of 109 teachers as a learning approach they used on a regular basis. 'the physical exploration of materials' was selected by 78% of 109 teachers as a learning approach they used quite often/very often. 'Fostering imagination' was used by 69% of respondents quite often/very often.

14% of the variation in frequency of use of the item 'physical exploration of materials' can be explained by county. This item was the UK's third highest mean (2.54)Greece's 6th highest mean (2.14) and Belgium's 2nd highest mean (2.00). Other countries rated it less frequently, it was Norway's 7th highest mean (1.83), Serbia's 13th highest mean (1.77) and Italy's 14th highest mean (1.56).

Less frequently used learning/teaching approaches related to the Arts were open/unstructured play or exploration (used frequently by 45%), and role play, which was only used quite/very often by under a quarter of respondents (24%). All countries except Belgium and Serbia had the second lowest mean for 'role-play'. Serbia had this rated as third lowest mean.

1.8 Teaching FOR creativity

Purpose of fostering creativity

Participants were asked to rate 6 purposes of fostering creativity in science, from 0 – not at all an important purpose, to 4 – a highly important purpose. The statements with the highest means, and thus are thought to be important purposes of fostering creativity in science through education are:

- To enrich the understanding and interaction with phenomena in nature and technology
- To develop more innovative thinkers
- To develop positive attitudes to science
- To develop socially and environmentally aware and responsible citizens

The statements with the lowest means, and could be seen as less important purposes, are:

- To develop important attitudes and dispositions as a foundation for future learning
- To provide a foundational education for future scientists and engineers

(It should be pointed out however, that the mean values for each statement are very similar, ranging between 3.24 – 3.62 out of a possible 4.)

When each statement is ranked in order of means for each country, Greece and Italy's highest mean is 'To enrich the understanding and interaction with phenomena in nature and technology'. Belgium, Norway, Serbia and the UK's highest mean is for 'To develop more innovative thinkers'. 4 of the 6 countries had the lowest mean for the statement 'To develop

Lifelong Learning Programme

The CREAT-IT project has been funded with support from the European Commission under grant agreement 2013 – 3637 / 001 - 001

important attitudes and dispositions as a foundation for future learning' – Greece, Norway, Serbia and the UK. Belgium and Italy's statement with the lowest mean is 'To provide a foundational education for future scientists and engineers'.

There is demonstrable variation that can be explained by country for two of the purposes, albeit a small one. 8% of the variation in response to the statement 'to enrich the understanding and interaction with phenomena in nature and technology' can be explained by country. 7% of the variation in rating the statement 'to provide a foundational education for future scientists and engineers' can be explained by country.*

The role of the teacher in fostering inquiry skills

The role of the teacher in fostering inquiry skills (a key element of fostering creativity) was explored through a question were teachers were asked to rate levels of agreement to 4 approaches of teaching these skills. Three of the statements have high levels of agreement. This is reflected across all countries[6]. 'Teachers should allow children to find solutions to problems on their own' had a mean of 3.47 out of 4; 'Teachers should facilitate children's own inquiry' had a mean of 3.36 out of 4; 'Teachers should give children ample time to work out their own solutions to problems before showing them how they are solved' had a mean of 3.27, out of 4.

The teacher led approach 'Teachers should demonstrate first the correct way to solve a problem' has lowest level of agreement (mean 1.98 out of 4), with most participants selecting 'disagree' (41). This was rated with the lowest mean by all countries.

Contexts that contribute to the development of children's creativity

Teachers were asked to select 3 items that were most likely to contribute to the development of children's creativity in science. The top 6 (of 11) items are listed below. (It should be noted however that only the item 'working in small groups/working collaboratively' had more than 50% of the respondents selecting it. After these 6 items, there is a discussion on the development of inquiry skills.

Working in small groups/working collaboratively

51% of the 109 respondents selected this as a context most likely to contribute to the development of children's creativity. It was the Serbia, the UK and Norway's most selected item, selected by 65%, 60% and 44% of these countries participant's respectively.

* Please see (Question 4, Appendix A.1, p 72)

[6] With the exception of the statement 'teachers should allow children to find solutions to problems'. Belgium had a relatively low mean of 2.75 (s.d. 0.50), compared to the other countries who gave it a mean of 3.29-3.64. (It must be remembered that Belgium only had 4 respondents, so this should not be taken as representative.)

Lifelong Learning Programme

The CREAT-IT project has been funded with support from the European Commission under grant agreement 2013 – 3637 / 001 - 001

Problem-based learning

41% of the 109 respondents selected this as a context most likely to contribute to the development of children's creativity. This was selected by more than half of the respondents from the UK and Belgium.

Integrating science with other curricular areas

39% of the 109 respondents selected this as a context most likely to contribute to the development of children's creativity. It was Norway's most selected item, selected by 44% of respondents from Norway.

Physical exploration of materials

38% of the 109 respondents selected this as a context most likely to contribute to the development of children's creativity. This item is Italy's most selected item, 42% of respondents from Italy selected it.

Teaching science from or through stories

32% of the 109 respondents selected this as a context most likely to contribute to the development of children's creativity. All of the participants from Belgium selected this as a strategy most likely to contribute.

Taking children on field trips

32% of the 109 respondents selected this as a context most likely to contribute to the development of children's creativity. This was Greece's most selected item, 57% of respondants from Greece selected it.

Teaching approaches that will contribute to the development of children's creativity

Participants were asked to select from a list of items that they felt were most likely to contribute to the development of childrens creativity. The most selected items follow.

Encouraging children to try out their own ideas in investigations (more than half of participants selected this)

This was the item with the most selections from the UK and Serbia, the second most selected item by Belgium, Italy and Norway, and the third most selected item by Greece.
Lessons that fostered creativity in science were those that guided the pupils to find new ideas by themselves (general teacher, Belgium). Children should be permitted to investigate their own ideas and create their own projects (scientist/teacher, Greece).

Relating science to everyday life

Lifelong Learning Programme

The CREAT-IT project has been funded with support from the European Commission under grant agreement 2013 – 3637 / 001 - 001

This was the most selected item by Italy, the second most selected item by Belgium, Greece and Serbia, and the third most selected item by Norway and the UK.
When asked to comment why a lesson they had witnessed was creative, some of the comments were related to links with the real world (scientist/teacher, UK); pupils' own intersts (scientist/teacher, UK); "relat[ing] what they have learnt in science with every day life (and the reverse)" (general teacher, Greece); based on everyday experiences (teacher with experience of a specific approach, Greece).

Encouraging different ways of recording and expressing ideas

A creative science lesson observed by a CREATIT consortium member/teacher from Norway was one that "generated several perspectives of the subject matter simultaneously". "Resources were based on what the pupils came up with" in a creative lesson observed by a scientist/teacher from the UK; an example of this was provided by a teacher from Serbia who described the children creating "kaledioscopes and periscopes by the rules of mathematics, physics and art". Pupils' art work demonstrated an understanding of a specific scientific field in a lesson observed by a teacher in Norway. In another session a scientist/teacher from Greece commented how drama was used to teach the curriculum. A concrete example was given by a general teacher from Greece – "the students participated in a theater based on the chemistry they have been tought and also they organized a show with experiments.In that way they developed their creativity, their imagination and their crtical skills".

Encouraging problem finding e.g. children asking questions

A cross-tab analysis shows some of the variation in the selection of this item can be explained by country. 9% of the variation in the choice between yes and no can be explained by country.[*] A concrete example of this technique in practice was given by a scientist/teacher from the UK – "the students were driving their learning forward by setting the questions to be answered themselves. [The] teacher then pull[ed] all the threads together at the end so that students ha[d] a common learning outcome".

Rewarding/praising creative behaviours

Several creative behaviours were listed and teachers were asked to rate how often they praised/rewarded the behaviours. Each of the characteristics are rewarded/praised by teachers on a frequent basis, with means ranging from 2.19-2.40 out of a possible 3. The statements 'ability to collaborate' and 'a clear sense of iniative' had no one selecting they never rewarded the described characteristic. Only one person selected they never rewarded are praised 'Ability to connect what they have learnt to other subjects'; 'use of curiosity'; 'evidence of motivation'; 'thinking critically' or 'ability to come up with something new'. The characteristic of 'use of imagination' was stated as never used by 2 people.

[*] See Appendix A.1, Question 5, p 74.)

Lifelong Learning Programme

The CREAT-IT project has been funded with support from the European Commission under grant agreement 2013 – 3637 / 001 - 001

There is variation by country in some of the items. The item with the highest overall mean (ability to connect with what they have learnt to other subjects) was one of the highest means for the UK and Norway (2.58 and 2.33 respectively), and was Serbia's highest mean (2.62,). However, it was also Greece's lowest mean (2.27), and one of Belgium's lowest means (1.50). However, there is a high proabability this may have occurred due to sampling error. The item with the third highest mean, (evidence of motivation) was one of the UK's highest means (2.58). However, it was Norway's lowest mean (1.83), one of the lowest rated items by any country. Tests show that 12% of the variation between frequency of rewarding use can be explained by country. None of the other items had significant variation by country.

1.9 Educating teacher trainees to be creative science teachers

In addition to the need for teacher training to involve inquiry based learning; learning that is connected to the real world; collaborative learning; and cross-curricular learning, as described above, there were further suggestions made about good practice in teacher education that fosters creative teaching.

Provide mentors in creative teaching

A scientist/teacher from Greece suggested the following use of a trainer "practise creative science with the presence of trainer before applying it alone to the class. Discuss with the trainer any problems that could be arisen and how they can be handled". A curriculum developer/teacher from Greece saw the role for "gentle and really supportive coaching" and a curriculum developer/teacher from the UK suggested trainees should be given the "opportunities to try alongside an outstanding practitioner".

Provide time to be creative

This heading was suggested by a scientist/teacher from Norway. A Curriculum developer/teacher from Greece simply noted that trainee teachers "need to slow down". A UK curriculum developer/ teacher suggested this be approached through science days, allowing "full immersion in a topic, giving time to develop and build on ideas."

Provide the physical resources to be creative

Resourcing was seen as important in the fostering of trainee teachers creative teaching. These included scientific instruments; well-equipped laboratories; and computers (Greek curriculum developer/teacher). They also included curriculum materials (Serbia consortium member) and teaching materials (Serbia curriculum developer/teacher).

Trainee teachers should be taught:

- effective science communication techniques (Scientist/teacher, Norway)

Lifelong Learning Programme

The CREAT-IT project has been funded with support from the European Commission under grant agreement 2013 – 3637 / 001 - 001

- the principles of creative science (Scientist/teacher, Greece)
- to improvise (CREATIT consortium member, Serbia)
- subject knowledge (curriculum developer/teacher, UK)

Trainee teachers should experience:

- examples of creative science lessons (Scientist/teacher, Italy), contrasting these with examples of 'traditional' teaching (Scientist/teacher, Greece)
- ways of creating a creative classroom (curriculum developer/teacher, UK)
- a hands-on approach to creative teaching (Scientist/teacher, Italy)
- reflecting on what creativity in science is (scientist, Norway)
- interactive training (CREATIT consortium member, Serbia)
- support from the head teacher/manager (curriculum developer/teacher, UK)
- creative autonomy (curriculum developer/teacher, Greece)

Actual approaches

Teacher training could involve:

- training in how to use a Science Theatre or Science Café (CREATIT consortium member, Italy)
- game training according to the method of Ludopedagogy (Centro de Investigacion y capacitación La Mancha, Montevideo, Uruguay)(Curriculum developer/ teacher, Italy)
- engagement with activities of the *Center for the Promotion of Science* which involves teacher training activities as well as and programs for schoolchildren (CREATIT consortium member, Serbia)
- using other languages through the CLIL (Content and Language Integrated Learning) method (Scientist/ teacher, Italy)
- participation in science busking festivals (curriculum developer/teacher, Serbia)
- participation in a school science festival (Curriculum developer/teacher, Serbia)
- participation in science days (curriculum developer/teacher, UK)

1.10 What barriers need to be dealt with?

Barriers to creative science teaching can be seen at an organisational, attitudinal and knowledge level. Different countries recognise some barriers to different degrees.

All 130 participants were asked to discuss the barriers to creative science teaching in their country. Participants were asked to pick any of 8 listed items that applied, results for each item were totalled, and the results in column 1 and 2 of the table below show how frequently each item was mentioned. HOWEVER, there is significant variation by country.

Lifelong Learning Programme

The CREAT-IT project has been funded with support from the European Commission under grant agreement 2013 – 3637 / 001 - 001

The order of items varied by country. It may be that the UK, with its large sample size, and Belgium, with its extremely small sample size may be skewing findings. When they are removed from the analysis, the order of the list changes (see table 1).

Barrier	**Number and % of 130 respondents who selected each item**	**Barrier (when UK and Belgium removed)**	**Number and % of 81 respondents who selected each item**
Time*	79 (60.8%)	Teacher training approaches*	52 (64.2%)
Curriculum constraints *	71 (54.6%)	Resources	44 (54.3%)
Resources	69 (53.1%)	Teacher motivation*	39 (48.1%)
Teacher training approaches	66 (50.8%)	Time	38 (46.9%)
Teacher motivation*	52 (40%)	Curriculum constraints*	33 (40.7%)
Teacher confidence	42 (32.3%)	Teacher confidence	21 (25.9%)
Others' opinion on how science in school should be taught	31 (23.8%)	Others' opinion on how science in school should be taught	20 (24.7%)
Pupil motivation	24 (18.5%)	Pupil motivation	16 (19.8%)

(Table 1) Barriers to creative science teaching ranked from MOST selected to LEAST selected

When each country's most selected items are listed (those selected by 50% or more of the respondents from each country), the following patterns can be seen: **teacher training approaches** are seen as the biggest barrier to creative science teaching - all countries mention it as a barrier (though only 27% of UK participants do so); **resources** - all countries except Belgium and Italy mention it as a barrier; **time** (seen as a barrier by more than 50% of respondents from Greece, Italy and the UK); **teacher motivation** (seen as a barrier by Belgium, Italy and Serbia); **curriculum constraints** (seen as a barrier by 50% or more of respondents from the UK and Belgium); **teacher confidence** (only seen as a major barrier by the respondents from Norway).

* When a cross-tabulation is run, to show if there is a significant relationship between COUNTRY and selected BARRIERS, these items demonstrated some association. Please see appendix A.1 pp53-54 for more details

Lifelong Learning Programme

The CREAT-IT project has been funded with support from the European Commission under grant agreement 2013 – 3637 / 001 - 001

Others' opinion on how science in school should be taught and **pupil motivation** are **not** seen as a major barrier by any country. However, 42.9% of Greek respondents did select **others' opinion on how science in school should be taught** as a barrier, (whereas no one in Belgium selected it as a barrier). A quarter of the participants from Italy selected **pupil motivation** as a barrier, whereas other countries select this item less (in fact no-one in Norway or Belgium select it as a barrier).

These 8 barriers can be split into 3 areas (Kochhar, West & Taymans, 2000): **organisational barriers** (time, resources, curriculum constraints); **knowledge barriers** (teacher training approaches, teacher confidence); and **attitudinal barriers** (teacher motivation, others' opinion on how science in school should be taught, pupil motivation). These are defined and discussed below, with reference to other barriers that participants suggested.

Organisational barriers

These are barriers related to the different ways in which schools, classrooms and educationally systems are structured and resourced. Time, curriculum constraints and resources are listed as the top 3 barriers by respondents from the UK; respondents from Greece select time and resources as the top 2 barriers. The other countries only have 1 organisational barrier in their top 3 most selected barriers: resources is Serbia's most mentioned barrier, and Norway's third most mentioned barrier; time is Italy's second most selected barrier; and curriculum constraints is Belgium's third most selected barrier.

Other organisational barriers listed when the option of 'other barriers' was selected were:

- increased emphasis on assessment/testing (UK general teacher)
- class size (UK general teacher)
- timetabling (UK curriculum developer/ teacher)
- content-based national curriculum (UK curriculum developer/ teacher)
- fear of inspection (comment made by 2 UK CREAT-IT Consortium member)

The content-based curriculum barrier was raised later in the questionnaire by a UK curriculum developer/teacher who noted that "schools that do not rely on QCA[7] documents" are examples of good practice in initial teacher training that fosters creative teaching.

Organisational barriers to creative teaching were raised by some participants in response to the question where they were asked to rate their levels of confidence, skills and knowledge in creative science teaching. These included: not having enough time to develop creative

[7] QCA – Qualifications and Curriculum Authority (an executive non departmental body set up by government in 1997, to regulate and provide guidance to schools. Disbanded in 2007)

Lifelong Learning Programme

The CREAT-IT project has been funded with support from the European Commission under grant agreement 2013 – 3637 / 001 - 001

experiences (general teacher, Italy, scientist/teacher, UK, general teacher, UK)); the traditional nature of the education system (general teacher, Greece); lack of training "my previous science and methodological inputs through formal system of education haven't gone enough in this direction" (General teacher, Serbia); curriculum restraints (2 general teachers, UK); pressures of exams (scientist/teacher, UK); and having a focus on pupil attainment (General teacher, UK). As one scientist/teacher from the UK reports "I believe in [the creative teaching of science] much more than I practise it! It isn't my default position - under curriculum & time pressure it doesn't always seem an efficient way to teach 'what they have to know' for exams".

A final organisational barrier is related to how creative science teaching is introduced. A scientist/teacher from Greece comments on the need to "grow creative science teaching culture [with] students from the first day at school... Otherwise if we introduce it suddenly students will think that it is their best chance to escape from the pressing studying program and the whole attempt will collapse".

Knowledge barriers

These are barriers related to the differences in the knowledge and skills of various stakeholders (primarily teacher). Norway listed both teacher training approaches and teacher confidence as their first and second most selected reasons. Teacher training approaches were the most selected item by Italy, the second most selected item by Belgium and Greece, and the third most selected item by Serbia. (Just over a quarter of UK respondents selected it as a barrier).

The open ended responses also highlighted teacher training as a barrier, a scientist/teacher from Greece thought there was a lack of experiential education for teachers (for example watching & then practicing a creative teaching lesson before applying it to their class) so they can use it effectively. A teacher with experience of a specific creative science project from Norway thought that teachers' own experience of education is a barrier. When asked to comment on good practice in initial teacher education that fosters creative teaching a scientist/teacher from Serbia stated that training needed to be long term. This was reinforced by a scientist, also from Serbia, who stated that there should be long term planning training, rather than short term.

When asked to rate their knowledge, confidence and skills in the creative teaching of science some knowledge barriers were raised. These were either related to: knowledge of science (some respondents were teachers of other curriculum areas); or knowledge of creative approaches: "I did not study any courses about how to study science in a creative way" (teacher with experience of a specific creative project, Italy). On the other hand, some teachers reported they did have knowledge, but were limited by levels of skill: "I know how to do more than I can actually do well" (general teacher, UK)and "I don't use all the things I have learned yet" (general teacher, Belgium).

Lifelong Learning Programme

The CREAT-IT project has been funded with support from the European Commission under grant agreement 2013 – 3637 / 001 - 001

Some people wanted to be creative teachers, but felt they did not know where to gain access to ideas or resources. A scientist/teacher from the UK said "I love teaching science and will try anything but it is difficult to find different innovative ways of teaching the subject". A general teacher, also from the UK echoed this, saying they were unsure "where to go to get" new ideas for creative activities.

The complexities of a creative scientific culture were seen as barriers, a CREATIT consortium member from Greece thinks that "teachers understand science as **knowledge** only without any relation to **well-being**". A scientist/teacher from Italy widened the knowledge barrier to include other stakeholders, saying the lack of scientific culture at all levels (including parents) is a barrier.

Attitudinal barriers

These are barriers that relate to the beliefs, motivations and attitudes that different stakeholders have. These stakeholders can be teachers, senior managers, policy makers, pupils and/or parents. Teacher motivation is the most selected barrier by participants from Belgium and Serbia, and is Italy's third most selected item. Other's opinion on how science in schools should be taught is selected by under a quarter of all participants; and pupil motivation is only selected by 19% of participants.

The Greek scientist/teacher who commented that a creative science teaching culture needs grown, rather than suddenly implemented adds that this approach will cause a change in attitudes of staff and pupils: "we have to introduce it gradually both to students and teachers so they can change their point of view about teaching".

Other attitudinal barriers listed in open-ended responses were tradition (scientist/teacher, UK) and school culture (scientist/teacher, UK). We recognise these could also be linked with organisational barriers.

When asked to rate their levels of confidence skills and knowledge in creative science teaching the issue of low self-confidence was mentioned by a general teacher from Greece, and a general teacher from the UK said how "they "don't always feel confident trying new ideas"

When asked to comment on good practice in initial teacher education that fosters creative teaching other elements of stakeholder attitudes were mentioned as examples of good practice. A scientist/teacher from the UK noted how a combination of the trainee teacher's drive and the inspiration of the training course develops good practice. Having support from the head teacher was seen as vital (curriculum developer/teacher, UK).

Lifelong Learning Programme

The CREAT-IT project has been funded with support from the European Commission under grant agreement 2013 – 3637 / 001 - 001

A final comment related to attitudinal barriers is that of the status of teachers. This is mentioned by a CREATIT consortium member from Serbia who sates that: "I believe that one of the biggest struggles is the frustration that the teachers develop with the low paychecks and low social standard of their profession. I believe that working on a wholesome job satisfaction in teachers is the first and fundamental pre-requisition for creativity in the classroom."

1.11 Current teachers' levels of knowledge/skills/confidence in creative science teaching

Teachers generally rate themselves as having good to high level (3.39-3.45 out of 5) of knowledge (3.45, s.d. 1.142); of skill (3.40, s.d. 1.115); and of confidence (3.39, s.d. 1.234). When level of agreement with each statement is listed from the country with the highest agreement with the statement, to the country with the lowest level of agreement, the following patterns are seen[8]:

- Level of knowledge – Serbia (mean=4.00), Greece (3.91), Belgium (3.50), UK (3.44), Italy (2.94), Norway (mean = 2.88).
- Level of skill – Serbia (mean=4.06), Greece (4.00), Norway (3.50), Belgium (3.25), UK (3.19), Italy (2.83).
- Level of confidence– Greece (mean = 4.09), Serbia (4.00), Norway/Belgium (3.25), UK (3.19), Italy 2.89)

Serbia and Greece consistently report good to high levels of knowledge, skill and understanding; participants from Italy tend to report moderate levels of knowledge skill and understanding.

1.12 Creativity at a country/policy level

- *The role of creativity in the teaching, learning and assessment of science*

When asked to rate the extent creativity plays a role in the teaching, learning and assessment of science in their country the majority saw creativity as playing a low role in the teaching, learning and assessment of science in their country (mean=1.46 out of 3). 9% selected no role, 51% select low role, 26% select moderate role and 14% select key role. By country, in order from highest mean (larger role) to lowest (smaller role): Belgium (mean=1.75), Serbia (1.69), Norway (1.63), Italy (1.39), Greece (1.36), UK (mean=1.34).

Qualitative responses on the extent of creativity playing a role by country:

[8] See pp 59-60 in the appendix for Table that shows the mean and mode values selected by participants broken down by country

Lifelong Learning Programme

The CREAT-IT project has been funded with support from the European Commission under grant agreement 2013 – 3637 / 001 - 001

Belgium:
All responses expressed a moderate role, citing low motivation of some teachers and that Arts education is taught separately from other subjects without integration.

Greece:
All responses expressed a low or no role, citing conservative learning models and education system, narrow evaluation of teachers, no concrete policy on creativity, a top to down authoritative system, no curriculum flexibility, creative learning happening through the cracks, examination focus, and creative science teaching and learning being obstructed by the educational system.

Italy:
Responses expressed varied from no role, through low role and up to moderate role. Comments were that very few teachers try to be creative, little attention given from the Ministry of Education, teachers are de-motivated and that there are too many teachers not trained to teach from a pedagogy of freedom and play.

Norway:
Responses expressed a low to moderate role (the 'key role' responses was only talking about their won teaching and not the country as a whole). Comments were that in recent years, reading and writing and their testing were emphasized at the expense of creativity, and that assessing creativity is difficult and hence is easily downplayed because spending much time on creative teaching strategies might be a risky business for a teacher.

Serbia:
The majority of responses expressed a low role, commenting that creative teaching is not sufficiently explored and that the focus has become that you complete the curriculum tasks, make sure the pupils know enough and get on with the next bit of work. Schools tend to encourage a uniform way of thinking: receive information, reproduce it, get a mark. It leaves no space for free expression of students' personal opinions. There was one response that expressed that creativity had a key role, which was from a teacher with experience of a specific creative science project/resource, who commented that thanks to the creativity and energy of individuals, science in schools is interesting for some students. In this way, teachers are encouraging the curiosity to explore the world around them through science.

UK:
The majority of responses expressed a low or moderate role, commenting often about assessment: there is no real creativity in assessment, that there is more creativity since the removal of the SATs exam; it is left to the individual teacher as to whether they include it; over emphasis on pupil attainment and test culture is stifling creative approaches in some aspects of science; assessment is largely pre-determined - pupils are taught the skills to be successful in GCSE exams and creativity is highly variable within that. Other comments were

Lifelong Learning Programme

The CREAT-IT project has been funded with support from the European Commission under grant agreement 2013 – 3637 / 001 - 001

about time constraints, that there was a tendency for children to know scientific facts rather than exhibit scientific approaches, and that good creative practice was down to individual teachers and is not systematic.

- *The promotion of creativity in science education through national level governmental policy*

School ethos and **initial teacher education** were seen to have had a neutral effect on the promotion of creativity in science education (means of 0.29 and 0.23 respectively in the range -5 to 5). **Curriculum policy**, **assessment practices** and **performance indicators** were seen as having a negative effect (means of -0.79, -1.25 and -1.39). Indeed they were seen by some as actively preventing the development of creativity in science.[9]

Nearly 21% of the variation in frequencies of rating for the national level policy regarding **performance indicators** can be explained by country. None of the correlations were significant for any of the other items, demonstrating that variance in results cannot be explained by the different countries.

Serbia had the most neutral responses - the majority of participants selected neutral values for each item. The **UK** had some of the lowest means, indicating a belief that the policies act to prevent creativity in science education. However, in the case of **school ethos**, it recorded the highest mean, indicating that this promotes creativity in science education. 4 of the six countries recorded a low mean for the impact of **assessment practices** on the promotion of creativity in science education, only **Belgium** and **Serbia** gave neutral responses. Half of the countries recorded **performance indicators** as a barrier, with **Belgium** and **Serbia** reporting this as a strategy that may actually promote creativity in science (albeit at a low level).

Current national level **strategies** were seen to have no effect on promoting creativity in science education (mean=0.000, in range -5 to 5). However, individual responses are spread from -4 (they prevent creativity in science) to 5 (strongly promote creativity).

The **UK** is the only country to register a negative mean for this statement, indicating a belief in the UK that national level strategies tend to prevent creativity in science education. However, the probability of this happening by chance was, showing that any association between variable may be due to sampling error.

[9] However, when histograms are drawn they show skewed distributions, this, along with large standard deviations, demonstrates that the means should be treated with caution. The presence of multiple modes in some items may indicate that there may be two separate populations in the sample. For example, the item called Assessment practices has multiple modes (-5, -2, and 0).

Lifelong Learning Programme

The CREAT-IT project has been funded with support from the European Commission under grant agreement 2013 – 3637 / 001 - 001

2. Interviews and observation findings

'Science is creativity – that's what science is about' (interviewed teacher)

2.1 Interviews

Semi structured interviews (see Appendix A. iii for question schedule) were conducted with one teacher from each country (UK; Serbia, Greece, and Norway) and four from Italy. The teachers had completed the survey and indicated that they were willing to be interviewed. They were all teachers with an interest in the subject of creative science teaching and had either taken part in a project promoting creative teaching or had developed approaches in their own practice. All the Italian respondents had taken part in the Science Theatre or Junior Science Cafe activities as described in the Case Studies (D2.1). All the teachers who were interviewed gave written consent for the interviews to be recorded, and for the to be used in the report and any other publications associated with the project. Anonymity is assured unless specific permission is given by the teacher for them to be identified.

Interviews were conducted by Skype or telephone either in English (by a member of the Exeter team) or in the home language by a member of the consortium. Interviews were recorded and relevant passages were transcribed and, if necessary, translated into English by the interviewer. The interview questions sought to elicit specific examples of creative teaching in science experienced by the teachers; and to learn more of what their ideas are about creative science teaching and its challenges. We distinguished between teaching creatively and teaching for creativity, and asked for their views on what characterised a creative science teacher.

2.2 Interview analysis

This section discusses the following interview data in the light of key aspects of the survey: Teaching creatively; teaching for creativity; barriers to creative teaching; value of creative teaching in science characteristics of the creative science teacher .

In this report interviewees are identified by Initials: KN; KB; KG; MS; NI; BI; MI; RI.

2.3 Examples of creative teaching

Interviewees were asked to describe a lesson or activity which they considered to be a good example of creative science teaching giving their reasons for 'nominating' the lesson. This could be a lesson they observed or conducted themselves.

Lifelong Learning Programme

The CREAT-IT project has been funded with support from the European Commission under grant agreement 2013 – 3637 / 001 - 001

KN asked her class to present their scientific field reports as an oral presentation, the groups were teamed with an artist, one group worked with a dancer, they had to give a 12 minute presentation to get their point across anyway they wanted.

In another example KN (working with an arts colleague) wanted her students to think differently rather than giving clichéd answers.

> *'Students stood on 'islands' (made from large sheets of paper) and I asked questions, for every wrong answer I would rip a bit of paper off the island, as it got smaller students had to think creatively how they were going to stay on the island, the children realized I was not going to censor their ideas'. I encouraged them to "think outside of the box".*

KB reported observing another teacher working with low ability year 7 and 8 students (12-13 years old).

> *'The lesson was about floating and sinking, the teacher preformed a magic trick. The students then conducted an investigation to solve how the trick was done using their scientific knowledge. …… the teacher was encouraging the children to sometimes go down the "wrong path" because she wanted them to work out what was wrong with their ideas.*

KG described a lesson involving practical experiments:

> *Recent surveys indicate that experiments enhance creative and inquiry-based learning so I decided to teach this session in this way. It was a class of 12 students …….. and the lesson was about mixtures and homogenous/ heterogeneous solutions.*

The students worked with different mixtures and solutions using everyday ingredients (coffee beans; sugar, water, alcohol etc.) to discover their properties. They worked collaboratively and developed a concept map to represent their knowledge in a graphic way.

One teacher talked more generally about her practice (in collaboration with a colleague)*'our method of teaching has become more experimental and less theoretical .'. (*BI)

NI emphasised the importance of play in her teaching:

> *Creativity in my opinion is natural in humans. You can only create the conditions so that you can express it freely. Play - from a pedagogical point of view – is an inexhaustible strategic key to lay the foundation of education in terms of creativity.....*

Lifelong Learning Programme

The CREAT-IT project has been funded with support from the European Commission under grant agreement 2013 – 3637 / 001 - 001

BI commented that teaching integrated science-based problems allows students to share their ideas, challenge them and find new solutions.

Responses to this question identify the following attributes of creative teaching: practical investigations and experimentation; playful and challenging approaches to learning; giving pupils opportunities to collaborate on problem solving and sharing knowledge.

2.4 Reasons for choosing the example

Interviewees were then asked to give reasons for their choice. These included the qualities of the teacher's flexibility and openness *'not working or sticking to the pre set plan… and not engaging in the standard question and answer route*' (KB). KN said '*I am not following any text book*' and MS also explained *'We work differently, we don't strictly stick to the official programme,'* KG explained: '*It was an experience where there was no prior correct solution or answer and characterized by curiosity, intuition, risk taking, developing new, uncommon, or unique ideas'*

KB describes the teacher as 'brave', suggesting that she took risks by letting pupils learn through their own *'independent learning journey which required them to engage in trial and error'*. KB said that to be creative she just needs a "*crazy little hook*" or a "*strange idea"* to get started.

So, for these teachers, a creative teacher is one that makes her own plans and decisions about how to teach. Following the text book means not only adopting a generally uncreative approach but also appears to limit or discourage learning through the kinds of practical investigative work that makes science learning relevant and motivating to pupils. Giving pupils problems, games or puzzles to solve pricks their curiosity and motivates them to learn. The playful approaches are engaging and perhaps also unthreatening, drawing them into thinking scientifically without them being aware of it. 'Novelty' and 'difference' were common words used in their responses. When pupils learn in this way they learn collaboratively and learn to communicate and discuss their ideas.

2.5 Teaching for creativity

The interviewees were able to describe and explain creative teaching (i.e. teaching creatively) and the characteristics of the teacher more easily that the idea of ' teaching for creativity'. This may be partly a language issue. A few respondents were able to give examples that relate to giving pupils space to make mistakes and to learn with and from each other:

Lifelong Learning Programme

The CREAT-IT project has been funded with support from the European Commission under grant agreement 2013 – 3637 / 001 - 001

> *We give kids the liberty of reaching the actual scientific conclusion via try and fail method; we let them attempt things on their own and also in teams of their peers*. (MS)

However, there is an important role for the teacher in supporting this way of learning:

> *..you also need to make the students feel safe so that they can take risks…. The administration ideas of teaching are completely irrelevant… good teaching happens in the space between the teacher and the student* (KN)

KN also uses feedback on her teaching, from her students, to inform her planning.

KB noted the importance of the teacher stepping into the shoes of the learner: '*You have to take yourself back to the stage of the learner and play with your lesson styles/approaches. You have to be willing to try something new yourself…'* KB used cooperative learning strategies (from www.kaganonline.com) and had learned through this that: ' t*eachers have to be prepared to let go, students can only do these things if given a space to do it, then the student is building resilience, and understand that they must not be put off if they don't succeed'*

KG 's response reflects these views and adds more:

- *Actively encouraging pupils to question, make connections, envisaging what might be possible and exploring ideas.*
- *Using failure or setbacks as opportunities to learn.*
- *Facilitating open discussion of the problems pupils are facing and how they can solve them.*
- *Asking open-ended questions such as 'What if…?' and 'How might you…?'*
- *Ensuring that assessment procedures reflect and reward creativity, enterprise and innovation.*

Thus, a combination of letting go but at the same time providing a safe environment in which to take risks and make mistakes or fail, is proposed. The teachers' role as provocateur, critic and support are all expressed here.

2.6 The value of creative teaching

All the teachers considered the values of creativity in teaching in relation to learning science but also to more generic skills and knowledge

Lifelong Learning Programme

The CREAT-IT project has been funded with support from the European Commission under grant agreement 2013 – 3637 / 001 - 001

This type of teaching has not only an educational value but also social one. It teaches you to communicate effectively among peers and to respect the ideas of others (RI)

The topics which are proposed with laboratory activities intrigue and induce reasoning and discussion , so that, with our help, the pupils slowly come to conclusions and to a better assimilation of the contents (BI)

KG summarised a broad range of positive outcomes:

Creativity improves the self-esteem, motivation and achievement of learners. Pupils who are encouraged to think creatively become more interested in discovering things for themselves and are more open to new ideas and challenge. They are more able to solve problems and can work well with others. They become more effective learners and have greater ownership over their learning.

All the respondednt believed that teachers could be taught to teach creatively and that there were really no topics that could not be taught using creative approaches, given time.

2.7 Challenges or barriers to teaching creatively

All the teachers agreed that time could be a constraint on whether to take a creative approach. Other issues were: classes that are large (although numbers were not mentioned); pressure from the prescribed curriculum and lack of support from other science teachers. MG commented that **'***If the students are not used to this kind of teaching maybe they feel that it is leisure time and the whole procedure will collapse'.* Similarly KN commented that it can be difficult '*to break (pupils') expectations of the "sage on the stage", making it valuable to be there and not just read the book, and not just to use technology'.* The difficulty of controlling pupils' excitement was also mentioned by one teacher.

2.8 Characteristics of the creative teacher

The idea that a creative teacher thinks independently and imaginatively was clearly reflected in the responses – and a strong argument is made for the motivational value for the teacher of teaching creatively:

'*I have always tried to use other practices than the much more "comfortable" ones recommended in texts …. because I believe that if the teacher does not find challenging the way in which he/she passes the "discovery of knowledge in her*

Lifelong Learning Programme

The CREAT-IT project has been funded with support from the European Commission under grant agreement 2013 – 3637 / 001 - 001

work, she will absolutely be unable to get back the pleasure necessary to bring forward her hard work every day' (MI)

KN offered these characteristics: a willingness to try out different ideas; having an element of risk; getting out of your normal comfort zone; being prepared for students to take control; and letting children be responsible for learning. She was clear that there was no necessity for the teacher to be "artistic".

2.9 In summary

A synthesis of the responses to all the questions provides the following profile of a creative science teacher:

- an independent thinker
- imaginative and experimental
- playful
- curious
- intuitive
- brave
- open
- interested in a wide range of interests
- positive
- encouraging
- confident to experiment and take risks in their teaching

They have the ability to:

- develop their own teaching approaches and plan flexibly – not following text book methods
- stand back and give space to their pupils' ideas, solutions and mistakes
- engage in genuine dialogue with learners
- work collaboratively with colleagues

The interviewees identified these characteristics of teaching creatively:

- provides regular opportunities for hands-on experimentation, problem solving, discussion and collaborative work
- actively encourages pupils to question, make connections, envisaging what might be possible and exploring ideas
- uses failure or setbacks as opportunities to learn
- facilitates open discussion of the problems pupils are facing and how they can solve them

Lifelong Learning Programme

The CREAT-IT project has been funded with support from the European Commission under grant agreement 2013 – 3637 / 001 - 001

- asks open-ended questions such as 'What if...?' and 'How might you...?'
- ensures that assessment procedures reflect and reward creativity, enterprise and innovation
- offers no prior correct solution or answer
- develops new, uncommon, or unique ideas
- uses student feedback to plan next session
- keeps trying something new, partly to find something that works better
- willingness to try out different ideas
- gets out of normal comfort zone
- is prepared for students to take control and be responsible for their learning
- enjoys the process
- teaching happens in the space between the teacher and the student
- fosters safety
- allows students to work out what is wrong with their ideas
- teacher and student can 'play around' before reaching the final answer

2.10 Observations

Five observations were carried out by members of the consortium (two in England and one in Norway, Serbia and Greece; Belgian and Italian observations were not undertaken). Teachers were chosen on the basis of availability, location and their willingness to be observed. Written consent was obtained from school principals, teachers and the parents of their pupils. Consent covered the observation itself and photographs of the classroom; students and their work. Schools, and names of students and teachers are not identified in the report (see Appendix A.ii).

The South West English lesson was undertaken with a class of 30 higher ability pupils, aged 13-14 years. The lesson was 60 minutes in length and was the penultimate lesson of a unit of work focused on modelling chemical reactions: creating a model to explain the reaction rate between Magnesium and Hydro Chloric Acid. The lesson took place in a well-resourced school science laboratory with plenty of space.

The sequence of activity involved the students sharing results from the previous lesson and plotting these on a graph. The students then fed back to each other using a variety of materials (blocks; 3D diagrams on screen) to create models of the molecules being studied. Students were engaged by this activity, dialogued with one another as they did so (for example, 'but don't we need more of these yellows?' 'No, because there are 21 atoms altogether and that's too many') - and keen to answer the teacher's questions. Their attention was maintained through the process of handling and interpreting data. As the observer put it: 'This was a period of pupils 'grappling' with translating statistics. The teacher allowed pupils to make mistakes and work through the process. Answers were not

Lifelong Learning Programme

The CREAT-IT project has been funded with support from the European Commission under grant agreement 2013 – 3637 / 001 - 001

given' (fieldnotes). The teacher used open ended questions, modelled the exploration process using the blocks but also stood back to give students time to generate their own solutions. Students were trusted to work out what resources they might need to help them in the task, rummaging through the store cupboard. In the next part of the lesson students used their mobile phones to capture images of their models and one student took the initiative to create a stop-motion animation using a programme on his mobile phone..

The observer commented that although the lesson was 'a great way to promote creativity' – models and send these to the teacher's desktop computer. Students, in pairs, were asked to 'tell the story' of how surface area affects rate of action, using the multi blocks, a white board to put them on and whiteboard pens to label the models. Students had to work together to discuss and negotiate – they made their own decisions about what resources to use. One student created a stop motion animation with the photographs (using a programme on his phone) . The teacher responded flexibly and encouragingly – giving feedback, praise and embracing new ideas. She offered encouraging evaluative feedback from general encouragement such as 'brilliant, fab' to more specific praise, ' I like the way you...' . She also reminded students' of key subject knowledge (the periodic table) and nudged them in the right direction, saying at one point, for example, 'Don't forget ONE magnesium atom sticks to ONE chlorine atom'. She also used a time countdown to ensure there was enough time for tidying away at the end of the lesson.

In this process the teacher provided space, agency and interactive technology resources to allow for creativity, including use of the arts. Students had ownership of the activity and of new understanding.

Finally the whole class evaluated the models critically . They asked questions to clarify their understanding of each others' models. The teacher asked 'What's (pupil) trying to demonstrate here?" to get pupils to grasp the scientific principles and gave feedback 'I like the way you.....? 'Students realized what they need to change through discussing together and interpreting the photos rather than through a written comment in a book. They experienced the feedback as revelation' (field notes).

The Hertfordshire English lesson took place at a high performing school judged outstanding by OfSTED. The school has been awarded National Teaching Standard status and provides outreach work to other schools in the area to develop local teachers skills. The lesson observation was conducted with an experienced male science teacher leading a class of 30 students aged between 11 and 12 years old. The one-hour lesson was the first lesson after the Easter break, therefore the teacher had not seen the class for nearly three weeks. The lesson objective was to recap previous theory and progress understanding. The teacher had a specific aim for the class, he wanted them to discover a chemical process by applying their previous knowledge and invent an experiment that would separate two chemicals. The

Lifelong Learning Programme

The CREAT-IT project has been funded with support from the European Commission under grant agreement 2013 – 3637 / 001 - 001

teacher discussed with the observer before the lesson about the dilemma he faced, there was one correct way he wanted the class to conduct the experiment but he did not want to tell the class how to do it, he wanted them to discover it for themselves. When probed further about what he would do if a pupil came up with another suggestion, he conceded that he was not sure what he would do as ultimately the pupils needed to understand how to conduct the experiment a certain way.

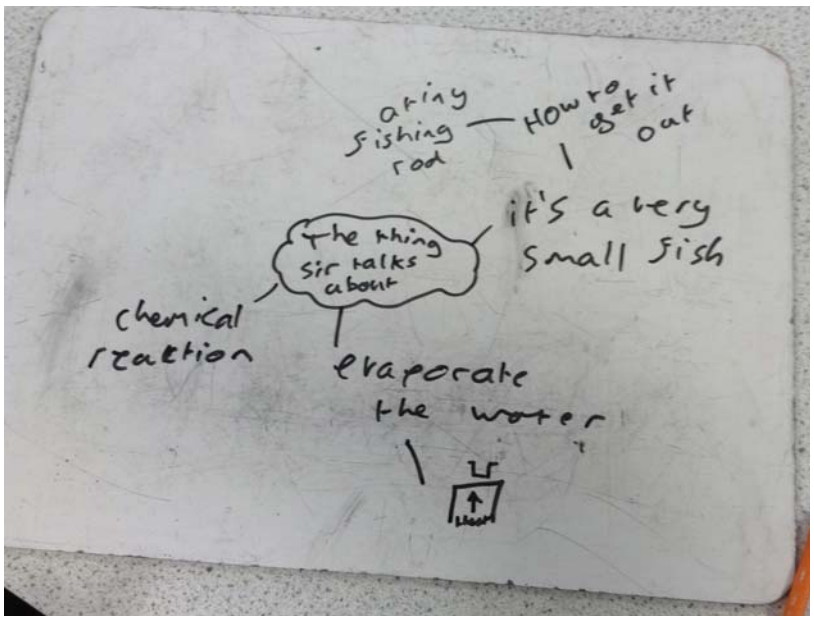
The room was set up with equipment on the benches: white boards, pens, chemicals, small ceramic basins and plastic measuring cylinders. The lesson began with a strict instruction from the teacher to close all exercise books and pack away any equipment. The class were then told to look at the image displayed on the interactive white board and write down everything they knew about the image. The pupils immediately grabbed the boards and pens and began discussing ideas with their partner. Pupils were keen to then feed back their collaborative ideas to the class teacher. At no point did the teacher correct the students' answers, if they gave a fact the teacher would ask the class if the fact given was correct, encouraging the pupils to respond to the statements being made. He was empowering the class by encouraging dialogue between students.

The class teacher then made a clear statement that he was not going to share the lesson objectives with the class until the end of the lesson so that pupils had "freedom of thinking". This demonstrated the teacher's professional wisdom and provided pupils with multiple possibilities as they developed their knowledge of chemical processes. It also demonstrated that the teacher trusted his pupils to discover the answers. Even if he wanted them to discover the one correct answer the pupils were given the freedom and agency to get the answer in their own way, they were developing knowledge through bottom up processes around a shared thread of knowing.

The class were instructed to devise their experiment, the pupils immediately began drawing out their ideas. The observer noted that they had all drawn the same experiment. The teacher had constructed an environment for the pupils to feel secure and empowered to prepare the possibility of their own ideas, and yet the pupils did not actually do this, they all prepared the same answer, with the correct technique and although they achieved the teacher's aim he appeared deflated that no one had suggested a different way to do this. Apart from one pair of boys who suggested that basin could contain a small fish, and that a tiny fishing rod would be needed to catch the fish, but they also prepared the correct answer alongside their alternative suggestion.

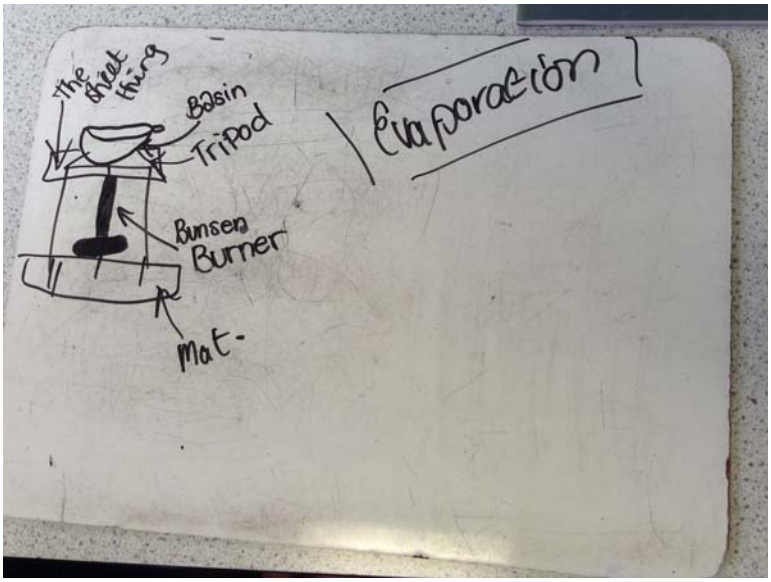
Lifelong Learning Programme

The CREAT-IT project has been funded with support from the European Commission under grant agreement 2013 – 3637 / 001 - 001



(Figure 1) Two pupils' alternative suggestion

The class were then instructed to set up and conduct the experiment, again the teacher did not tell them how to do it, he displayed one of the pupils' answers on the interactive whiteboard for the class to follow.



(Figure 2) One pupil's correct suggestion

Once again he empowered the pupils and used a suggestion from the class to explain how to set up the experiment.

The CREAT-IT project has been funded with support from the European Commission under grant agreement 2013 – 3637 / 001 - 001

The class conducted the experiment and discovered that by heating the chemicals the liquid evaporates and salt is left behind in the basin, thus they had separated two chemicals. The teacher asked the class to apply this knowledge to come up with a useful reason for conducting this experiment. The pupils were immediately immersed again into discussing ideas and began writing their collaborative suggestions on the white boards.

The lesson observed demonstrated a creative science teacher working in the classroom, the teacher provided the class with lots of opportunity to develop their own ideas and construct their knowledge. Throughout the pupils were keen and immersed in the subject matter.

The Serbian lesson took place in a gymnasium (for higher abilities) with a class of 27 15 and 16 year olds. The topic of the lesson was 'Algae' and this was the first of two lesson on this subject. The lesson was 45 minutes in a well equipped laboratory classroom (the equipment largely provided through donations from parents). Posters with images and information covered the walls.

The lesson 'wasn't a regular class' - giving students in advance preparations' for their own presentations on the topic. Two groups of students each gave a talk to the class about algae – they used the computer; projector; video and drawings on the white board. A third group devised a quiz - with prizes of cakes made in the different shapes of algae. The quiz was designed to help students in remembering important issues and connections. A fourth group sang a rap which they had prepared about algae.

The activities promoted an interdisciplinary approach to learning and encouraged creative ways to present information and ideas. However, the work had been done outside of the class (as homework) and that the focus was on presenting lesson content rather than engaging students in new learning during the lesson.

The group work encouraged collaboration and the teacher supported the students through a combination of standing back and interventions: underlining interesting facts, making connections, questioning to promote critical thinking and correcting errors in knowledge.

The Greek lesson involved a group of 25 students aged 14, in an ICT lab, sitting two to a computer working on a digital problem-solving task. During this forty-five minute lesson, which came just before the half-way poin of a unit of work, the teacher presented his expectations of the students, then invited one student to model what might be done. The class as a whole engaged in critical reflection on this student's activity offering evaluative comments before each pair undertook their own work, finishing the lesson by running through and evaluating their own construction. The pedagogical strategies involved ensuring students understood the task at hand, and encouraging shared critical reflection

Lifelong Learning Programme

The CREAT-IT project has been funded with support from the European Commission under grant agreement 2013 – 3637 / 001 - 001

before expecting paired problem-solving. The teacher offered time and space for students to do this but did not step forward evaluatively or to 'meddle in the middle' of their thinking.

The Norwegian lesson focused on the Solar System and involved a mixed ability group of nine 11-12 year olds (half of the class). The lesson took place in a standard open plan classroom. It was a final 'summary' lesson with their teacher, following several lessons taught by student teachers. The activities were aimed at ensuring that the students had learned the names of the planets in order followed by: learning facts about the planets through class discussion with an interactive smartboard presentation, and reading; and drawing the solar system.

The teacher led the activities devising some imaginative ways to sustain interest in what were effectively 'drills' 'finding clever ways to learn by heart' (fieldnote comment), for example chanting the list of the planets. Students generally enjoyed the activities and remained attentive and engaged although during the book research segment of the lesson there was some drop in concentration and focus.

2.11 Summary

The lesson observed in England reflects the most extensive use of teaching for creativity. The structure and activities of the lesson centred on the students solving problems and generating novel ways to present their understandings and ideas. In the Serbian lesson the creativity had been applied to students' independent study – and in many ways they had engaged with similar activities to the UK lesson but with less observable mediation and support from the teacher. This was also the case with the Greek lesson, where students were following a task in pairs and evaluating it, but with little scaffolding and evaluation from the teacher whilst they worked. The Norwegian lesson reflected teaching creatively rather than teaching for creativity.

Teachers used a range of strategies and roles during the lessons: standing back; facilitating; instructing and informing; asking open questions and encouraging discussion; trusting students to look for appropriate resources to answer their questions, encouraging, reminding, guiding and feeding back. In the UK lesson the teacher worked flexibly to encompass students' ideas and to give the space to develop their own responses to the task. This was also true of the Serbian teacher who had given students choice and ownership of their learning in preparing their presentations. All three teachers were concerned to ensure that factual scientific knowledge is accurate and understood, and that students can connect their learning to other relevant knowledge and understanding.

The teachers all used practical tasks and provided a range of resources. All the lessons included different forms of representation and communication (capturing and labelling still images; making stop motion animation; 3D modelling; drawing; raps, chanting and games).

Lifelong Learning Programme

The CREAT-IT project has been funded with support from the European Commission under grant agreement 2013 – 3637 / 001 - 001

National differences perceived in these observations may have reflected observer focus and familiarity with science classrooms, as much as actual differences in pedagogy. However this small selection of lesson observations does highlight the potential for teaching for creativity to turn out to be a creative teaching approach, which does not engage children thinking creatively about the science, and the danger of stepping back so far from students that they are not necessarily prompted, scaffolded, challenged, or encouraged in their scientific thinking.

2.12 The CREAT-IT Creative Science Teacher characteristics and role

From the analysis of the survey, interviews and observations, the following creative science teacher role has emerged:

Characteristics: the creative science teacher is:

- constantly developing – endeavouring to reflect, build principles and explore practice
- cupil focused and led – co-construction, pupil agency and high expectations
- emotionally connected – to the pupils and the work
- motivated through prioritising and facilitating creative teaching as a pedagogical approach
- collaborating with peers and pupils - in idea generation, support, high level outcomes
- seeking experience, including in the arts – both professionally through training and personally
- confident to take risks
- playful and flexibile
- independent

The creative science teacher adopts many roles in the course of their teaching:

- Instructor and demonstrator
- Guide and advisor
- Knowledgeable expert
- Observer
- Co-constructor
- Collaborator
- Researcher
- Resource manager
- Assessor, critic

Through the theoretical framework provided by D2.1 and the small scale research exercises undertaken for D2.2 it can be concluded that there is a broad consensus about the

Lifelong Learning Programme

The CREAT-IT project has been funded with support from the European Commission under grant agreement 2013 – 3637 / 001 - 001

importance of creativity in science education and what makes a creative science teacher. National differences are most significant in relation to policy, the culture of schooling and economic constraints. In developing the programme of training activities for this project, it is important to have a good understanding of the contexts in which teachers work, their concerns and aspirations. Professional development for teachers, although recognised as important in all the consortium countries, is provided and managed differently by them and the project's training workshops will need to be designed to be relevant to local conditions as well as model those characterisitics of creative teaching that have been so amply described here.

The CREAT-IT project has been funded with support from the European Commission under grant agreement 2013 – 3637 / 001 - 001

3. Reference List

Chappell, K. & Craft, A. (2011) Creative learning conversations: producing living dialogic spaces, *Educational Research*, 53:3, 363-385

Chappell, K., Rolfe, L., Craft, A., & Jobbins, V. (Eds) (2011) *Close Encounters: Dance Partners for Creativity*. Stoke on Trent: Trentham Books

Craft, A.R. (1998). UK Educator Perspectives on Creativity. *Journal of Creative Behavior*, 32(4), 244-257.

Cremin, T., Chappell, K. & Craft, A. (2013) Reciprocity between narrative, questioning and imagination in the early and primary years: Examining the role of narrative in possibility thinking, *Think Skills and Creativity,* 9, 135 – 151

Eisner, E.W. (2004) What Can Education Learn from the Arts about the Practice of Education? *International Journal of Education and the Arts,* 5:4, 1-12

Kochhar, C., West, L., & Taymans, J. (2000). *Successful inclusion: practical strategies for a shared responsibility*. Columbus: Prentice-Hall, Inc.

The CREAT-IT project has been funded with support from the European Commission under grant agreement 2013 – 3637 / 001 - 001

4. Appendices

A.1 Full results from online survey

This section reports the findings from the survey entitled 'Creative approaches in Science education - CREAT-IT survey' which ran from 31st Jan to 21st February 2014. The findings (both quantitative and qualitative) are reported question by question in 5 sections: Demographics; questions for all; questions for consortium members; questions for general teachers; questions for teachers with experience of a specific approach.

Lifelong Learning Programme

The CREAT-IT project has been funded with support from the European Commission under grant agreement 2013 – 3637 / 001 - 001

	Role									
Country	CREAT-IT Consortium member	CREAT-IT Consortium member/ teacher	Scientist	Scientist/ teacher	Curriculum developer	Curriculum developer/ teacher	General teacher	Teacher with experience of approach	Not specified	Total
Belgium				2			2			4 (3.1%)
Greece		2		5		1	2	3	1 (researcher)	14 (10.7%)
Italy	3		1	11		1	9	3		28 (21.5%)
Norway	1	1	2	5			2	1		12 (9.2%)
Serbia	7		1	4		6	5	2	2 (1 'science communicator'	27 (20.8%)
UK	2			13	1	11	18			45 (34.6%)
Total	13 (10%)	3 (2.3%)	4 (3.1%)	40 (30.8%)	1 (0.8%)	19 (14.6%)	38 (29.2%)	9 (6.9%)	3 (2.3%)	130

(Table 1) Demographics – roles and countries represented

Lifelong Learning Programme

The CREAT-IT project has been funded with support from the European Commission under grant agreement 2013 – 3637 / 001 - 001

Table 1 Number of responses by country of residence and role

130 valid questionnaires were received.

The UK has the greatest number of participants, accounting for a third of the total. People from Italy and Norway each accounted for a fifth of the participants, and Greece and Norway accounted for 10% apiece of participants. Only 4 responses were received from Belgium.

The majority of respondents have some experience of teaching, 84% of those surveyed are or have been teachers. 34% are scientists, 15 % are curriculum developers and 12% are members of the CREAT-IT Consortium. Only 7% selected that they have had experience of a specific creative science approach.

Questions for ALL, irrespective of role (n=130):

This is the first set of questions, which all participants were asked, regardless of role. In some places, due to the over-representation of UK participants, and under-representation of participants from Belgium, these two countries have been removed from the analysis (where this is occurred it will be clearly indicated).

Questions asked:

1/ This project defines creative science as generating alternative ideas and strategies within scientific enquiry as an individual or community, and reasoning critically between these. Do you agree with this definition of creative science?

2/ Creative science is driven by creativity in relation to everyday or 'little c', where children engage in purposive, imaginative activity generating outcomes that are original and valuable in relation to themselves. Do you agree with this definition of everyday creativity?

3/ What do you define as 'good practice' in terms of creativity in science education? (list of 8 items)

4/ Please indicate your views on the importance of the following purposes of fostering creativity in science through education. (Rating scale: 0 – 'not at all an important purpose' to 4 – 'a highly important purpose') (6 items)

5/ Which of these teaching approaches do you consider as MOST LIKELY to contribute to the development of children's CREATIVITY in science- Choose up to three answers. (16 items)

6/ What do you think might be barriers to creative science teaching in your country? (list of 8 items)

Analysis:

Lifelong Learning Programme

The CREAT-IT project has been funded with support from the European Commission under grant agreement 2013 – 3637 / 001 - 001

1/ ***This project defines creative science as generating alternative ideas and strategies within scientific enquiry as an individual or community, and reasoning critically between these. Do you agree with this definition of creative science?***

Agree with definition – 112 (86.2%)
Disagree with definition – 9 (6.9%)
No answer – 9 (6.9%)
Of those that disagreed with the definition, 3 were from Italy, 2 from Greece, 2 from the UK, and 1 apiece from both Norway and Serbia. Those that gave no answer to the question, 5 were from the UK, and 1 person apiece from Greece, Italy, Norway and Serbia.

The definition of creative science was agreed with for various reasons:

- teachers **create** new, alternative ways for their students to "see" and perceive the science. At the same time, students become more creative, they **develop** their thinking, their imagination and they learn how to **observe and interact** with everyday phenomena in nature and science. (Greek teacher with experience of creative science projects)
- to be creative is to be alternative (Greek teacher)
- science should not only discover, but **create** culture (Italian scientist/teacher)
- no **development** can be achieved without creative thoughts. Sound development should at the same time be based on **critical** scientific tests of the ideas behind. (Norwegian scientist)
- this kind of approach triggers more durable and functional knowledge (Serbian scientist/teacher)
- alternative ideas are very important and so are creative ways of presenting and interpreting through **critical reasoning**
- science should engage children in possibilities whilst broadening their experience and understanding of scientific concepts through **collaborative exploration**.
- it acknowledges **divergence and convergence**, **openness and criticality** within the domain of science (consortium member uk)
- to **develop** ideas and think about scientific concepts, pupils need to be creative thinkers (Uk curr dev/teacher)

The definition was disagreed with because:

- creative science is 1)creating **new fields** of knowledge, 2) reasoning science using new interpretations, applications or situations. (Greek teacher)
- while being consistent with the classical definition of creative processes, it **reduces** the concept to ideal process, **omitting** the experimental field of the body and materials, which are essential to every human creative process (Italian Curriculum developer/ teacher)

Lifelong Learning Programme

The CREAT-IT project has been funded with support from the European Commission under grant agreement 2013 – 3637 / 001 - 001

- scientific inquiry should be creative, but science teaching needs creativity. Using inquiry as a teaching method does generate alternative ideas (Norwegian scientist/teacher)
- the problem with the definition lies not mainly in the term "creativity" but in the use of the term **inquiry**, which might have various definitions and connotations (Norwegian scientist/teacher)
- it does not **generate** alternative ideas, but relative experiences (Uk curr dev/teacher)
- it does not mention the development of practical skills. Uk curr dev/teacher

Whether agreeing or disagreeing, there were general reminders and suggestions made. There was a reminder that creative science is not a new idea. (Belgium Scientist/teacher) and also that chemistry plays a controversial role in daily life; a new approach may be very helpful in order to reduce its negative perception. (Italian scientist/teacher). It was suggested that there could be more commitment to the possibility of involving the arts in the definition of the term (Norwegian consortium member). The definition could also include alternative ways of interpretation and explanations of "scientific" facts. (Serbian teacher) It was mentioned that the definition is not very accessible for teachers. (Uk curr/developer/teacher). And more globally, it was felt that critical thinking has to be a starting point for education in the 21st century. (CREAT-IT Consortium member Serbia).

2*/ **Creative science is driven by creativity in relation to everyday or 'little c', where children engage in purposive, imaginative activity generating outcomes that are original and valuable in relation to themselves. Do you agree with this definition of everyday creativity?***

Agree with definition – 113 (86.9%)
Disagree with definition – 6 (4.6%)
No answer – 11 (8.5%)
Of those that disagreed with the definition, 3 were from the UK, 2 from Italy and 1 from Norway, 4 respondents from the UK gave no answer to the question, and 2 respondents each from Italy, Norway and Serbia. 1 respondent from Greece gave no answer.
The definition of everyday creativity was agreed with for various reasons:

- imaginative activities **inherently generate** outcomes that are valuable (Belgium scientist/teacher)
- this is how students understand how science is **applied in the real world** (Greek teacher with experience of a specific creative science project/resource)
- it acknowledges that creativity in everyday classroom science involves **curiosity**, and the **generating** of original outcomes in relation to learners. (Uk consortium member)
- such an engagement moves your brain and your **personality** (Italy general teacher)

Lifelong Learning Programme

The CREAT-IT project has been funded with support from the European Commission under grant agreement 2013 – 3637 / 001 - 001

- through various explorations that are connected with **everyday phenomena and processes**, children can grasp and understand the things that surround them with ease (Serbian curr dev/teacher)
- it makes the important distinction between something **original to the child** and something **original to science** (Uk curr dev/teacher)
- this kind of working creatively (**exploring and manipulating** the world around them) helps to provide a context that helps in the **understanding** of concepts and **enquiry skills**. (uk gen teacher)
- it enables children to **explore and experience** science in a **non-threatening** way and is not teacher or adult directed (Uk gen teacher)
- it is about children **making sense of world for themselves** (Scientist/teacher)
- it relies on **individual** curiosity (Italy teacher)

The definition of everyday creativity was disagreed with on two counts: it was seen as a **vague** definition, referring **exclusively** to imaginative processes (Italian teacher) and if the outcomes are original they will be **out of context** to the children (UK curr developer/teacher)

Those that did agree with the definition also offered reminders and suggestions:

- add "with their **bodies**" within the definition (CREAT-IT Consortium member/ teacher Greek)
- science should relate to **everyday life**; children should see and be able to **match up experiences** in real life with learning (uk curr dev/teacher); creativity has to be expressive of be expressed by **everyday life**; topics have to be related to the children's **interests** (Greek scientist/teacher)
- everyday creativity should be a **mixture** of science and **play** (Serbian consortium member)
- science has to be relevant to the child and fall within their **zone of experience** or relevance. (Uk gen teacher)
- **playing** is fundamental to creativity (Norway scientist/teacher)
- using creativity allows children to feel free to explore and question **without boundaries** (Uk gen teacher)
- the core of science is **curiosity** (Serbian general teacher)
- it includes **meaningfulness to oneself**, **playfulness** and **joy**; the feeling of focusing on needs and **passions** within a **secure/safe** place (inner or outer) from whence explorations can start (Greek curr dev/teacher)

3/ What do you define as 'good practice' in terms of creativity in science education? *(A list of 8 items)*

Lifelong Learning Programme

The CREAT-IT project has been funded with support from the European Commission under grant agreement 2013 – 3637 / 001 - 001

Inquiry based learning and learning that is connected to the real world are seen as key examples of good practice. Offering children empowerment and agency; story-telling; and risk, immersion and play are seen by fewer people as examples of good practice.

The CREAT-IT project has been funded with support from the European Commission under grant agreement 2013 – 3637 / 001 - 001

Good practice	Number and % of 130 respondents who selected YES	Good practice (when UK and Belgium removed)	Number and % of 81 respondents who selected each item
Inquiry based learning	99 (76.2%)	Inquiry based learning	54 (66.7%)
Connected to the real world	90 (70.0%)	Connected to the real world	51 (63.0%)
Individual/collaborative/ communal learning	81 (62.3%)	Using the Arts to shed new light	51 (63.0%)
Cross-curricular learning	81 (62.3%)	Individual/collaborative/communal learning	43 (53.1%)
Using the Arts to shed new light	77 (59.2%)	Cross-curricular learning	43 (53.1%)
Risk, immersion, play	68 (52.3%)	Storytelling	34 (42.0%)
Storytelling	56 (43.1%)	Risk, immersion, play	31 (38.3%)
Offering children empowerment and agency	53 (40.8%)	Offering children empowerment and agency	26 (32.1%)

(Table 2) Good practice in terms of creativity in science education, ranked from MOST selected to LEAST selected

The place of using the Arts to shed new light; cross-curricular learning; individual, collaborative and communal learning; risk, immersion and play; and storytelling vary according to whether the UK and Belgium are included in the analysis or not. This variation is relatively small – a difference of between 1.1% - 14%.

Lifelong Learning Programme

The CREAT-IT project has been funded with support from the European Commission under grant agreement 2013 – 3637 / 001 - 001

Belgium (4)	Greece (14)	Italy (28)	Norway (12)	Serbia (27)	UK (45)
Cross-curricular learning (3) Individual/collaborative/ communal learning(3) Using the Arts to shed new light (3) Risk, immersion, play(3) Storytelling(3)	Cross-curricular learning (11) Using the Arts to shed new light	Inquiry based learning (18) Connected to the real world	Inquiry based learning (10) Using the Arts to shed new light	Connected to the real world (22)	Inquiry based learning (43)
	Inquiry based learning (10) Individual/collaborative/ communal learning (10)	Using the Arts to shed new light (17)	Individual/ collaborative/ communal learning (8%)	Inquiry based learning (16)	Connected to the real world (38)
	Storytelling (9)				Cross-curricular learning (35) Individual/ collaborative/ communal learning
					Risk, immersion, play (34)

(Table 3) Each country's MOST selected items (selected by 60% or more of responses per country.)

When each countries most selected items (being selected by 60% or more of the respondents from each country) are collated, the patterns above are reinforced. Inquiry based learning is selected by more than 60% of participants in 5 countries (only Belgium has less than 60% of participants selecting it, this could be due to Belgium's extremely low participant number). Using the Arts to shed new light and individual, collaborative and communal learning are selected by more than 60% of participants in 4 countries (only Serbia and the UK neglect to select the former as frequently; and Italy and Serbia the latter). Learning that is connected to the real world and cross-curricular learning are selected by more than 60% of participants, in Italy and Serbia for the former, Belgium and Greece for the latter, and the UK for both.

Lifelong Learning Programme

The CREAT-IT project has been funded with support from the European Commission under grant agreement 2013 – 3637 / 001 - 001

It is interesting to note that the item about offering children empowerment and agency is the only item not to appear at all in table 2, being selected by only 40.8% of respondents. It was selected as good practice however by 55.6% of participants from the UK, and half of the respondents from both Belgium and Greece. Just over 40% of respondents from Serbia and Norway selected it as good practice. It was seen as good practice by 10.7% of those from Italy.

Additional definitions offered by participants:

- students should be **encouraged** to make **conclusions** and definitions about the knowledge that it is gathered and **apply to similar problems** and subjects/innovate something (Greek scientist/ teacher)
- **person-to-person** relations alongside a philosophical and epistemological **grounding** in science learning (Greek Curriculum developer/ teacher)
- **peer discussion**, **consideration** of ideas different from their own (Italy general teacher)
- **self-awareness, personal engagement** with subject matter, good guidance, resourceful (teacher Norway)
- it is not so much what you do, as **how you do it**. (Norway Scientist); good practice doesn't pertain to WHAT you do but **HOW you do** whatever you do (Norway Scientist/ teacher)
- **inspirational** teachers (UK Scientist/ teacher)
- using **any form** to develop originality (UK Curriculum developer/ teacher)

4/ Please indicate your views on the importance of the following purposes of fostering creativity in science through education. (Rating scale: 0 – 'not at all an important purpose' to 4 – 'a highly important purpose') (6 items)

The statements with the highest means, and thus are thought to be important purposes of fostering creativity in science through education are:

- To enrich the understanding and interaction with phenomena in nature and technology
- To develop more innovative thinkers
- To develop positive attitudes to science.

The statements with the lowest means, and could be seen as less important purposes, are:

- To develop important attitudes and dispositions as a foundation for future learning
- To provide a foundational education for future scientists and engineers

(It should be pointed out however, that the mean values for each statement are very similar, ranging between 3.24 – 3.62 out of a possible 4.)

Lifelong Learning Programme

The CREAT-IT project has been funded with support from the European Commission under grant agreement 2013 – 3637 / 001 - 001

Purposes of fostering creativity in science through education	Number, Mean (s.d.)	Rating scale	Frequency
To enrich the understanding and interaction with phenomena in nature and technology	N=127, 3.62 (0.59)	2	7
		3	34
		4	86
To develop more innovative thinkers	N=130 3.55 (0.86)	0	3
		1	3
		2	4
		3	30
		4	90
To develop positive attitudes to science	N=126, 3.54 (0.89)	0	3
		1	3
		2	7
		3	23
		4	90
To develop socially and environmentally aware and responsible citizens	N=130, 3.48 (0.85)	0	3
		1	1
		2	9
		3	35
		4	82
To provide a foundational education for future scientists and engineers	N=128, 3.39 (0.88)	1	7
		2	13
		3	31
		4	77
To develop important attitudes and dispositions as a foundation for future learning	N=130, 3.24 (0.97)	0	5
		1	1
		2	16
		3	44
		4	64

Lifelong Learning Programme

The CREAT-IT project has been funded with support from the European Commission under grant agreement 2013 – 3637 / 001 - 001

(Table 4) the importance of the following purposes of fostering creativity in science through education, ranked from highest mean to lowest.

When each statement is ranked in order of means for each country, Greece and Italy's highest mean is 'To enrich the understanding and interaction with phenomena in nature and technology'. Belgium, Norway, Serbia and the UK's highest mean is for 'To develop more innovative thinkers'. 4 of the 6 countries had the lowest mean for the statement 'To develop important attitudes and dispositions as a foundation for future learning' – Greece, Norway, Serbia and the UK. Belgium and Italy's statement with the lowest mean is 'To provide a foundational education for future scientists and engineers'.

A multi-variable cross-tabulation was carried out to see if there was a significant relationship between the rating of a statement and the country. There is demonstrable association between two items. For the item 'To enrich the understanding and interaction with phenomena in nature and technology' 56% of the cells have an expected value less than five so Fisher's Exact probability was used. This gave p=0.026. The value of Cramer's V was 0.274, showing that 8% of the variation in the rating of purpose can be explained by country. Another item, 'To provide a foundational education for future scientists and engineers' 67% of the cells have an expected frequency of less than 5, thus Fisher's Exact probability was used, giving p=0.008. Again, the value of Cramer's V was relatively low - 0.266, showing that only 7% of the variation in the importance of purpose can be explained by country.

Lifelong Learning Programme

The CREAT-IT project has been funded with support from the European Commission under grant agreement 2013 – 3637 / 001 - 001

5/ Which of these teaching approaches do you consider as MOST LIKELY to contribute to the development of children's CREATIVITY in science- Choose up to three answers. (16 items)

Teaching approaches most likely to contribute to development of children's creativity in science.	**Number and % of 130 who selected each item**
Encouraging children to try out their own ideas in investigations	69 (53.1%)
Relating science to everyday life	61 (46.9%)
Encouraging different ways of recording and expressing ideas	57 (43.8%)
Encouraging problem finding – e.g. children asking questions	55 (42.3%)
Encouraging observation and making connections	50 (38.5%)
Encouraging problem solving defined by children	50 (38.5%)
Fostering imagination	46 (35.4%)
Fostering classroom discussion and evaluation of alternative ideas	44 (33.8%)
Encouraging reflective, reasoned conclusions based on evidence	40 (30.8%)
Building on children's prior experiences	34 (26.2%)
Using questioning as a tool in science teaching	28 (21.5%)
Using digital technologies with children for science teaching/learning	28 (21.5%)
Encouraging problem solving defined by teacher	27 (20.8%)
Fostering collaboration	20 (15.4%)
Attending carefully to what pupils say and do	17 (13.1%)
Fostering students' agency	6 (4.6%)

(Table 5) Teaching approaches most likely to contribute to development of children's creativity in science, ranked from MOST selected to LEAST selected

Lifelong Learning Programme

The CREAT-IT project has been funded with support from the European Commission under grant agreement 2013 – 3637 / 001 - 001

The four teaching approaches most likely to contribute to the development of children's creativity in science are:

- Encouraging children to try out their own ideas in investigations (more than half of participants selected this)
- Relating science to everyday life
- Encouraging different ways of recording and expressing ideas
- Encouraging problem finding –e.g. children asking questions

Encouraging children to try out their own ideas in investigations was the item with the most selections from the UK and Serbia, the second most selected item by Belgium, Italy and Norway, and the third most selected item by Greece. Relating science to everyday life was the most selected item by Italy, the second most selected item by Belgium, Greece and Serbia, and the third most selected item by Norway and the UK.

Some of the variation in one of the items can be said to be explained by country. A cross-tab analysis shows that 'Encouraging problem finding' has a chi-squared value of 11.747, an associated probability value of p=0.038, df 5. Cramer's v was 0.301, thus 9% of the variation in the choice between yes and no can be explained by country.

The four teaching approaches thought least likely to contribute to the development of children's creativity in science are:

- Fostering students' agency
- Attending carefully to what pupils say and do
- Fostering collaboration
- Encouraging problem solving defined by teacher

Only 4.6% of respondents selected 'Fostering students' agency' as likely to result in the development of children's creativity. No-one from Belgium, Italy or Norway selected it; one person from Greece did, as did two from Serbia. 3 UK based respondents selected it. No one from Belgium, 1 person from Italy and 2 people from Serbia selected 'fostering collaboration' as a teaching strategy likely to result in the development of children's creativity.

Lifelong Learning Programme

The CREAT-IT project has been funded with support from the European Commission under grant agreement 2013 – 3637 / 001 - 001

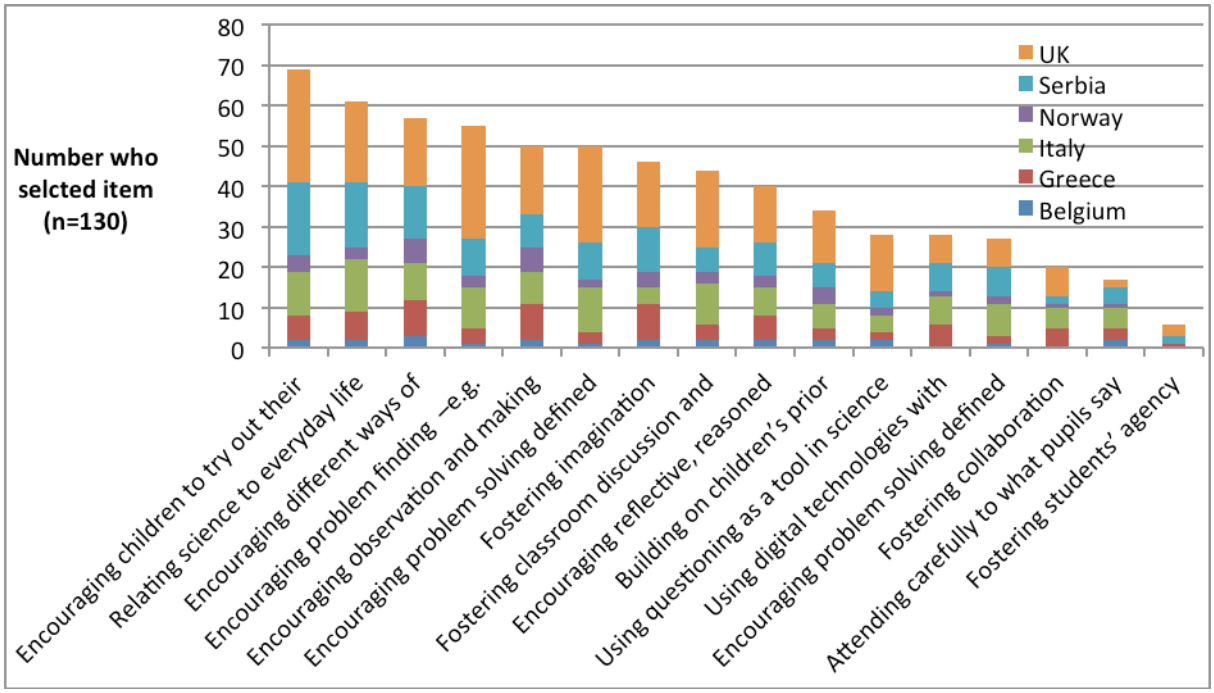


Figure 1. Graph to show number who selected teaching approaches most likely to contribute to development of children's creativity in science from each country

6/ What do you think might be barriers to creative science teaching in your country? (A list of 8 items)

The order of items varied by country. Time was selected by the majority of UK participants as the biggest barrier to creative teaching – 89% of the 45 UK participants selected time. Greece also selected time as the biggest barrier, 79% of the 14 Greek participants selected this item. 50% of participants from Italy also selected time as a barrier, this was the second most selected item by participants from Italy.

It may be that the UK, with its large sample size, and Belgium, with its extremely small sample size may be skewing findings. When they are removed from the analysis, the order of the list changes.

The CREAT-IT project has been funded with support from the European Commission under grant agreement 2013 – 3637 / 001 - 001

Barrier	Number and % of 130 respondents who selected each item	Barrier (when UK and Belgium removed)	Number and % of 81 respondents who selected each item
Time	79 (60.8%)	Teacher training approaches	52 (64.2%)
Curriculum constraints	71 (54.6%)	Resources	44 (54.3%)
Resources	69 (53.1%)	Teacher motivation	39 (48.1%)
Teacher training approaches	66 (50.8%)	Time	38 (46.9%)
Teacher motivation	52 (40%)	Curriculum constraints	33 (40.7%)
Teacher confidence	42 (32.3%)	Teacher confidence	21 (25.9%)
Others' opinion on how science in school should be taught	31 (23.8%)	Others' opinion on how science in school should be taught	20 (24.7%)
Pupil motivation	24 (18.5%)	Pupil motivation	16 (19.8%)

(Table 6) Barriers to creative science teaching ranked from MOST selected to LEAST selected

There is a significant association between the variable of time and country. When a crosstab analysis was run, using Fisher's exact probability, p=0.000. The value of Cramer's v was 0.505, showing that just over a quarter of the variation in frequencies of those choosing this as a barrier can be explained by country.

Curriculum constraints is another item where variation can be explained by country. Pearson's chi-squared value of 28.691 with an associated probability of p=0.000, df 5, gives a Cramer's V of 0.470, thus 22.1% of the variation can be explained by country.

In terms of the item 'Teacher motivation', significant variation appears again, Fisher's exact probability is p= 0.001, the value of Cramer's v=0.384, meaning that just under 15% of the variation in selecting yes or no for this item can be explained by country.

Lifelong Learning Programme

The CREAT-IT project has been funded with support from the European Commission under grant agreement 2013 – 3637 / 001 - 001

Belgium (4)	Greece (14)	Italy (28)	Norway (12)	Serbia (27)	UK (45)
Teacher motivation (3)	Time (11)	Teacher training approaches (18)	Teacher training approaches (8)	Teacher motivation (19)	Time (40)
Teacher training approaches (2)	Teacher training approaches (9)	Time (11)	Teacher confidence (7)	Resources (19)	Curriculum constraints (36)
Curriculum constraints (2)	Resources (9)	Teacher motivation (11)	Resources (6)	Teacher training approaches (17)	Resources (25)

(Table 7) Each country's MOST selected items (Top 3, which account for 50% or more of country's selection)

When each country's most selected items are listed (those selected by 50% or more of the respondents from each country), the following patterns can be seen: **teacher training approaches** are seen as the biggest barrier to creative science teaching - all countries mention it as a barrier (though only 27% of UK participants do so); **resources** - all countries except Belgium and Italy mention it as a barrier; **time** (seen as a barrier by more than 50% of respondents from Greece, Italy and the UK); **teacher motivation** (seen as a barrier by Belgium, Italy and Serbia); **curriculum constraints** (seen as a barrier by 50% or more of respondents from the UK and Belgium); **teacher confidence** (only seen as a major barrier by the respondents from Norway).

Others' opinion on how science in school should be taught and pupil motivation are **not** seen as a major barrier by any country. However, 42.9% of Greek respondents did select others' opinion on how science in school should be taught as a barrier, (whereas no one in Belgium selected it as a barrier). A quarter of the participants from Italy selected pupil motivation as a barrier, whereas other countries select this item less (in fact no-one in Norway or Belgium select it as a barrier).

Other barriers suggested by participants:

Lifelong Learning Programme

The CREAT-IT project has been funded with support from the European Commission under grant agreement 2013 – 3637 / 001 - 001

- a lack of experiential education for teachers (watching and then practising a creative teaching lesson before applying it to their class) so they can use it effectively
- not being able to grow a creative science teaching culture to students from the first day at school. Introduced suddenly, it can be seen as an escape from the pressing studying program and the attempt may well collapse. (Greece Scientist/ teacher)
- teachers understanding science as knowledge without any relation to well-being (Greece CREAT-IT Consortium member/ teacher)
- lack of scientific culture at all levels (including teachers and family) (Italy Scientist/ teacher)
- teachers' own education (Norway teacher with experience of a specific creative science project/resource)
- school culture (Norway Scientist/ teacher)
- tradition (UK scientist/ teacher)
- increased emphasis on assessment/testing (UK general teacher)
- class size (UK general teacher)
- timetabling and content-based national curriculum (UK curriculum developer/ teacher)
- fear of inspection (UK CREAT-IT Consortium member); inspection (UK CREAT-IT Consortium member)

Questions for ALL except TEACHERS AS SOLE ROLE, (Consortium members, scientists, curriculum developers and none stated) (n=83, UK 27, Serbia 20, Italy 16, Norway 9, Greece 9, Belgium 2):

This set of questions was directed to consortium members, scientists, curriculum developers and those who gave no role. The questions were related more to national strategies and policies, rather than school level detail.

1/ To what extent do you think national level governmental policy promotes creativity in science education in your country? (5 items) (Scale from -5 [strongly prevents creativity in science], through 0 [no effect], to +5[strongly promotes creativity in science])
2/ Please name any policy documents that promote creativity in science education in your country or region. [List complied, passed on to team].
3/ To what extent do you think current national level strategies promote creativity in science education- (This could be strategies from non-governmental organisations). (Scale from -5 [strongly prevents creativity in science], through 0 [no effect], to +5[strongly promotes creativity in science])
4/ Please name any national strategies that promote creativity in science education in your country or region. [List complied, passed on to team].
5/ Which of these approaches do you see as creative science teaching- Please select the three you think are most important. (list of 16 items)

Lifelong Learning Programme

The CREAT-IT project has been funded with support from the European Commission under grant agreement 2013 – 3637 / 001 - 001

6/ Have you taken part in: {Write a Science opera, Science Theatre, science café, other creative approach]

7/ How do you think we can educate trainee teachers to be creative science teachers- (Do you currently know of any good practice in initial teacher education that fosters creative teaching-)

1/ To what extent do you think national level governmental policy promotes creativity in science education in your country? (5 items) (Scale from -5 [strongly prevents creativity in science], through 0 [no effect], to +5[strongly promotes creativity in science])

The means in Table 8 below shows that school ethos and initial teacher education were seen to have had a neutral effect on the promotion of creativity in science education, whereas assessment practices and performance indicators were seen as having a negative effect – indeed they actively prevent the development of creativity in science.

	School ethos	Initial teacher education	Curriculum policy	Assessment practices	Performance indicators
N Valid	58	62	62	63	62
N Missing (n=83)	25	21	21	20	21
Mean	0.29	0.23	-0.79	-1.25	-1.39
Median	0	1	-1	-2	-2
Mode	0	2	-3	-5, -2, 0	-5
Std. Deviation	2.499	2.563	2.823	2.759	2.700

(Table 8) Mean mode and standard deviation of selection of items on -5 to +5 scale on extent of government policy in promoting creativity in science education.

However, when histograms are drawn they show skewed distributions, this, along with large standard deviations, demonstrates that the means should be treated with caution.

The presence of multiple modes in some items may indicate that there may be two separate populations in the sample. For example, the item called Assessment practices has multiple modes (-5, -2, and 0).

Lifelong Learning Programme

The CREAT-IT project has been funded with support from the European Commission under grant agreement 2013 – 3637 / 001 - 001

The results were analysed by country, using a cross-tabulation of responses according to country. A multi-variable chi-squared test was used to test for relationships between country and level of agreement on the rating scale. The only significant result was for the item of

Performance Indicators. Since all of the cells had an expected frequency of less than 5, the appropriate statistical test was Fisher's Exact Probability. This gave p =0.009. The value of Cramer's V was found to be 0.457, thus nearly 21% of the variation in frequencies of rating can be explained by country. None of the correlations were significant for any of the other items, demonstrating that variance in results cannot be explained by the different countries. It should be noted that only 2 respondents from Belgium responded to this question, and in some cases, only 1 gave an answer. Thus, the results from Belgium cannot be said to be representative.

Country		Initial teacher education	Assessment practices	Performance indicators	Curriculum policy	School ethos
Belgium	Mean (s.d)	3.00 (1.414)	.50 (.707)	1.00 (.000)	2.00 (n/a)	.00 (n/a)
	N (missing)	2 (0)	2 (0)	2(0)	1 (1)	1 (1)
	Median	3	0.5	1	2	0
	Range, Min-Max	2, 2 to 4	1, 0-1	0, 1 to 1	0, 2 to 2	0, 0 to 0
Greece	Mean (s.d)	-.17 (2.787)	-.83 (2.787)	-.67 (2.733)	-.33 (2.503)	.00 (2.608)
	N (missing)	6 (3)	6 (3)	6 (3)	6 (3)	6 (3)
	Median	0	-1	-1.5	-0.5	-0.5
	Range, Min-Max	8, -4 to 4	8, -5 to 3	7, -3 to 4	6, -3 to 3	7, -3 to 4
Italy	Mean (s.d)	-.50 (3.344)	-.92 (3.554)	-1.08 (3.118)	-.36 (3.202)	-.73 (3.036)
	N (missing)	12 (4)	12 (4)	12 (4)	11 (5)	11 (5)

The CREAT-IT project has been funded with support from the European Commission under grant agreement 2013 – 3637 / 001 - 001

	Median	-0.5	-1	-1	1	-2
	Range, Min-Max	10, -5 to 5	10, -5 to 5	8, -5 to 3	9, -5 to 4	9, -5 to 4
Norway	Mean (s.d)	-.57 (2.370)	-2.71(2.360)	-.50 (2.345)	.57 (2.299)	-.33 (2.160)
	N (missing)	7 (2)	7 (2)	6 (3)	7 (2)	6 (3)
	Median	-1	-3	-0.5	1	-0.5
	Range, Min-Max	6, -3 to 3	6, -5 to 1	6, -3 to 3	6, -3 to 3	6, -3 to 3
Serbia	Mean (s.d)	.00(2.236)	.00(1.813)	.20(2.042)	-.50 (2.733)	.00 (1.797)
	N (missing)	15 (5)	15 (5)	15 (5)	16 (4)	14 (6)
	Median	0	0	1	0	0
	Range, Min-max	7, -4 to 3	7, -4 to 3	7, -5 to 2	9, -5 to 4	5, -3 to 2
UK	Mean (s.d)	.95 (2.235)	-2.14 (2.744)	-3.38 (1.910)	-1.95 (2.783)	1.35 (2.581)
	N (missing)	20 (7)	21 (6)	21 (6)	21 (6)	20 (7)
	Median	1.5	-3	-4	-3	1.5
	Range, Min-Max	8, -3 to 5	9, -5 to 4	7, -5 to 2	10, -5 to 5	9, -4 to 5

Red = negative value <-0.5 (prevent creativity in science education)
Grey = neutral value -0.5 to 0.5
Green = positive value >0.5 (promotes creativity in science education)

(Table 9) Country level rating of extent of government policy in promoting creativity in science education

Serbia had the most neutral responses - the majority of participants selected neutral values for each item. The UK had some of the lowest means, indicating a belief that the policies act to prevent creativity in science education. However, in the case of school ethos, it recorded the highest mean, indicating that this promotes creativity in science education. 4 of the six

The CREAT-IT project has been funded with support from the European Commission under grant agreement 2013 – 3637 / 001 - 001

countries recorded a low mean for the impact of assessment practices on the promotion of creativity in science education, only Belgium and Serbia gave neutral responses. Half of the countries recorded performance indicators as a barrier, with Belgium and Serbia reporting this as a strategy that may actually promote creativity in science (albeit at a low level).

[2/ Named policy documents passed to team]

3/ To what extent do you think current national level strategies promote creativity in science education- (This could be strategies from non-governmental organisations). (Scale from -5 [strongly prevents creativity in science], through 0 [no effect], to +5[strongly promotes creativity in science])

The overall mean indicates that current national level strategies have no effect on promoting creativity in science education. However, individual responses are spread from -4 (they prevent creativity in science) to 5 (strongly promote creativity).

The UK is the only country to register a negative mean for this statement, indicating a belief in the UK that national level strategies tend to prevent creativity in science education. However, when a cross tabulation was run Fisher's Exact Probability was 0.332 showing that any association between variable may be due to sampling error.

N	Valid	61
	Missing	22
Mean		0.00
Median		0
Mode		1
Std. Deviation		2.352

(Table 10) Mean mode and standard deviation of selection of items on -5 to +5 scale of extent national level strategies promote creativity in science education

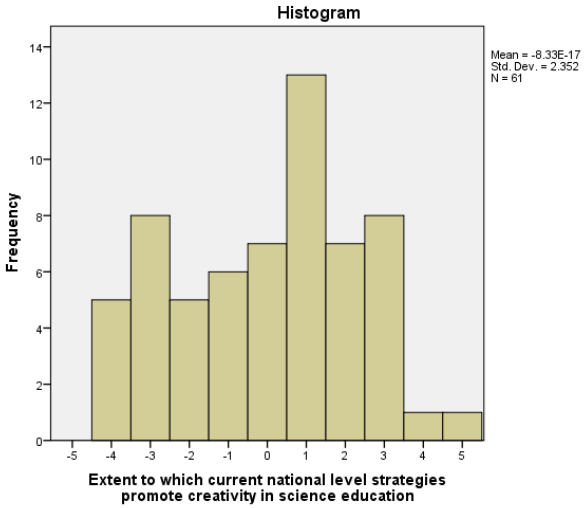


Figure 2

The CREAT-IT project has been funded with support from the European Commission under grant agreement 2013 – 3637 / 001 - 001

Country		Current national level strategies
Belgium	Mean (s.d)	2.00 (1.414)
	N (missing)	2 (0)
	Median	2
	Range, Min-Max	2, 1 to 3
Greece	Mean (s.d)	0.17 (2.229)
	N (missing)	6 (3)
	Median	0.5
	Range, Min-Max	6, -4 to 2
Italy	Mean (s.d)	0.25 (2.832)
	N (missing)	12 (4)
	Median	1
	Range, Min-Max	9, -4 to 5
Norway	Mean (s.d)	1.00 (2.098)
	N (missing)	6 (3)
	Median	1.5
	Range, Min-Max	6, -3 to 3
Serbia	Mean (s.d)	0.81(2.073)
	N (missing)	16 (4)
	Median	1
	Range, Min-max	7, -4 to 3
UK	Mean (s.d)	-1.42 (1.924)
	N (missing)	19 (8)
	Median	-2
	Range, Min-Max	9, -4 to 5

(Table 11) Country level rating of extent national level strategies promote creativity in science education

The CREAT-IT project has been funded with support from the European Commission under grant agreement 2013 – 3637 / 001 - 001

[4/ - Named national stratagies passed to team]

5/ Which of these approaches do you see as creative science teaching- Please select the three you think are most important. (list of 16 items)

The four approaches seen by most as creative science teaching are:

- Encouraging children to try out their own ideas in investigations
- Relating science to everyday life
- Encouraging problem finding –e.g. children asking questions
- Encouraging different ways of recording and expressing ideas

Encouraging children to try out their own ideas in investigations was the item with the most selections from the UK and Greece, the second most selected item by Belgium, Italy and Serbia, and the third most selected item by Norway. Relating science to everyday life was the most selected item by Italy, Serbia and Belgium, the third most selected item by Greece and Norway, and the fifth most selected item by the UK. (The UK's second most selected item was encouraging problem finding).

The four approaches thought by the least as creative science teaching are:

- Fostering students' agency
- Attending carefully to what pupils say and do
- Fostering collaboration
- Encouraging problem solving defined by teacher

Only 8.4%% of respondents selected 'Fostering students' agency' as creative science teaching. No-one from Belgium, Italy or Norway selected it; two people from both Greece and Serbia. 3 UK based respondents selected it. No one from Belgium, 1 person from Italy, 2 people from Greece and Norway, 3 people from Serbia and 4 from the UK selected 'attending carefully to what pupils say and do' as creative science teaching approach.

Lifelong Learning Programme

The CREAT-IT project has been funded with support from the European Commission under grant agreement 2013 – 3637 / 001 - 001

Approaches seen as creative science teaching	Number and % of 83 who selected each item
Encouraging children to try out their own ideas in investigations	42 (50.6%)
Relating science to everyday life	40 (48.2%)
Encouraging problem finding –e.g. children asking questions	36 (43.3%)
Encouraging observation and making connections	33 (39.8%)
Encouraging different ways of recording and expressing ideas	32 (38.9%)
Encouraging problem solving defined by children	30 (36.1%)
Fostering imagination	30 (36.1%)
Fostering classroom discussion and evaluation of alternative ideas	30 (36.1%)
Building on children's prior experiences	22 (26.5%)
Using questioning as a tool in science teaching	21 (25.3%)
Encouraging reflective, reasoned conclusions based on evidence	19 (22.9%)
Using digital technologies with children for science teaching/learning	19 (22.9%)
Encouraging problem solving defined by teacher	19 (22.9%)
Fostering collaboration	18 (21.7%)
Attending carefully to what pupils say and do	10 (14.5%)
Fostering students' agency	7 (8.4%)

(Table 12) Approaches seen as creative science teaching ranked in order most selected to least

Participants also gave other suggestions of creative science teaching approaches as part of their qualitative response:

Lifelong Learning Programme

The CREAT-IT project has been funded with support from the European Commission under grant agreement 2013 – 3637 / 001 - 001

- arts in science education (Norway CREAT-IT Consortium member/ teacher)
- encounter groups in a person-centred way (not only focus groups)
- engagement of parents and the local community in learning and teaching science
- making things with our hands
- play and freedom of choices in education (Greece curriculum developer/ teacher)
- feedback that is short, positive and targeted appropriately (UK scientist/ teacher)

6/ Have you taken part in: {Write a Science opera, Science Theatre, science café, other creative approach]

Write a Science opera	4
Science Theatre	13
Science café,	14
Other creative approach	29

N=83

(Table 13) number taken part in specific creative approach

1 participant has taken part in all 3, 5 have taken part in both theatre and café and 3 have taken part in both theatre and opera.

7/How do you think we can educate trainee teachers to be creative science teachers? Do you currently know of any good practice in initial teacher education that fosters creative teaching?

- take art outside the classroom to the **real world** and offer real opportunities (Belgium Scientist/ teacher)
- teach the trainees the **principles** of creative science; watch videos with examples of creative science and discuss with the trainer how the major principles are applied and lead to learning; in contrast, watch videos with traditional teaching and discuss the student's attitude to the lesson and the effectiveness of each method; practise creative science in the **presence of a trainer** before applying it alone. Discuss with the trainer any problems that could arise and how they can be handled (Greece Scientist/ teacher)
- give them more (creative) autonomy, gentle and really **supportive coaching**, a good number of various scientific instruments, labs, computers, and **more time** to slow down (Greece Curriculum developer/ teacher)
- the trainee teachers train in groups and **collaborate** as they ask their pupils to do (Greece Scientist/ teacher)
- use a **hands-on approach**, using other languages through the CLIL (Content and Language Integrated Learning) method (Italy Scientist/ teacher)

Lifelong Learning Programme

The CREAT-IT project has been funded with support from the European Commission under grant agreement 2013 – 3637 / 001 - 001

- offer them a creative science approach experience and interaction with **scientists** (Italy Scientist/ teacher)
- showing teachers the **practical** and useful aspects about their studies (Italy scientist/ teacher)
- **game training** according to the method of Ludopedagogy (Centro de Investigacion y capacitación La Mancha, Montevideo, Uruguay) (Italy Curriculum developer/ teacher)
- get them to do **research** (Italy CREAT-IT Consortium member)
- train them to use **Science theatre** or Science Café (Italy CREAT-IT Consortium member)
- teach them effective **science communication techniques** which do not involve sage-on-the-stage principles (Norway Scientist/ teacher)
- try out in **collaboration** with other teachers and advisors the possible methods they consider using with the pupils; training courses (Norway Scientist)
- **reflect** on what creativity in science is: being a creative science teacher is not the same as fostering creativity in science (Norway Scientist)
- giving them the **time** to be creative (Norway Scientist/ teacher)
- engage in activities at/from the **Center for the Promotion of Science**: teacher training and programs for school children (Serbia CREAT-IT Consortium member)
- **interactive training** (Serbia CREAT-IT Consortium member)
- **interdisciplinary** training and the mixture of skills and knowledge; give opportunities to social science and art teachers to learn about natural sciences, phenomenon or laws they can use in their work (Serbia CREAT-IT Consortium member)
- **long-term teacher training planning** (Serbia Scientist)
- teach them to improvise; encourage them to be creative; use constructive, inquiry-based and collaborative teaching methods that emphasize **classroom collaboration**; ensure that curriculum materials relate to classroom practice; emphasize teaching as a creative art (Serbia CREAT-IT Consortium member)
- exchange experiences; long-term training of teachers; checking the practical application (Serbia Scientist/teacher)
- support through teaching materials; encourage them to participate in the **science busking festivals**; create science teaching **blogs** for sharing ideas (Serbia Curriculum developer/ teacher)
- work on wholesome **job satisfaction** in teachers as a fundamental pre-requisite for creativity in the classroom. A big struggle is the frustration that the teachers develop with low pay and low social standard of their profession (Serbia CREAT-IT Consortium member)
- a **school science festival** (Serbia Curriculum developer/ teacher)
- confidence with **subject knowledge**, support from the head teacher (UK curriculum developer/ teacher)

Lifelong Learning Programme

The CREAT-IT project has been funded with support from the European Commission under grant agreement 2013 – 3637 / 001 - 001

- encourage **collaborative planning with students from an open question generated by the students** (UK Scientist/ teacher)
- a combination of the trainee's drive and the inspiration of the training course (UK Scientist/ teacher)
- create a creative classroom through effective group work, **pupil-led investigations** or using **technology** (UK Curriculum developer/ teacher)
- Science days - **full immersion** in a topic, giving time to develop and build on ideas (UK curriculum developer/ teacher)
- through schools that don't rely on QCA documents (UK Curriculum developer/ teacher)
- opportunities to **try alongside** an outstanding practitioner (UK Curriculum developer/ teacher)

General points:
Alongside the suggestions, one Greek teacher expressed that it is important to consider good teachers first and then good SCIENCE teachers. They highlighted that there is a global crisis in education, and a generalized authority, yet Science itself acts as a kind of curriculum authority. Finally, felt that initial teacher education should be as creative as we would like science teaching and pupils to be.

Questions for ALL TEACHERS (General teachers, teachers with experience of a specific approach and dual role teachers) (n=109, UK 42, Italy 24, Serbia 17, Greece 13, Norway 9, Belgium 4):

1/ By the end of this school year, how long will you have been working as a teacher?
2/ Which age group/s do you teach?
3/What do you feel is your level of knowledge, skill and confidence in the creative teaching of science? (5 point scale: low, moderate, good, high, very high)
4/ To what extent does creativity play a role in the teaching, learning and assessment of science in your country?
5/ Which of these creative behaviours do you see students displaying in your science lessons on an individual, collaborative and/or communal basis? (list of 14 items, click any that apply)
6/ How often do you use the following learning/teaching contexts and approaches in your SCIENCE teaching (26 items on scale from never (0) to very often (3).)
7/ Which of these contexts do you consider as MOST LIKELY to contribute to the development of children's CREATIVITY in science? (11 items, choose up to 3)
8/ How strongly do you agree or disagree with each of the following statements about the role of the teacher in fostering INQUIRY skills (4 items, 4 point scale from strongly disagree to strongly agree)

Lifelong Learning Programme

The CREAT-IT project has been funded with support from the European Commission under grant agreement 2013 – 3637 / 001 - 001

1/ By the end of this school year, how long will you have been working as a teacher?

	Belgium	Greece	Italy	Norway	Serbia	UK	**Total**
Fewer than 5 years	1	0	1	0	3	2	**7**
5-10 years	0	4	2	3	5	12	**26**
11-20 years	1	5	6	3	6	13	**34**
More than 20 years	2	2	9	2	2	9	**26**
Total	**4**	**11**	**18**	**8**	**16**	**36**	**93**
No data	0	2	6	1	1	6	**16**

(Table 14) years working as a teacher

2/ Which age group/s do you teach?

	Belgium	Greece	Italy	Norway	Serbia	UK	**Total**
Age taught 0-3	0	0	0	0	0	0	**0**
Age taught 4-11	0	4	2	3	2	17	**28**
Age taught 11-16	1	8	7	2	11	20	**49**
age taught 16-18	2	6	8	1	6	15	**38**
age taught 18+	1	2	2	7	0	0	**12**
Total	**4**	**20**	**19**	**13**	**19**	**52**	**127**

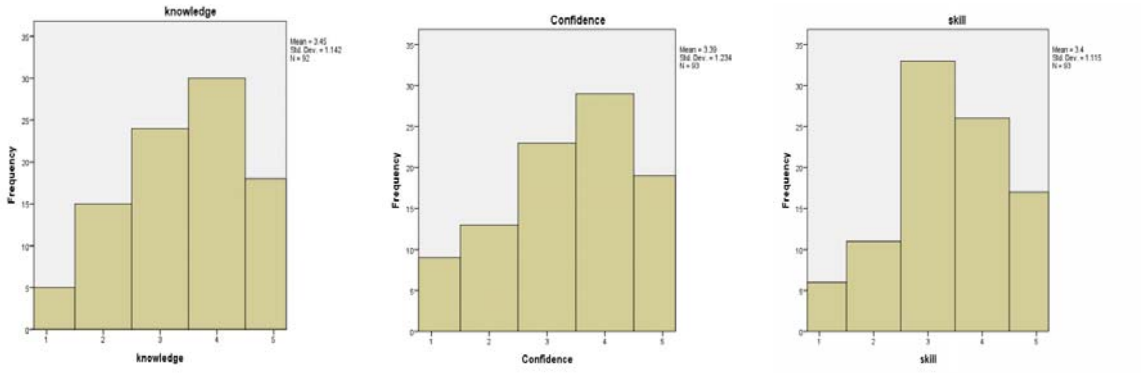
(Table 15) age group/s taught

Lifelong Learning Programme

The CREAT-IT project has been funded with support from the European Commission under grant agreement 2013 – 3637 / 001 - 001

***3/What do you feel is your level of knowledge, skill and confidence in the creative teaching of science? (5 point scale: low, moderate, good, high, very high*)**

All items had a relatively high mean, between 3.39 to 3.45 out of a possible 5. The item with the highest mean was level of knowledge (3.45, s.d. 1.142), followed by level of skill (3.40, s.d. 1.115); closely followed by level of confidence (3.39, s.d. 1.234).



Figures 3-5: frequency barcharts for teachers level of knowledge, skill and confidence scale 1-5

When level of agreement with each statement is listed from the country with the **highest** agreement with the statement, to the country with the **lowest** level of agreement, the following patterns are seen:

Level of knowledge – Serbia (mean=4.00), Greece, Belgium, UK, Italy, Norway (mean = 2.88).

Level of skill – Serbia (mean=4.06), Greece, Norway, Belgium, UK, Italy (2.83).

Level of confidence– Greece (mean = 4.09), Serbia, Norway/Belgium, UK, Italy 2.89)

The CREAT-IT project has been funded with support from the European Commission under grant agreement 2013 – 3637 / 001 - 001

Country		Knowledge	Skill	Confidence
Belgium	Mean (s.d)	3.50 (1.000)	3.25 (0.957)	3.25 (0.957)
	N (missing)	4 (0)	4 (0)	4 (0)
	Median	4	3.5	3.5
	Range, Min-Max	2, 2 to 4	2, 2 to 4	2, 2 to 4
Greece	Mean (s.d)	3.91 (1.446)	4.00 (1.342)	4.09 (1.221)
	N (missing)	11 (2)	11 (2)	11 (2)
	Median	5	5	4
	Range, Min-Max	4, 1 to 5	4, 1 to 5	4, 1 to 5
Italy	Mean (s.d)	2.94 (0.837)	2.83 (1.043)	2.89 (1.323)
	N (missing)	18 (6)	18 (6)	18 (6)
	Median	3	3	3
	Range, Min-Max	3, 1 to 4	3, 1 to 4	4, 1 to 5
Norway	Mean (s.d)	2.88 (1.246)	3.50 (1.069)	3.25 (1.389)
	N (missing)	8 (1)	8 (1)	8 (1)
	Median	3	3	3
	Range, Min-Max	4, 1 to 5	3, 2 to 5	4, 1 to 5
Serbia	Mean (s.d)	4.00 (1.069)	4.06 (0.998)	4.00 (1.033)
	N (missing)	15 (2)	16 (1)	16 (1)
	Median	4	3	3
	Range, Min-max	4, 1 to 5	4, 1 to 5	4, 1 to 5
UK	Mean (s.d)	3.44 (1.081)	3.19 (0.980)	3.19 (1.142)
	N (missing)	36 (6)	36 (6)	36 (6)
	Median	4	3	4
	Range, Min-Max	4, 1 to 5	4, 1 to 5	4, 1 to 5
Total	Mean (s.d)	3.45 (1.142)	3.40 (1.115)	3.39 (1.234)
	N (missing)	92 (17)	93 (16)	93 (16)
	Median	4	3	4
	Range, Min-Max	4, 1 to 5	4, 1 to 5	4, 1 to 5

Lifelong Learning Programme

The CREAT-IT project has been funded with support from the European Commission under grant agreement 2013 – 3637 / 001 - 001

(Table 16) Country level rating of teachers self-reported level of knowledge, skill and confidence in the creative teaching of science

Qualitative responses to the above by country: Knowledge/skill/confidence [this will need to be referred to in the deliverable, but not giving all examples as is here]

Belgium (teachers)

Moderate/Moderate/Moderate. Science teaching is not my main field of teaching activity
High/Good/Good. I don't use all the things I have learned yet.
High/High/High. Am an active painter and work as such part-time, plus an initiator of art projects for the past 10 years with adults and young people.

Greece Knowledge/skill/confidence
Very High/Very High/Very High. I am educated in this approach of teaching through my studies and I am always trying to make my lesson an interesting experience that makes my students wiser. We often use applets in classroom and do experiments through the lesson so the students are getting very curious. I really care about them and they feel that and they don't hesitate to express their thoughts and the difficulties. So we are a team that we are collaborating and trying for the best. (Teacher)

Moderate/Good/Very High. My main discipline is Music and specifically Music performance. My knowledge in Science can be considered limited although I do have a strong interest in Acoustics and it's relation to the construction of the modern flute. Teaching music mostly in one-in-one environments and less in classrooms, I considered my skill as Good. I do feel confident though when it comes to make strong points on the relation between Music and Acoustics. (Greece CREAT-IT Consortium member/ teacher)

High/Very High/High. Creativity in teaching makes me very happy. I know when I am really creative and I very much enjoy it (the whole process, from finding an idea, to making it happen in the classroom). Although our educational system in Greece is really old and bad, the light of a new idea captures the minds of students too ... (not only mine) (teacher)

Very High/Very High/Very High. I have attended a lot of seminars in various fields. Apart from Science, I possess high-level skills in electronics, informatics and arts. Teacher with experience of a specific creative science project/resource (such as Write a Science Opera, Science Theatre, Science Café or other)

Very High/Very High/Very High. I have implemented more than 150 projects focusing on innovative ways to teach science in both formal and informal settings. These projects have involved more than 6000 students. Teacher with experience of a specific creative science project/resource (such as Write a Science Opera, Science Theatre, Science Café or other)

Lifelong Learning Programme

The CREAT-IT project has been funded with support from the European Commission under grant agreement 2013 – 3637 / 001 - 001

Very High/High/High. I think I have much knowledge because I have been teaching different lessons and I also have knowledge of pedagogies and approaches that promote creativity. I cannot say that my skills are very high (somebody else could say that for me). I cannot say I have very high confidence because this is a perpetual procedure of helping yourself be better and better. Teaching skills have no end. You can always be more sufficient than you used to be before. (teacher)

Good/Good/Good I am an experienced and motivated educator (teacher)
Low/Low/Low It is due to lack of self-confidence. (teacher)

Italy Knowledge/skill/confidence
High/High/Very High. Since I have started teaching I have always considered creativity a matter of the utmost importance, along with carefully updated knowledge of the taught topics (scientist/teacher)

Good/Good/Good I don't have enough time to develop creative experiences (teacher)

Good/Good/Good My past and current training involves a knowledge of different approaches in teaching. Also my background is in biological research laboratory. (teacher/scientist)

Moderate/Moderate/Moderate . I have the perception science should be taught with a more effective approach but I have no clear idea on how to do better (just trying to try new resources every year) Scientist/teacher

High/High/High I have practiced creative teaching in science for many years (teacher with experience of a specific creative science project
Good/Good/Good. I am not a Science teacher, but I like cooperate with science colleagues (teacher)

Moderate/Good/Good I did not study any courses about how to study science in a creative way. In fact, I do not have any skills or resources to do it. Teacher with experience of a specific creative science project/resource (such as Write a Science Opera, Science Theatre, Science Café or other)

Norway Knowledge/skill/confidence
High/Very High/Very High. I am not trained as a scientist but have much experience in the field of creativity in science education (CREAT-IT Consortium member/ teacher)

Very High/Very High/Very High have been teaching graduate level science for >20 years and publishing in peer reviewed journals for >30 years (Scientist/ teacher)

Lifelong Learning Programme

The CREAT-IT project has been funded with support from the European Commission under grant agreement 2013 – 3637 / 001 - 001

Low/Good/Low I am an artist and not trained in any scientific field Teacher with experience of a specific creative science project/resource (such as Write a Science Opera, Science Theatre, Science Café or other)

Good/High/Good Science education research has for several decades focussed on inquiry approaches to learning science. And from the definition of creative teaching in science above many inquiry approaches would most likely qualify as creative approaches. Consequently, inquiry approaches should be well known to most researchers as well as educators in the field who are well oriented in science education research. Scientist/ teacher

Good/Good/Good still learning (teacher)
Moderate/Moderate/Moderate Creative teaching has not been my main focus (teacher)

Serbia Knowledge/skill/confidence
High High High I can always be better if I get the support of the education system Curriculum developer/ teacher

Very High Very High Very High I tried to make and succeed in many math project with my students, and many other students thru activities of science popularisation. Teacher with experience of a specific creative science project/resource (such as Write a Science Opera, Science Theatre, Science Café or other)

Low Low Low My previous science and methodological inputs through formal system of education haven't gone enough in this direction. Thats why i don't feeel too confident while i'm trying some new approaches. General teacher

Very High Very High Very High years of experience, success in competitions, participate in various seminars Curriculum developer/ teacher

High High High I know a lot and I have certain skills, but I think I need to develop more. Teacher with experience of a specific creative science project/resource (such as Write a Science Opera, Science Theatre, Science Café or other - please state)

Very High Very High High With my knowledge and skills I help students to apply their knowledge in everyday life. Curriculum developer/ teacher

High Good Good Finding the best way to get the result I want is not always a reflection of what I know, but depends largely on child's involvement and readiness. Curriculum developer/ teacher

Lifelong Learning Programme

The CREAT-IT project has been funded with support from the European Commission under grant agreement 2013 – 3637 / 001 - 001

Good/high/high I think that for creative education you need constant cooperation and exchange of experience among schools, students and professors. Also need advanced education for teachers. General teacher

UK Knowledge/skill/confidence
Very High Very High Very High I train other teachers in creative approaches to teaching and learning. General teacher

High High High I am science co-ordinator and experienced teacher so I am confident, I know how to manage children how to interest them and adapt to the ages, needs of the children Curriculum developer/ teacher
Good Good Good I endeavour to find creative ways of teaching science and inquiry skills within the creative curriculum. General teacher

Good Good Good The restraints of the curriculum prevernt lots of creativitiy to take place. General teacher

Low Low Low Have difficulty giving time over to a more creative approach when the confines and pressures of exams are intense. Scientist/ teacher

High High High I am on the cusp of outstanding in my observations, my support network at the school mentors etc are phenomenal and I have much to inspire me here. The team that back you up with behaviour management give you all the support you need to get creative in the classroom. Scientist/ teacher

Moderate Moderate Moderate I trial some creative activities but many things limit what I feel I can do & don't always feel confident trying new ideas, or where to go to get them General teacher

High Good High I have used enquiry based learning as part of my lesson planning and delivery for 8 years in 2 different schools. Curriculum developer/ teacher

Very High High High Many years of teaching experience. I ran and delivered a primary school science outreach program and have organised and run "hands on" science stands at science festivals and events (Scientist/ teacher)

Good Good Good I feel I always have new elements to learn myself, and use of IT could be stronger. General teacher

Very High High High Having a degree in Science and a scientific background, plus experience in teaching science from 4 - 11, gives me the confidence to try exciting activities

Lifelong Learning Programme

The CREAT-IT project has been funded with support from the European Commission under grant agreement 2013 – 3637 / 001 - 001

and strategies e.g. cooking with fire, stick insect camouflage games etc. Curriculum developer/ teacher

High Good High I am a confident scientist with a good level of scientific understanding. My skills are good but I am aware that my teaching is often focussed on pupil attainment rather than creativity. General teacher

Good Good Moderate I could always improve my knowledge & skill, there are always new things to learn and practice. I don't think I'll ever be confident enough to rate my knowledge & skill as any higher. My confidence in the classroom is good. General teacher
High High Very High Creative science enables children to use their own starting points not going over things they already know. The teacher's role is then to facilitate children taking their learning forward. Curriculum developer/ teacher

High Good Good I know how to do more than I can actually do well. General teacher

Good Good Very High I love teaching science and will try anything but it is difficult to find different innovative ways of teaching the subject. Scientist/ teacher

High Good Good Confidence is found in the freedom to make mistakes and learn from them, both as a teacher and as a pupil learning. Confines of the National curriculum and all it requires and the constraints of time curtail this freedom. General teacher

Moderate Moderate Moderate As a teacher who promotes creativity cross curricular - this can be applied to science Curriculum developer/ teacher

Good Good Good My own educational background is not science based, but as I believe that Science is of critical importance, I hope I deliver a standard of Science lesson which engages children. General teacher

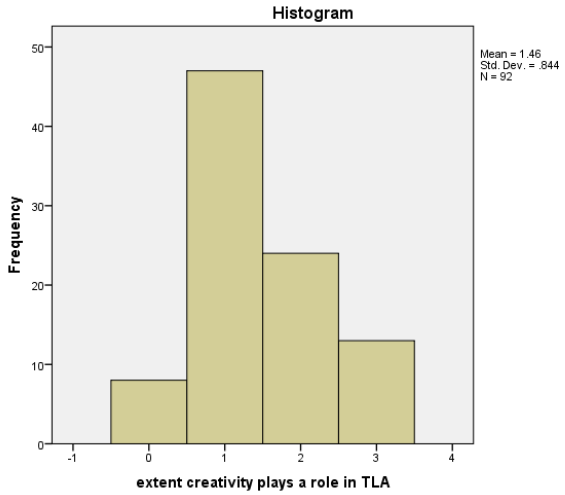
Moderate Moderate Moderate I believe in it much more than I practise it! It isn't my default position - under curriculum & time pressure it doesn't always seem an efficient way to teach "what they have to know" for exams. Scientist/ teacher

4/ To what extent does creativity play a role in the teaching, learning and assessment of science in your country?

The majority saw creativity as playing a **low role** in the teaching, learning and assessment of science in their country. 9% selected no role, 51% select low role, 26% select moderate role and 14% select key role. By country, in order from highest mean (larger role) to lowest (smaller role): Belgium (mean=1.75), Serbia, Norway, Italy, Greece, UK (mean=1.34).

Lifelong Learning Programme

The CREAT-IT project has been funded with support from the European Commission under grant agreement 2013 – 3637 / 001 - 001



0 = no role,
1 = low role,
2 =moderate role,
3 = Key role

Country	Mean (s.d)	N (missing)	Median	Range, min-max
Belgium	1.75(0.500)	4 (0)	2	1, 1 to 2
Greece	1.36 (0.924)	11 (2)	1	3, 0 to 3
Italy	1.39 (0.979)	18 (6)	1	3, 0 to 3
Norway	1.63 (0.916)	8 (1)	1	2 91 to 3
Serbia	1.69 (0.946)	16 (1)	1.50	3, 0 to 3
UK	1.34 (0.725)	35 (7)	1	3, 0 to 3
Total	1.46 (0.844)	92 (17)	1	3, 0 to 3

(Table 17) Country level breakdown of extent creativity plays a role in the teaching, learning and assessment of science.

Qualitative responses on the extent of creativity playing a role by country:

Belgium:

All responses expressed a moderate role, citing low motivation of some teachers and that Arts education is taught separately from other subjects without integration.

Greece:

All responses expressed a low or no role, citing conservative learning models and education system, narrow evaluation of teachers, no concrete policy on creativity, a top to down authoritative system, no curriculum flexibility, creative learning happening through the cracks, examination focus, and creative science teaching and learning being obstructed by the educational system.

Italy:

Lifelong Learning Programme

The CREAT-IT project has been funded with support from the European Commission under grant agreement 2013 – 3637 / 001 - 001

Responses expressed varied from no role, through low role and up to moderate role. Comments were that very few teachers try to be creative, little attention given from the Ministry of Education, teachers are de-motivated and that there are too many teachers not trained to teach from a pedagogy of freedom and play.

Norway:

Responses expressed a low to moderate role (the 'key role' responses was only talking about their won teaching and not the country as a whole). Comments were that in recent years, reading and writing and their testing were emphasized at the expense of creativity, and that assessing creativity is difficult and hence is easily downplayed because spending much time on creative teaching strategies might be a risky business for a teacher.

Serbia:

The majority of responses expressed a low role, commenting that creative teaching is not sufficiently explored and that the focus has become that you complete the curriculum tasks, make sure the pupils know enough and get on with the next bit of work. Schools tend to encourage a uniform way of thinking: receive information, reproduce it, get a mark. It leaves no space for free expression of students' personal opinions. There was one response that expressed that creativity had a key role, which was from a teacher with experience of a specific creative science project/resource, who commented that thanks to the creativity and energy of individuals, science in schools is interesting for some students. In this way, teachers are encouraging the curiosity to explore the world around them through science.

UK:

The majority of responses expressed a low or moderate role, commenting often about assessment: there is no real creativity in assessment, that there is more creativity since the optional SAT; it is left to the individual teacher as to whether they include it; over emphasis on pupil attainment and test culture is stifling creative approaches in some aspects of science; assessment is largely pre-determined - we teach pupils the skills to be successful in GCSE exams and creativity is highly variable within that. Other comments were about time constraints, that there was a tendency for children to know scientific facts rather than exhibit scientific approaches, and that good creative practice was down to individual teachers and isn't systematic.

5/ Which of these creative behaviours do you see students displaying in your science lessons on an individual, collaborative and/or communal basis? (list of 14 items, click any that apply)

Curiosity/problem identification was the creative behaviour with the most selections from Norway, the second most selected item by Belgium, Greece, Italy, Serbia and the UK. Making connections was the most selected item by Italy, the second most selected item by Serbia and the third most selected item by the UK, Belgium and Norway. Engagement was the creative behaviour selected most by the UK and Norway.

Lifelong Learning Programme

The CREAT-IT project has been funded with support from the European Commission under grant agreement 2013 – 3637 / 001 - 001

Creative behaviours you see students displaying in your science lessons	Number and % of 109 who selected each item
Curiosity/problem-identification	67 (61.4%)
Making connections	57 (52.3%)
Engagement	51 (46.8%)
Behaviours that respond to questions	47 (43.1%)
Critical reasoning	44 (40.4%)
Playfulness	40 (36.7%)
Being imaginative	38 (34.9%)
Reflection	37 (33.9%)
Innovative thinking and outcomes	35 (32.1%)
Willingness to take risks	30 (27.5%)
Initiative-taking	28 (25.7%)
Willingness to explore strategies that might generate explanations	25 (22.9%)
Challenging assumptions	23 (21.1%)
Persistence	20 (18.3%)

(Table 18) Creative behaviours you see students displaying in your science lessons

6/ How often do you use the following learning/teaching contexts and approaches in your SCIENCE teaching (26 items on scale from never (0) to very often (3).)

The 26 items are reported in the tables below by order of descending means. The higher the mean, the more frequently the learning/teaching contexts and approaches are used in science teaching.

Lifelong Learning Programme

The CREAT-IT project has been funded with support from the European Commission under grant agreement 2013 – 3637 / 001 - 001

	Relating science to everyday life	Using questioning as a tool in science teaching	Encouraging observation and making connections	Working in small groups	Attending carefully to what pupils say and do	Encouraging reflective, reasoned conclusion based on evidence
N, (Missing)	85 (24)	84 (25)	83 (26)	84 (25)	84 (25)	84 (25)
Mean	2.60	2.36	2.35	2.33	2.31	2.30
Median	3.00	2.00	2.00	2.00	2.00	2.00
Mode	3	3	2	2	2	2
S.D	.561	.705	.614	.665	.694	.708
% who selected quite often/very often	96.4%	86.9%	92.7%	92.7%	89.2%	88.1%
% who selected very often	63.5%	48.8%	48.8%	42.2%	42.2%	42.9%

	Building on children's prior experiences	Encouraging problem solving – e.g. children solving practical tasks framed by you	Fostering classroom discussion and evaluation of alternative ideas	Physical exploration of materials	Encouraging different ways of recording and expressing ideas	Encouraging problem finding – e.g. children asking questions
N, (Missing)	84	86 (23)	84 (25)	83 (26)	84 (25)	83 (26)
Mean	2.17	2.16	2.10	2.10	2.08	2.02

Lifelong Learning Programme

The CREAT-IT project has been funded with support from the European Commission under grant agreement 2013 – 3637 / 001 - 001

Median	2.00	2.00	2.00	2.00	2.00	2.00
Mode	2	2	2	2	2	2
S.D	.758	.648	.786	.850	.795	.715
% who selected quite often/very often	88.3%	86.0%	81.0%	78.3%	82.1%	80.7%
% who selected very often	35.7%	30.2%	32.1%	36.1%	31.0%	24.1%

	Using digital technologies with children for science teaching and learning	**Encouraging children to try out their own ideas in investigations**	**Integrating science with other curricular areas**	**Encouraging problem solving – children solving practical tasks which they have framed**	**Fostering imagination**	**Ensuring sufficient time and space for exploration and problem-based learning**
N, (Missing)	85 (24)	83 (26)	88 (21)	83 (26)	84 (25)	83 (26)
Mean	1.99	1.88	1.84	1.82	1.82	1.82
Median	2.00	2.00	2.00	2.00	2.00	2.00
Mode	2	2	2	2	2	2
S.D	.732	.755	.869	.783	.679	.718
% who selected quite often/very often	75.3%	69.9%	69.3%	71.1%	69.0%	68.7%
% who selected very often	24.7%	20.5%	22.7%	16.9%	14.3%	15.7%

	Using	**Using**	**Open or**	**Fosterin**	**Taking**	**Teaching**

Lifelong Learning Programme

The CREAT-IT project has been funded with support from the European Commission under grant agreement 2013 – 3637 / 001 - 001

	history or geography to teach science	outdoor learning activities	unstructured play or exploration	g students' own agency	children on field trips and/or visits to science museums and industry	science from or through stories
N, (Missing)	84 (25)	86 (23)	85 (24)	71 (38)	85 (24)	84 (25)
Mean	1.79	1.57	1.41	1.38	1.34	1.32
Median	2.00	1.50	1.00	1.00	1.00	1.00
Mode	2	1	1	1	1	1
S.D	.695	.875	.863	.763	.853	.763
% who selected quite often/very often	70.2%	50.0%	44.7%	43.7%	37.6%	35.7%
% who selected very often	11.9%	16.3%	10.6%	5.6%	10.6%	7.1%

	Role play	Drama
N, (Missing)	83 (26)	84 (25)
Mean	1.02	.73
Median	1.00	1.00
Mode	1	0
S.D	.749	.766
% who selected quite often/very often	24.1%	14.3%
% who selected	2.4%	2.4%

Fostering students' own agency is an interesting item, as only 71 out of 109 selected it, compared to the 83-88 who responded to the other items.

The CREAT-IT project has been funded with support from the European Commission under grant agreement 2013 – 3637 / 001 - 001

very often		

(Table 19) frequency of use of the learning/teaching contexts and approaches in science teaching

The table below shows statements that were the countries' first, second and/or third highest mean. It demonstrates discrepancies between countries, and where this is statistically significant the significance is described.

All countries except Belgium had the highest mean for the item 'relating science to everyday life'. It was one of Belgium's second highest means. Belgium and Greece had encouraging observation and making connections as the second highest mean. Norway had both using digital technologies and working in small groups as the second highest mean. Working in small groups was Serbia's third highest mean, it had and do as its second highest mean.

All countries with the exception of Belgium had the lowest mean for the use of Drama as a frequently used teaching group. All countries except Belgium and Serbia had the second lowest mean for 'role-play'. Serbia had this rated as third lowest mean and had 'fostering students' own agency' as the second lowest mean.

The CREAT-IT project has been funded with support from the European Commission under grant agreement 2013 – 3637 / 001 - 001

Item	Highest mean	Second highest mean	Third highest mean	Other rankings
Relating science to everyday life	UK, Italy, Serbia, Greece, Norway	Belgium		
Using questioning as a tool Fisher's exact test, value 23.480, exact significance p=0.002, Cramer's v=0.368, 13.5% of variation explained by country	UK		Serbia	Belgium 4th, Norway 5th, Greece & Italy 7th
Encouraging observation and making connections		Belgium, Greece	Italy	Norway & Serbia 5th, UK 6th
Working in small group		UK, Norway	Serbia, Belgium	Greece 5th, Italy 8th
Attending carefully to what pupils say and do		Serbia, Belgium	Greece, Norway	Italy 4th, UK 7th,
Encouraging reflective, reasoned conclusions based on the evidence Fisher's exact test, value 24.519, exact significance p=0.024, Cramer's v=0.313, 9.8% of variation explained by country		Italy		Norway, Belgium & Greece 4th, UK 5th, Serbia 7th
Building on children's prior experiences Fisher's exact test, value 30.163, exact significance p=0.01, Cramer's v=0.393, 15.4% of variation explained by country			Greece, Belgium	UK 4th, Serbia 6th, Norway 7th, Italy 12th
Encouraging different ways of recording and expressing ideas			Greece, Belgium	Italy 5th, Norway 6th, UK 10th, Serbia 11th
Physical exploration of materials Fisher's exact test, value 34.352, exact significance p=0.00, Cramer's v=0.374, 14.0% of variation explained by country		UK, Belgium		Greece 6th, Norway 7th, Serbia 13th, Italy 14th.
Using digital technologies		Norway, Greece		Belgium 4th, Serbia 5th, Italy 10th, UK 5th
Encouraging children to try out their own ideas in investigations	Belgium			Greece 5th, Norway 9th, Italy 11th, UK & Serbia 12th

Lifelong Learning Programme

The CREAT-IT project has been funded with support from the European Commission under grant agreement 2013 – 3637 / 001 - 001

(Table 20) statements that were the countries' first, second and/or third highest mean, that is, most frequently used learning/teaching contexts and approaches in science teaching

7/ Which of these contexts do you consider as MOST LIKELY to contribute to the development of children's CREATIVITY in science? (11 items, choose up to 3)

The table below shows the statements in order from the largest amount of yes responses to the smallest. Each country's highest amount of yes responses has been highlighted in green.

	Belgium (4)	Greece (14)	Italy (24)	Norway (9)	Serbia (17)	UK (42)	Total (109)
Working in small groups/working collaboratively							
No	2	8	15	5	6	17	53
Yes	2	5	9	4	11	25	**56**
Problem-based learning							
No	2	9	16	6	11	20	64
Yes	2	4	8	3	6	22	**45**
Integrating science with other curricular areas							
No	2	8	16	5	8	28	67
Yes	2	5	8	4	9	14	**42**
Physical exploration of materials							
No	2	9	14	8	13	22	68
Yes	2	4	10	1	4	20	**41**
Teaching science from or through stories							
No	0	9	15	7	8	35	74
Yes	4	4	9	2	9	7	**35**
Taking children on field trips							
No	2	5	18	7	11	31	74
Yes	2	8	6	2	6	11	**35**

The CREAT-IT project has been funded with support from the European Commission under grant agreement 2013 – 3637 / 001 - 001

Using outdoor learning activities							
No	3	9	17	9	12	33	83
Yes	1	4	7	0	5	9	**26**
Open/unstructured play							
No	4	11	21	8	15	29	88
Yes	0	2	3	1	2	13	**21**
Using history or geography to teach science							
No	3	9	17	9	14	37	89
Yes	1	4	7	0	3	5	**20**
Role play							
No	2	9	20	8	15	39	93
Yes	2	4	4	1	2	3	**16**
Drama							
No	2	11	22	7	16	40	98
Yes	2	2	2	2	1	2	**11**

(Table 21) Country breakdown of contexts thought MOST LIKELY to contribute to the development of children's CREATIVITY in science

8/ How strongly do you agree or disagree with each of the following statements about the role of the teacher in fostering INQUIRY skills (4 items, 4 point scale from strongly disagree to strongly agree)

The table below shows results for each of the 4 items, with the item with the highest mean on the left (indicating most agreement) to the item with the lowest mean on right (indicating least agreement).

The first three statements have high levels of agreement. This is reflected across all countries, except Belgium which has a mean of 2.75 for the statement 'children should allow children to find solutions to problems'. This statement had a mean of 2.75 (s.d. 0.50), compared to the other countries who gave it a mean of 3.29-3.64. (It must be remembered that Belgium only had 4 respondents, so this should not be taken as representative.) None of the other variation by country was found to be significant.

Lifelong Learning Programme

The CREAT-IT project has been funded with support from the European Commission under grant agreement 2013 – 3637 / 001 - 001

'Teachers should demonstrate first the correct way to solve a problem' has lowest level of agreement, with most participants selecting 'disagree' (41). This was rated with the lowest mean by all countries.

		Teachers should allow children to find solutions to problems	Teachers should facilitate children's own inquiry	Teachers should give children ample time to work out their own solutions to problems before showing them	Teachers should demonstrate first the correct way to solve a problem
N	Valid	90	90	90	88
	Missing	19	19	19	21
Mean		3.47	3.36	3.27	1.98
Median		4.00	3.00	3.00	2.00
Mode		4	3	3	2
Std. Deviation		.603	.641	.596	.884
Range		2	3	3	3
Minimum		2	1	1	1
Maximum		4	4	4	4

(Table 22) Agreement on 4 point scale of role of the teacher in fostering INQUIRY skills

Lifelong Learning Programme

The CREAT-IT project has been funded with support from the European Commission under grant agreement 2013 – 3637 / 001 - 001

8/ How often do you reward/praise the following characteristics in your pupils in science? (8 items, 4 point scale from NEVER to VERY often).

Each of the characteristics are rewarded/praised by teachers on a frequent basis, with means ranging from 2.19-2.40 out of a possible 3. 2 of the 8 statements had no one selecting they never rewarded the described characteristic, 5 of the 8 statements had only 1 person stating they never rewarded/praised these behaviours. The characteristic of 'use of imagination' was stated as never used by 2 people.

	Ability to connect what they have learnt to other subjects	Use of curiosity	Evidence of motivation	Ability to collaborate	Thinking critically	Ability to come up with something new	Use of imagination	A clear sense of initiative
Valid	88	90	90	89	89	89	87	89
Missing	21	19	19	20	20	20	22	20
Mean	2.40	2.40	2.39	2.37	2.36	2.36	2.28	2.19
Median	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Mode	3	3	2,3	3	3	3	2	2
Std. Deviation	.653	.650	.648	.664	.711	.711	.726	.689
Range	3	3	3	2	3	3	3	2
Minimum	0	0	0	1	0	0	0	1
Maximum	3	3	3	3	3	3	3	3

(Table 23) Frequency of reward/praise of the following characteristics in your pupils in science, 4 point scale

There is variation by country in some of the items. The item with the highest overall mean (ability to connect with what they have learnt to other subjects was one of the highest means for the UK (2.58, s.d 0.50), Norway (2.33, s.d. 0.516), and was Serbia's highest mean (2.62, s.d. 0.506). However, it was also Greece's lowest mean (2.27, s.d. 0.647), and one of Belgium's lowest means (1.50, s.d. 1.291). A multi-variate cross tab analysis was carried out to measure if there was a significant relationship between country and frequency of use. Fisher's exact probability was p=0.056. This is above the significance level of 0.05, and so any association may have happened by chance.

Lifelong Learning Programme

The CREAT-IT project has been funded with support from the European Commission under grant agreement 2013 – 3637 / 001 - 001

The item with the third highest mean, (evidence of motivation) was one of the UK's highest means (2.58, s.d 0.50). However, it was Norway's lowest mean (1.83, s.d 0.983), one of the lowest rated items by any country. The multi-variate crosstab analysis gave Fisher's exact probability at 0.007, and the value of Cramer's v at 0.346, indicating that 12.0% of the variation between frequency of rewarding use can be explained by country.

None of the other items had significant variation by country.

Questions for TEACHERS with experience of specific approaches (teachers with experience of a specific approach and dual role teachers) (n=71, UK 24, Italy 15, Serbia 12, Greece 11, Norway 7, Belgium 2):

1/ Have you experienced a creative science lesson which fostered creativity in science? (Yes/not sure/no)

2/ What was your role? (4 options)

3/ Why in your opinion was it creative/did it foster creativity science?

4/ Have you taken part in: {Write a Science opera, Science Theatre, science café, other creative approach]

5/ What was the most important thing you learnt about creative science teaching through the event/project/resource/approach?

6/ Have you continued to use the ideas introduced in these projects- (4 point scale, never-very often)

1/ Have you experienced a creative science lesson which fostered creativity in science? (Yes/not sure/no)

	Belgium	Greece	Italy	Norway	Serbia	UK	Total
No	0	1	1	0	1	2	5
Not sure	1	1	0	0	1	3	6
Yes (% of teachers)	1 (50%)	5 (45.5%)	9 (60.0%)	4 (57.1%)	9 (75.0%)	14 (58.3%)	42 (59.2%)
Total ans (total teachers)	2 (2)	7 (11)	10 (15)	4 (7)	11 (12)	19 (24)	53 (71)

2/ What was your role? (4 options)

teacher of session	1	4	3	2	4	11	25
observer	1	0	4	1	0	5	11
trainee teacher	0	2	1	1	4	0	8
pupil	0	0	1	0	2	0	3

The CREAT-IT project has been funded with support from the European Commission under grant agreement 2013 – 3637 / 001 - 001

(Table 24) experience of, and role in, a creative science lesson which fostered creativity in science?

3/ Why in your opinion was it creative/did it foster creativity science?

- the strategy was to **guide the pupils** to **find each new idea by themselves** (Belgian teacher)
- we **worked together** and the students tried to **relate** what they have learnt in science with **everyday life** and the reverse. Then the students participated in theatre based on the chemistry they have been taught and organized a show with experiments. In that way they **developed** their **creativity**, their **imagination** and their **critical skills** (Greek teacher)
- **all students** could **participate**, **express themselves** and their **curiosity**, and **feel smart** in their **own way** (Greek scientist, teacher)
- **autonomy**; able to **collaborate freely**; a **down [bottom?] to top approach**; teacher was actually a **facilitator** (Greek Curriculum developer/ teacher)
- it presented rather **complex phenomena in a very simple way** based on **everyday experiences** (Greece teacher with experience of a specific creative science project)
- used **drama** in order to teach **lessons of the curriculum**, and **let the children investigate their own ideas**, **create their own projects** (Greek Scientist/ teacher)
- the pupils **discuss** among themselves about a question (Italy Scientist/ teacher)
- a **learning space** was given by **experimenting** with materials (ItalyCurriculum developer/ teacher)
- it **generated several perspectives** of the subject matter **simultaneously** (Norway CREAT-IT Consortium member/ teacher)
- it encouraged **creative exploration** in a manner where there was **no wrong answer** ie it was **"safe" to be unconventional** (Norway Scientist/ teacher)

- in the pupils art work it **showed their understanding** of the **scientific field** we were working on (Norway Teacher with experience of a specific creative science project)
- focussed on **exploring a phenomenon** of the **students own choice**; **promoted argument**, **evidence**, **planning** and **thinking strategically** in **designing** and **carrying out experiments** (Norway Scientist/ teacher)
- It helps students to **better understand** the materials (Serbia Curriculum developer/ teacher)
- resources were **based on what the pupils came up with**; little planning in advance - **teacher responded to the pupils feedback** and **that decided the path of the lesson** (UK Scientist/ teacher)

The CREAT-IT project has been funded with support from the European Commission under grant agreement 2013 – 3637 / 001 - 001

- **testing concepts** based on knowledge **without** specific instruction **using obtained skills** (UK Curriculum developer/ teacher)
- **students were driving their learning** forward by setting the questions to be answered themselves; teacher then pulls all the threads together at the end so that students have a **common learning outcome** (UK Scientist/ teacher)
- it **encouraged discussions** and **predictions linking children's understanding** of science through an **unusual way** (UK Curriculum developer/ teacher)
- children given a range of materials including cellophane, toilet rolls, cardboard, batteries , wires, bulbs and bulb holders, plus sellotape, masking tape, glue etc. children worked in pairs, first to create a circuit to light the bulb (or Bulbs), then **use this knowledge** to make a torch for a story character (UK Curriculum developer/ teacher)
- children **driving their own learning** (UK Curriculum developer/ teacher)

- open-ended **student led** investigations; problem solving tasks and challenges (UKCurriculum developer/ teacher)
- **grabbed childrens' attention** and related science to **real world** (UK Scientist/ teacher)
- exploring **pupil's own interests** (UK Scientist/ teacher)
- it showed the **essence of ideas** but needed further follow up (UKCurriculum developer/ teacher)
- **open-ended** tasks, **pupil-directed problem-solving** and **collaboration** towards ends (UK Scientist/ teacher)

4/ Have you taken part in: {Write a Science opera, Science Theatre, science café, other creative approach]

Write a Science opera	2
Science Theatre	2
Science café,	1
Other creative approach	7

N=71

(Table 25) number taken part in specific creative approach

1 respondent had taken part in both theatre and opera

5/ What was the most important thing you learnt about creative science teaching through the event/project/resource/approach?

Responses=7

The CREAT-IT project has been funded with support from the European Commission under grant agreement 2013 – 3637 / 001 - 001

- that promotes the students **interest** in science (Greek teacher with experience of approach)
- Pupils are more **interested** on subject, they collaborate and learn without tension and math anxiety. (Serbian teacher with experience of approach)
- The rise of the **interest** of the students for study (Italian teacher with experience of approach)
- That they learn something in a new efficient **way** (Italian teacher with experience of approach)
- That the more alternative **ways** you use to teach a subject, the most students you manage to approach. (Greek teacher with experience of approach)
- I myself learned something about the theme we were artistically working on. (Norwegian teacher with experience of approach)
- I'm not sure (Serbian teacher with experience of approach)

6/ Have you continued to use the ideas introduced in these projects- (4 point scale, never-very often)

4 = yes, sometimes, 4=yes frequently.

Lifelong Learning Programme

The CREAT-IT project has been funded with support from the European Commission under grant agreement 2013 – 3637 / 001 - 001

A.2 Ethical permissions

To comply with the University of Exeter's Policy on ethical research, and the ethical code of the British Educational Research Association, all those involved in interviews and observations were given written information about the nature and purpose of the research and asked to sign a letter of consent. Blank copies of these are presented here.

The CREAT-IT project has been funded with support from the European Commission under grant agreement 2013 – 3637 / 001 - 001

Information for Teachers and Headteachers

CREAT-IT Implementing Creative Strategies into Science teaching

This project is being funded by the EU as part of their Lifelong Learning Programme. The Project aims to develop training materials and conduct training events to support science teachers (of upper primary and lower secondary age) in using creative approaches which draw on the arts, in their teaching.
The project consortium includes members from Norway (the coordinating team); Belgium; Serbia; Greece; Italy and the UK (more information can be found at http://creatit-project.eu)

One of the tasks in the project is to interview a small number of teachers (one from each country) to learn more about the practice of creative teaching in science and what approaches and strategies are used.
Interviews will be conducted by skype or telephone, and by members of the project team at the University of Exeter. The interviews will be audio recorded and partially transcribed for use in the written text.

The outcomes will be used within the project reporting and academic publications that might be produced by members of the consortium.
For this reason anonymity as appropriate is assured.

Code of Ethical Conduct

- Data collection will only take place with the permission of participants.
- Any participant has the right to withdraw from the study at any time, by requesting withdrawal from Sarah Hennessy (s.j.e.hennessy@ex.ac.uk) or by verbal request. Participation is voluntary and any individual may withdraw at any stage, or avoid answering questions if they so wish. If this occurs no data concerning the participant will be analysed or published. Any isolated data concerning the participant will be destroyed
- All data will be stored confidentially and unless permission is given for it to be otherwise, stored data will not make reference to names or contact details and will therefore be untraceable. Images will be used for subsequent publication and presentations. Consent for publication of images is also included on the Informed Consent Form.

Contact: For further information, please contact Sarah Hennessy University of Exeter, St Luke's Campus, Heavitree Road, Exeter, EX1 2LU, or s.j.e.hennessy@ex.ac.uk.

The CREAT-IT project has been funded with support from the European Commission under grant agreement 2013 – 3637 / 001 - 001

Consent form for Headteachers

CREATIT Implementing Creative Strategies into Science teaching

Dear ……..

I am writing to ask permission for ……..to be observed teaching a science lesson.

The observation will help in the work of an international project 'CREATIT' which is funded by the EU Lifelong Learning Programme. The Project aims to develop training materials and conduct training events to support science teachers (of upper primary and lower secondary age) in using creative approaches which draw on the arts. The project consortium includes members from Norway (the coordinating team); Belgium; Serbia; Greece; Italy and the UK (more information can be found at http://creatit-project.eu)

One of the tasks in the project is to observe a small number of teachers (one from each country) to learn more about the practice of creative teaching in science and what approaches and strategies are currently used.
The observation will be conducted a member of the project team in the relevant country. The observer will take written notes during the lesson which will be written up and shared within the team. Any planning material and photographs of teaching resources that can be provided will also be requested. While pupils will not be photographed we would like permission to record anonymised examples of their work during the lesson.

The outcomes will be used within the project reporting and academic publications that might be produced by members of the consortium.

For this reason anonymity as appropriate is assured.

Code of Ethical Conduct

- Data collection will only take place with the permission of participants.
- Any participant has the right to withdraw from the study at any time, by requesting withdrawal from Sarah Hennessy (s.j.e.hennessy@ex.ac.uk) or by verbal request. Participation is voluntary and any individual may withdraw at any stage, or avoid answering questions if they so wish. If this occurs no data concerning the participant will be analysed or published. Any isolated data concerning the participant will be destroyed
- All data will be stored confidentially and unless permission is given for it to be otherwise, stored data will not make reference to names or contact details and will therefore be untraceable. Images will be used for subsequent publication and presentations. Consent for publication of images is also included on the Informed Consent Form.

Contact: For further information, please contact Sarah Hennessy University of Exeter, St Luke's Campus, Heavitree Road, Exeter, EX1 2LU, or s.j.e.hennessy@ex.ac.uk.

The CREAT-IT project has been funded with support from the European Commission under grant agreement 2013 – 3637 / 001 - 001

Consent form for Teachers

'CREAT-IT' Implementing Creative Strategies into Science teaching

This form must be completed in advance of observations.

Please read the Information Sheet about this study before signing below.

Consent to participate: teachers

I agree to being involved in this study. I understand that agreeing to do this means that I am willing:

- To be observed by a member of the project team during a teaching session
- The observed situations to be documented and, if possible, photographed.

I give permission for data about me to be stored securely, analysed and published, as part of the research and also for this information to be used within future online publications, written reports, presentations and journal articles which make reference to this research on the understanding that real names and contact information will not be used, unless otherwise agreed.

I understand that my participation is voluntary, that I can choose not to participate in part or all of the project, and that I can withdraw at any stage of the project without being penalized or disadvantaged in any way. (Consent can be withdrawn by contacting Sarah Hennessy during the sessions, or on s.j.e.hennessy@ex.ac.uk and simply requesting withdrawal)

My Name ..... (please print)

My Signature: .....Date: .....

Please email to ..... or give to the researcher.

Lifelong Learning Programme

The CREAT-IT project has been funded with support from the European Commission under grant agreement 2013 – 3637 / 001 - 001

Informed Consent Form: PARENTS

CREATIT Implementing Creative Strategies into Science teaching
Information for Pupils and Parents

This project is being funded by the European Union as part of their Lifelong Learning Programme. The Project aims to involve teachers in the use of creative ways of teaching and learning science in schools. This will involve giving teachers training sessions which use different ideas – such as drama music and art – to make science teaching relevant and exciting for pupils

The project includes members from Norway; Belgium; Serbia; Greece; Italy and the UK (more information can be found at http://creatit-project.eu)

For part of the work that we are doing in the project we are visiting a school in each country to observe a science lesson. During the lesson the observer will take notes about how the lesson is taught and what pupils do and learn. He or she might also ask to take some photographs to show how the classroom is organised and to record some of the activities and the work that you do.

The observer will be a member of staff of .....(institution).

The research is designed by the University of Exeter (UK) and follows its Code of Ethical Conduct which states that

- **You have the right to withdraw at any time, by request to Sarah Hennessy (s.j.e.hennessy@ex.ac.uk) In this case nothing that has been recorded by the observer concerning you will be used. All such data would be destroyed.**
- The names of schools/groups and those of the teachers and pupils will be anonymised unless they specifically request otherwise.
- All data regarding you will be stored confidentially and unless permission is given for it to be otherwise, stored data will not make reference to names or contact details and will therefore be untraceable. Images may be used for subsequent publication and presentations. Consent for publication of images is included on Informed Consent Form.

If you have any further questions, please do contact the researchers using the details below.

For the UK

Contact : Sarah Hennessy, email s.j.e.hennessy@ex.ac.uk; telephone: 01392 264858

(Insert name and contact details for other countries)

The CREAT-IT project has been funded with support from the European Commission under grant agreement 2013 – 3637 / 001 - 001

A.3 Example of semi structured interview questions for science teachers

1.Can you describe a recent example of a science teacher, whom you consider works creatively? This could be someone you worked with / who taught you / you have observed / or yourself.
What age / phase are they working in?
2.Why do you consider them to be creative?
3.What kinds of teaching situations or science topics would you expect to use a more creative approach?
4.Are there science topics / teaching situations where you would not use creative approaches?
5.Do you think it is important that teachers use creative pedagogies in the teaching of science?
6.Can you describe what teaching for creativity might entail?
7.Do you think it is something that teachers can learn to do i.e. to teach creatively or for creativity or is it a natural talent a teacher has?
8.What are the challenges you face when teaching creatively in the classroom?
9.What kind of characteristics do you think a creative teacher has?
10 Is there anything else you would like to say?

The CREAT-IT project has been funded with support from the European Commission under grant agreement 2013 – 3637 / 001 - 001