FOSTERING CREATIVE PEDAGOGIES IN SCIENCE TEACHING: EXPERIENCES FROM ARGENTINE AND SCOTTISH TEACHERS

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Abstract: In a rapidly changing world, characterized by large scale impacts of human activities on the environment, creativity has been foregrounded as a key capability in science to envision alternatives to current modes of development. We believe that the learning of science, as an intrinsically creative endeavor, can particularly foster students' creativity and prepare future generations to address global matters. Curricula worldwide have incorporated creative thinking as an important educational goal. However, developing creativity in students demands for creative pedagogies and the deconstruction of more orthodox ideas of science and associated learning and teaching practices. This paper reports on the findings of an ongoing three-year collaborative research between the University of Aberdeen, UK, and the University of San Andrés, Argentina, which aims to deepen the understanding of what constitutes creative pedagogies in science education, based on the construction of a model that links creativity with the "what?", the "how?" and the "what for?" of science. We explore teachers´ views on the opportunities and challenges of adopting creative pedagogies and the contexts that influence their practice through semi-structured interviews with 13 primary and secondary teachers from both countries. Our findings point to the epistemological enculturation of teachers, which in most cases confine creativity as a tool for the delivery of scientific information. Teacher conceptions on science and learning seem to strongly shape what they define as creative pedagogies. However, seeking for creativity also appears to open up opportunities for teachers to explore new ways of teaching and relating to knowledge. We conclude with suggestions for reframing science teacher education programs to include teachers´ engagements in critical, interdisciplinary and practical learning contexts in order to support the development of creative pedagogies.

Keywords: Creativity; creative pedagogies; science teachers; socio-materiality; sustainability science.

INTRODUCTION

Many countries across Europe, Latin America and the United States have recently undertaken reforms in their educational systems, which include explicit references to the importance of creativity as a key educational aim (Hadzigeorgiou et al., 2012; Wyse & Ferrari, 2015). As it is most generally defined, creativity involves a person´s ability to solve problems and come up with new ideas that are surprising yet intelligible, and also valuable in some way (Boden, 2001). While portrayed as a crosscutting dimension of learning, creativity is particularly promoted in science education as a means to prepare young people with the skills to develop innovative ideas for the future benefit of society.

On the one hand, the 'power of innovation' provided by an expanding scientific and technological enterprise promises smart solutions for further economic growth in a context of unprecedented profound and fast-paced transformations. Yet it is also a world with impending risks, which demands alternative readings of the role and aims of science in society. In this sense, interesting insights are derived from the field of sustainability science, focusing on the need to discuss complex, 'wicked', socially relevant problems both at local and global levels. From this perspective, creativity is essential to envision and develop alternatives to currently

failing systems, involving interdisciplinary approaches and collective work to address multidimensional problems.

So *scientific creativity* is a multi-faceted and complex notion set out to serve what may be radically different agendas and purposes. As reported by Kind & Kind (2007), this demands for a stronger analysis of its meaning and how it articulates with the ideas and practices adopted by teachers in science education.

Commonly, much emphasis on creativity in educational reform is framed within an economic paradigm. As widespread by policy reports and academic literature worldwide (UNESCO, 2006), creativity is defined as a process that serves individuals to meet the challenges of life and work in the 21st century. However, this definition is increasingly challenged by socio-cultural accounts of cognitive development and learning. Glăveanu (2010) describes the individualistic view of creativity as the "I-paradigm".. Counter to this relational and systemic views of creativity are put forth to consider individuals as 'expanded' actors. Known as the "We-paradigm" by Glăveanu (2010), creativity in this sense involves a collective interplay of ideation, exploration, creation and application in extended social, historical and contextual assemblages.

In science education, such conception becomes particularly relevant. Firstly, it can be argued that creativity has a key role in teaching in general, as teachers are routinely involved in a series of tasks that require them to make complex decisions with the aim of engaging students and fostering lifelong learning habits. On the other hand, given the current context in which reform processes around the globe also encourage teaching approaches that integrate enquiry as a central key for science learning and position students as knowledge producers in a community of learning (CFCE, 2004; NGSES, 2013), creativity (and more specifically creative pedagogies) can present an interesting opportunity.

However, a number of studies have pointed to narrow interpretations of creativity limiting the scope of application in science education to active learning pedagogies leaving aside more serious considerations about the nature of science and the nature of creative learning. By drawing on this framework, it is apparent that creativity in science education is a contested and shifting arena calling for further theorizing in light of the changing epistemological, social and political landscape. The purpose of this paper is to contribute to the discussion on the role of science education to prepare citizens for a world in transformation, with awareness of equity and sustainability. Particularly, we focus on the sets of tensions and possibilities for creative pedagogies in science education by looking at teachers´ perspectives. The following research questions guided the study:

- What are the teachers´ views on creativity?
- How are these visions related to their ideas of science?
- How do teachers´ views of creative teaching get enacted in varying contexts in Scotland and Argentina?
- How can teachers´ perspectives on creativity inform the development of professional development activities that aim to promote creative teaching in science?

CONTEXT OF THE STUDY

This study is part of an on-going three-year collaborative research between the University of Aberdeen, Scotland, and the Universidad de San Andrés, Argentina, aimed at characterizing teachers' engagement with creative pedagogies in science education. We adopted a comparative perspective to analyse if teachers´ views differ in varying contexts.

Scotland and Argentina share the global policy interest in creativity as a desirable dimension of teaching and learning (Wise & Ferrari, 2015). In addition, both countries have

incorporated an emphasis on skills-oriented education and a growing emphasis in promoting inquiry-based learning in science education. However, they differ greatly in terms of educational traditions, curricular structures and teachers' preparation. Most importantly, there are substantial differences regarding the social context in which schools and teachers operate.

In Scotland, national exams provide a specific framework of expected student learning achievements. However, the newly implemented Scottish Curriculum for Excellence promotes the pro-active role of teachers, who are required to "apply professional judgment in planning programmes and activities to respond to the needs of individual children" (Scottish Executive, 2004: 16). Scottish teachers are trained within the pragmatic and socio-constructivist tradition (Driver et al., 1994), which is expected to provide the philosophical orientation for science education pedagogy in pursuit of social and educational inclusion.

In Argentina, curricular guidelines are defined at jurisdictional level drawing on a set of national priority learning goals (NAP, for its Spanish acronym). They provide general orientations for teachers to follow and only loosely prescribe expected student outcomes. Moreover, students do not need to take standardized exams to accredit for their learning achievements. Despite the socio-constructivist approaches claimed by local curricula and having relatively high levels of autonomy, studies have shown that in Argentina (as in most Latin countries) teachers adopt traditional pedagogical methods based on the transmission of knowledge (Valverde & Näslund-Hadley, 2010). In addition, the country has a very high dropout rate at secondary level (Rivas et al., 2010).

So the teachers working in the two countries are influenced by very different sets of constraints and opportunities: within the scheme of a mandate curriculum, Scottish teachers appear to be more accustomed to socio-constructivist pedagogies including a range of active learning strategies in science education. Conversely, in Argentina teaching approaches could play an important role to get children to come to school and to value their own education.

METHODOLOGY

This study took an international, constructionist and exploratory orientation. We adopted a qualitative and inductive method to inquire on teachers´ perceptions on creative pedagogies in science education. Forty-minute semi-structured interviews were held with 13 teachers, 7 from Argentina and 6 from Scotland (See Table 1 below), where teachers shared their professional biographies, their views and practices regarding creative science teaching and their perspectives on the contextual factors that shaped creative pedagogies.

It must be noted that participating teachers all had prior involvement with arts-based and inquiry-based approaches in science education and displayed a generally positive orientation towards creative pedagogies. Hence, this was not meant to be a 'representative' group of the entire teaching population. On the contrary, they were willing to share their efforts to introduce pedagogical innovation by means of creativity.

Equally, teaching contexts varied greatly in an attempt to enrich the analysis. The Argentine system features a three-way school system, including public, private and also private faith schools catering for students in large deprived areas. Scottish teachers were all working in State, secondary schools, including both rural and urban areas.

Table 1. Characterization of participating teachers and teaching contexts

Argentina		
Alisa	Private School	Kindergarten
Martha	State School	Primary Level
Felicia	Private School	Primary Level
Natalia	Non-profit organization	Secondary Level
Andreina	Private School	Secondary Level
Carmen	Private, Catholic faith School	Secondary Level

Valeria	State School	Secondary Level
	Scotland	
Jackie	State School	Secondary Level
Janine	State School	Secondary Level
Macy	State School	Secondary Level
Linda	State School	Secondary Level
Lorraine	State School	Secondary Level
Hailey	State School	Secondary Level

Data was analysed through thematic-analysis looking at teachers´ visions on the nature of science and science teaching. We also looked at the characteristics of the school context, including support, opportunities for collaboration with colleagues and professional development, as well as the role of curriculum and assessment systems. Teachers' views of were analysed as stemming from a range of performative practices (Edwards, 2010) embedded within institutional, cultural and epistemological contexts.

FINDINGS

Looking at the cases of Scottish and Argentine teachers, we reconstructed a definition of creativity and creative practices, and identified tensions and possibilities for their implementation in science teaching. We also found key similarities in the ways teachers conceive these notions in their respective contexts, as well as some interesting differences. We believe these findings give us important clues for the creation of future professional development programs on creative pedagogies in science.

Defining creativity in science teaching

While all the teachers interviewed were acknowledged to have been employing creative pedagogies, we found interesting differences in their notions of creative teaching and how they saw themselves as creative practitioners. In most cases, teachers appealed to concrete examples from their teaching practices to define creativity. When analysing their testimonies, we could distinguish three main categories to describe their views: a) as a more attractive way to present scientific content or communicate knowledge, including the construction of a product on behalf of the students (what we will call the "what" of science), b) as linked to the scientific way of knowledge generation (the "how" of science), and c) as a means to address socio-scientific issues (the "what for" of science).

Making knowledge attractive

Most teachers defined creativity as finding new and more attractive ways to deliver scientific content to students (the "what" of science), with the aim of catching the students´ attention and interest. In Janine´s words: "*I think it´s just about finding ways of making...engaging with science that´s not boring to them*" (Janine/S).

In broad terms, teachers converged on the idea that creative teaching injects an element of pedagogical innovation as opposed to having students work with textbooks. For instance, Jackie expressed: "*it just allows you to step away from a textbook at the core but achieving outcomes just in a different way*" (Jackie/S). In this sense, a common approach amongst teachers is to utilize posters and images as a way to present facts and concepts, recognizing that pupils have different learning styles and thus require a variety of opportunities to engage with content material. Another creative strategy implemented by teachers is the design and use of board games to address curricular content.

It becomes evident then that some teachers consider that creativity has to be incorporated to "sugar coat" scientific content, which, otherwise, is not engaging enough for students. As one teacher from Argentina expressed: "*the challenge in science is finding a more creative approach, precisely because everything is totally determined and specified, and the*

scientific method is pretty repetitive. I think it´s all about finding a creative approach to science to make it attractive for children" (Alicia/A).

At this point it is interesting to note that in Jackie's (S) reference to the word 'outcome', and to some extent also in Alisa's (A) remark on the 'fixed' nature of scientific content, a certain conjunction emerges between science as a body of facts and learning science as some kind of pre-determined end-point, which is set *a priori* by the teacher following a curriculum. In this sense, creativity is defined in the main as a medium, often a strategy or a tool, which appears to be strongly regulated by the need to draw students' interest to specified content. Thus such definition of creative pedagogies is strongly related to the teachers´ own conceptions on science and learning, even trespassing the commitment teachers may have to socio-constructivist pedagogical practice.

Secondly, although very closely related to this perspective, teachers also identify as creative pedagogies initiatives where *students* have to communicate knowledge. That is, having an audience - peers, younger students or the community in general- or building a product of any kind as a result of their learning process. The most typical example of this is having students build models or posters, but some teachers from both countries also mentioned the production of different awareness campaigns either through videos or leaflets.

Figures 1 and 2 below provide examples of students' products, which include their display as a means for exhibiting their knowledge and sharing it with others. Figure 1, for example, shows the final product made by students in an activity in which they had to recreate the diversity of species of flowers in a garden using a variety of materials.

Figure 1. An example of creative display of content ("Making worlds", Janine/ S)

Figure 2. An example of creative display of content (Doggy genetics, Janine/ S)

In this sense, some teachers seem to show awareness of the relevance of the creative medium for 'translating' canonical, static information (the facts of science) into a dynamic process. Moreover, they relate the engagement of students in creative products with the purpose of reaching learning goals in a more memorable way, activating personal preferences and emotional drive. So the creative medium is not only a means to an end - that is, reorganizing and remembering content - but a way to expand one's possibilities to learn about the subject in a more dynamic and integrated manner.

Figure 2, on the other hand, shows an activity Janine (S) proposed to work on the concept of gene selection. This presents an interesting example whereby the use of coloured cardboards act as symbolic representations of genes, allowing students to tamper with concrete materials to deepen their understanding on the topic. About this Janine stated: "*Obviously, we can't, you know, use real animals… so I do my doggy genetics…*" (Janine/S).

Similarly, the experience described in Figures 1 and 2 could represent a first type of socio-material engagement involving the act of working with physical resources and *'making worlds'* (Ingold & Hallam, 2007). By having students use modelling to produce knowledge, Janine (S) could extend cognitive activity and engage students with the epistemological (knowing) and ontological (being) aspects of science (Daugbjerg et al., 2015).

However, from this perspective, creative teaching is still strongly associated with knowledge acquisition. In every example given there is a persistent, strong pull towards curriculum and content delivery. Therefore, despite the potential of some of these activities, the opportunity to grapple with the more uncertain and imaginative aspects of science is undervalued; they still have untapped potential to pursue a deeper understanding of science.

Thus, creative pedagogies seem insufficient to promote a deep understanding of science within the strong frame of science as content. A tension emerges between creativity as a medium for acquiring knowledge or as a process for its generation, which requires to be further analysed in terms of the models of scientific inquiry that teachers hold.

Science as a creative endeavour

Stepping away from the conception of science as a body of facts and teaching as the delivery of content, some teachers referred to creative pedagogies in ways which relate to the scientific way of approaching the world (the "how" of science), by positioning students as knowledge generators through activities that foster scientific skills and inquiry practices. In expressing their ideas of creativity, teachers drew a conscious connection between their own sense of creativity in teaching and science as a creative endeavour.

Teachers agreed that teaching creatively involves skills that are not commonly promoted in class, such as to hypothesize, to experiment, to explain and to draw conclusions within open inquiries linked to real life situations. For example, Alisa (A) described an activity in which her kindergarten students had to grow vegetables in the orchard. She defined this activity as creative because students had to identify and solve different incidentals that arose during the growing process by finding possible causes and testing alternatives. Moreover, she explained that *"what was creative was that they allowed error"* as a constituent part of the learning process: *"we do not follow recipes; we test, make mistakes and we sat down to reflect on what it was that happened, what went wrong"* (Alisa/ A).

Along similar lines, Natalia (A) offered a specific articulation of inquiry-based teaching in science. In one of the activities described, she showed students how a magnet attracts a nail and consequently acquires certain properties. She then encouraged the students to work in groups to think out questions related to this phenomenon, collaboratively design experiments, draw diagrams, compare and debate over their results, formulate theories to explain it and pose new questions that opened up from what they have learned. In doing so, she pointed out that there is a constant dialogue between students and teachers and that knowledge is built by taking part in guided investigations within a community of learning.

Inquiry-based pedagogies in this sense present an interesting opportunity to enable the "learners´ world of knowing" draw closer to "the science world of knowing" (Braund et al., 2015), valued for its cognitive, social and emotional dimensions. In Natalie´s words: "*Science is all about asking questions and finding the way to answer them, and that is creative. (…) This process can be easily replicated in class"* (Natalia/ A).

It must be noted as well that these teachers highlight the importance of relating more directly with phenomena, which in turn implies trespassing the limits of the classroom and even of the laboratory. Martha (A), for example, made deliberate use of the outdoor space for teaching about concepts in astronomy, fostering "*research in direct contact with the environment"*. Therefore this take on creativity in science not only involves a socio-constructivist approach but also stretches into exploring inquiry into the materials and actions

in the open world; *"experiential openness"*, as Martha (A) defined it. In so doing, they stretch beyond laboratory science and introduce students to more contemporary forms of scientific inquiry that are taking place in the real world, with its complexities and unknowns.

On the other hand, also in looking to engage students in the process of scientific inquiry, some teachers mentioned the integration of its historic dimension. Andreina (A), for example, deliberately challenged the false expectation that science is a linear process by engaging students in researching and making up stories about scientists in their real life, such as Darwin. Through this activity, Andreina stimulated students to get immersed –cognitively, socially and emotionally- in the historical and cultural context of the time, thus helping them make sense of ambiguous and challenging ideas.

We have seen in these examples that creative approaches can relate to the "how" of science, presenting opportunities for students to learn beyond scientific knowledge as a body of facts and engage in the nature of science as a process. Moreover, extending the inquiry through space and time uncovers important dimensions of a more holistic, interdisciplinary science, which in turn has the potential to raise key questions about the ethics of science and technology. It must be noted, however, that the deliberate move away from conventional laboratory practices is not directly linked to or driven by an articulated, critical reflection on the purposes of science or the need to address the inevitable ethical issues. Therefore, we have also identified in the activities described further untapped potential to promote a more comprehensive idea of science as a creative, social endeavour, far beyond enhancing pre-determined curricular topics.

Engaging students with the purposes and dilemmas of science

Within a context that demands the solution of pressing socio-environmental issues and constant innovation, the need to frame science teaching within a deeper reflection on the purposes and dilemmas that science presents to society –the "what for"- may become evident. However, none of the teachers specifically defined creativity in science teaching as addressing socio-scientific or global issues such as the ones described by Montuori(2012).

The only example that comes closer to this conception of a creative approach in science teaching is an experience described by Carmen (A). In the context of a class called "Environment and Society" in a private faith-school in a heavily deprived area of Buenos Aires, Carmen asked her students to explore the school and the community in search for risky situations that needed to be investigated. As a result, students designed and conducted a research focused on the garbage treatment and consequent pollution in a nearby stream, combining both scientific aspects and social impacts. Working in groups, students had to design an investigation, hypothesize, interview key actors and members of the community, perform tests and draw pertinent conclusions based on the gathered data.

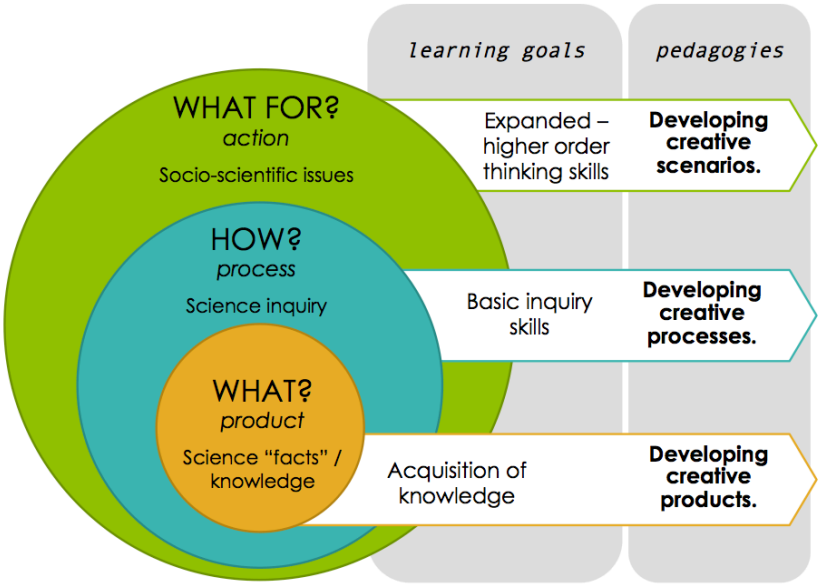
It is remarkable to note how the activity described by Carmen moves away from the conventional practice of science education in schools. Carmen makes a deliberate choice to *involve* her pupils, far beyond content knowledge. In her own words: *"by observing the environment to determine where the garbage is going and find a solution, and by making them be part of that solution, you are also teaching them how to live"* (Carmen / A). Hence creativity in this sense exceeds the notion of a pedagogical strategy or tool to become a 'modus operandi' or 'pedagogy', with the power of changing the status of the students from 'passengers' to 'inhabitants' of their own world (Ingold, 2007). It sets the spirit for an inquiry moved by real necessities by real people, which reminds us of the ultimate purposes of science and science education.

Creativity in science education: a tentative model

In all, teachers seem to refer to rather different ideas and purposes of creative pedagogy and practices. As we described earlier, we found a continuum between the conception of creativity as a vehicle to deliver scientific knowledge in more attractive ways and understanding creative teaching as providing opportunities for students to engage with scientific explorations in order to understand the natural world around them and themselves in their own communities. Along this continuum there are different underlying ways of understanding science education as a context that promotes the development of creative teaching, which are profoundly related to the ways teachers conceive the nature of science and learning. On the one hand, most teachers find scientific content difficult or arid for children, and therefore attempt innovative ways to present it to their pupils. Some others, as described, believe science is creative in itself and associate learning with involving students in the process of scientific inquiry. Finally, we only incipiently found a broader understanding of science and its purposes linked to higher expectations for education in general.

Drawing on the literature review and these findings, we constructed a tentative model to represent different approaches linking science and creativity: the "what", the "how" and the "what for" of science, as illustrated in Figure 3 below.

Figure 3. A model to present different approaches linking science and creativity



In the centre of the model, creativity is understood as a vehicle for the acquisition of knowledge mainly understood as a body of facts. These initiatives are usually related to an instrumental view of creativity as a means to transfer content and are commonly associated with the elaboration of products, either by students or by teachers. However, it must be noted that this perspective is not always limited to superficial, aesthetic approaches, but sometimes also includes initiatives that promote students´ understanding of key concepts of science.

Secondly, in line with a definition of science as intrinsically creative, creative pedagogies can be linked to scientific inquiry (the "how" of science). These usually include emulating basic skills and practices (experimentation, hypothesizing, etc.) within the context of inquiry-based pedagogies and engaging students in the process of knowledge generation.

Finally, close to what Montuori(2012) proposes, we believe creativity can (and should) be linked to science to address complex socio-scientific issues through the development of creative scenarios with interdisciplinary approaches. These initiatives aim to develop in students expanded higher order thinking skills and a reflection on the purposes (the "what for") of science. This is depicted as the third level of the model.

Despite these levels implying increasing complexity and completeness in addressing scientific content, we do not intend to present them as a fixed hierarchy. On the contrary, they can be related dynamically according to the teaching purposes and goals. In fact, as found in the interviews, teachers often combine these views when planning their lessons.

Different contexts, converging practices

In addition to describing teachers´ perspectives on creative pedagogies in science, we were interested in understanding the ways in which contexts shape teachers´ creativity. We found some interesting differences in the ways Scottish and Argentine teachers conceive and implement creative pedagogies in their respective contexts, but also some key similarities.

On the one hand we found that teachers in both countries define creativity as an individual trait, something that you bring (or not) to the profession. Teachers connected creativity to their own personalities, which they defined as imaginative, permeable, curious, innovative, restless and fearless, as well as being "hands-on" kinds of people. To them, creativity had to do with a particular mind-set implying the aim to do something innovative in the classroom. All of them described how creativity was not too common in their school scenarios and how they stood out as going "against the grain". Some even expressed a feeling of solitude or "being in a vacuum" (Hailey/ S): *"I feel that, you know, these kids are getting quite a good deal from me, but then they go to another subject or they get another teacher and they´re back to a copy off the board"* (Janine/ S).

Along this line, teachers defined contexts as enabling or limiting their personal creative features, rather than creating the conditions for collective creativity to develop. To this regard, most teachers pointed out the importance of the headmaster´s role to provide them with the necessary resources, freedom to do the activities they envision and the possibility to take professional development courses on science and science teaching. For example, Felicia (A), when asked what kind of support teachers need to adopt creative pedagogies expressed: *"First of all, support from the heads. If the heads believe that science is an important subject they will give the teachers the freedom to be able to work in that area. That freedom also has to do with allowing the teacher to be able to investigate, to be able to go to courses, to be able to gather the knowledge in order to become a teacher that will teach science creatively".*

Teachers in both countries also considered the availability of resources as a key factor to enable their individual creativity. For example, Alisa (A) and Martha (A) emphasized the importance of having the required materials and an adequate place (like a well-equipped lab) to carry out creative activities successfully. However, Carmen (A) described the limitation of resources as a trigger for creative pedagogies. On one occasion, she was unable to take her students to the local zoo given budget restraints and therefore decided to build one inside the school. *"The condition was that everybody had to bring an animal, whether dear or alive"*, she explained. As a result, *"students brought marvellous things, a lizard, a bunny, a turtle found in the nearby stream, insects, embalmed owls"*, which they had to analyse and classify. Thus Carmen openly uses creativity to address the limitations of context and resources and actively draws on the community of the school, "working within and around the system" (Cochran-Smith, 2004). Her experience not only exposes the dual incidence the availability of resources may have on creative pedagogies, but also provides evidence of the transformative and empowering nature of creativity as a way of becoming involved in the world.

Another concerning factor for pursuing a creative agenda is the limited time to cover extensive curricula, as teachers from both countries reiteratively pointed out. For example, Janine (S) clearly stated that *"there is no time to deal with controversial issues"* in class. Many teachers also explained that they have lots of innovative materials and activities prepared, but if they find themselves struggling with time, they have to go back to more traditional lectures using blackboard and chalk: *"…at the end of the day when you´ve got a deadline coming up it, it ends up its chalk and talk to get the course finished if we need to"* (Lorraine/ S). Hence we

see that material choices regarding the use of time are inevitably reflecting value-choices of teachers operating within a curricular structure. This was particularly true in the Scottish context, given the highly prescribed curricular guidelines. Teachers described how, in combination with the external exam system driven by the Scottish Qualification Authority, curriculum acts as a pressing constraint to adopt creative approaches, particularly in senior years. We begin to notice here a tension between the drive to put forward a way of teaching and learning that is creative and dynamic and the inevitable confinement within particular boundaries.

However, it is interesting to note that even in a different educational context such as Argentina, where there are no national or state student examinations and curricular guidelines are more broadly defined, teachers appear to adopt very similar approaches, often linking creative pedagogies to the delivery of scientific knowledge. Thus, even with looser time and content constraints, teachers seem to find other difficulties that shape their teaching practices.

We believe that despite the profound differences in macro and institutional contexts, the particular type of creative approach teachers put into practice (in this case predominantly from the first level of the model) is more closely related to their epistemological enculturation, that is, the way they conceive science, the purposes of science and science education, and learning in general, rather than contextual constraints.

Finally, one of the significant points of commonality between teachers from both countries was that they all mentioned trying to find new creative ways to teach science for their students´ benefit; they explained that their motivation is rooted on the impact these approaches have on students´ learning and well being. As Alisa (A) declared, she was moved by *"what kids gave to her in return"*; she said that their interest and natural curiosity *"encouraged her to change her practice"*. Others expressed that those students that are more reluctant or seem to have difficulties specially motivated them (Carmen/A and Janine/S).

DISCUSSION

There is little doubt that creativity is an important trait of all good teachers. Following the argument developed by Ingold and Hallam (2007), creativity is ubiquitous in cultural life and, by extension, also in school life.

Considering creativity from this perspective of the cultural life of teachers can open up new understandings on their ability to operate in different contexts and to establish important connections with the scientific enterprise. We begin to see that according to this analysis bringing creativity within science education can be a means to counteract some of the concerns advanced by Ryder (2015), who laments teachers´ state of disempowerment. As we have seen, curricular prescriptions do appear to constrain or baulk the creative process, but teachers also have the ability to create and make worlds through creative endeavours.

In this study we found that teachers predominantly define creativity as an individual attribute linked to their core identities, a personal (and distinctive) input to the profession. For most of them, being creative often means going 'against the grain'. Nevertheless, teachers also recognized that creative practices demand wider social networks for their development. This recalls the arguments of McWilliam & Dawson (2008), who pointed to a mixture of "first generation" (individualistic) and "second generation" (social, pluralistic) understandings of the teaching profession and –we could arguably include- of creative pedagogies. In this sense we believe that moving the focus from the individual to a more social approach of creative teaching can open up opportunities of engaging with the new epistemological, ontological and pedagogical aspects of the profession.

However, it must be noted that calling to this broader perspective of creativity does not imply taking the context as a mere framework, a set of external features that can unilaterally enable or limit creative practices (as expressed in the teachers´ testimonies), but points towards

considering the complex interplay between the person, the social system in which he creates (the field) and the symbols related to culture in which he operates (the domain). From this systemic perspective, creativity is contextual and generative; it is embedded within a socio-historical and cultural setting, and emerges from pre-existing knowledge (Csikszentmihalyi, 1999). The We-paradigm comes forth in this sense as an interesting lens to study creative pedagogies in science, for it promotes a contextual and situated study of creative acts, persons and communities (Glăvenau, 2010).

On the other hand, we found that creativity itself is of little value when detached from a deeper reflection on the nature and role of science education. There is a widely shared idea that science education is key to prepare future citizens to envision actions that will tackle urgent global matters, such as environmental and public health issues. This requires subject matter knowledge, but also a significant deal of contextual sensitivity. From this perspective, then, scientific literacy does not only imply the enunciation of scientific facts or contents, but to embody a particular way of knowing in which creativity is fundamental. However, this seems inconsistent with what happens in real classrooms. In our case studies, both Argentine and Scottish teachers predominantly engage with creative pedagogies for the delivery of scientific content (Level 1 of the model) and we only found very tentative evidence of a deeper understanding of the scientific way of knowing and its purposes.

When analysing the data, we have found that while external conditions can trigger teachers to adopt creative pedagogies (or not), the particular type of approach they implement is more closely related to their epistemological enculturation. That is, as we have exposed, their conceptions on science, science education and learning. This has interesting implications in teacher education, for it strongly suggests the need to foster a more comprehensive understanding of science, not only as a product but mainly as a process involving cognitive, emotional and social skills. Enhancing practices that engage both teachers and students in the third level of our model –the "what for" of science- implies participating in science as a process of inquiry and being in the world, which involves working with others and the integration of multiple disciplines and languages.

Thus, our data points to the significance of fostering this reflection as a fundamental component of science teacher education, alongside helping future teachers develop creative strategies to enhance their practice. It is not simply and not only a matter of curriculum. On the contrary, it requires teachers to be able to sharpen their ability to articulate meta-reflection as well as 'reflection in action', both on the nature of science and science learning.

In all, our work offers a starting point to design teacher workshops on the topic of creativity in science teaching, which was a key part of the research collaboration amongst our two countries. Our findings show the importance of building with teachers a conceptual framework of the nature and purposes of science and science education alongside the development of creative professional skills in order to 'work from the existing sets of practices and understandings to create new ones' (Ingold & Hallam, 2007). In addition, our findings point out to the importance of engaging teachers in critical, interdisciplinary and practical learning contexts in order to support the development of creative pedagogies.

This research steers away from previous studies, which accurately described teachers´ beliefs and views of science as a pre-condition for justifying the practices of teachers. Rather it suggests another way of looking at teachers´ preparation: it is through the idea of teachers´ proto-perspectives of knowledge, values and practices, which are fluid and *in-action*. Important new lines of research can be developed in order to find appropriate methods to describe and to support teachers´ reflection *in-action.* Moreover, this idea reveals the importance of understanding creativity as a key component of teachers' identity, to nurture and include more social views on the matter to help them embrace a collective paradigm.

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