Science Education in Europe: Pedagogical Challenges

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Abstract

In 2007, the Rocard report highlighted concerns with the type of science education presented in European classrooms [1]. Despite research on consrtructivism research teaching science remained mainly through a 'transmission approach' whereby the teacher passed on all the scientific knowledge that students had to then assimilate [2]. The result was a combination of active teachers and passive students. Furthermore, whereas science became more poignant in everyday life and science related careers increased, students' interest and specialization in the field decreased drastically, creating a significant disparity between supply and demand. In this perspective, research and science educators have acknowledged the need for a change in both the quality and methodology of teaching science wherein students are given the opportunity to explore and engage in science and in doing so, to be the drivers of their own learning [3]. The European Commission has taken on the responsibility to support professors and academics working in this field, to adopt this inquiry based learning approach (IBSE) by financing projects such as PRI-SCI-NET, which focuses on equipping educators, particularly teachers, with the tools, skills, networking and collaboration opportunities to further enhance their repertoire. This paper focuses on the methodology and objectives of PRI-SCI-NET in addressing science education at primary level.

1. Introduction

Educating young learners to actively participate and drive their learning process is one of the main challenge for 21st century science education. This challenge has been recognized for science education as well as the need to foster such independend in learning from an early age. The European Commission has acknowledged the need to have a constant supply of scientists to feed into research and innovation in industry. This bring with it the challenge of developing, over and above the traditional scientific process and contence knowledge, the skills of reflection, opinion formation, and of advocacy in order to have active citizens. There are various problems with the current pedagogy ptovision of science education with young children at primary level. Research in the United Kingdom shows how children's conceptual level of understanding has decreased since the 1970's [4]. Various studies have offered different reasons for this phenomenon, these including; poor teacher attitude, lack of investment, lack of community engagement and poor textbooks and educational material [5]. Gender and cultural issues were also highlighted as catalyst with some suggesting that although females and minority groups express similar or more interest in learning science and participating in science activities they are allowed less or experienced more limited opportunities than male cohorts, resulting in a narrower perspective of science and its usefulness [6]. In addition, socio-economic dilemmas were also noted to decrease the uptake and investment in science careers [7] with students from lower socio-economic areas performing less well than those from middle class localities. Furthermore, the current pedagogy has also been criticized for being too reliant on language proficiency, creating difficulties for those learning science through a foreign language, in particular as many scientific concepts lack adequate translation from English into the various languages [8]

Over the years there were many attempts to address these issues. However, the limited impact of various education systems reforms attempts and the significant irrelevance that primary science education seems to have for polilcy makers, has resulted in a decrease in the uptake of scientific careers. This has led the European Commission to invest significantly to address this situation [9]. In this perspective, the Rocard Report [1] identified inquiry-based learning as that pedagogical approach which enables students within compulsory level of education to develop both an understanding of scientific concepts as well as the necessary critical skills for questioning and testing their own ideas, and eventually that of others, whereby they are capable of using the evidence collected to draw conclusions and formulate informed opinions.

PRI-SCI-NET is just one of the mainly initiatives supported by the European Commission that addresses primary science education. The project addresses the empowerment and professional development of teachers and teacher-trainers. It is a 3 million euro project coordinated by the Malta Council for Science and Technology (MCST) and has 17 partners from 14 European countries. Through its execution, it provides a platform for teachers to learn how to implement, engage with and develop Inquiry-based activities for use in the classroom. Some of the project's milestones include the development of 45 IBSE activities to be translated in 15 different languages and the training and networking of primary level teachers in the partner countries. The great challenge faced by the project is that of promoting a change in pedagogy across Europe across different contexts and cultural and linguistic ways of doing things.

3. Literature Review

Through the Lisbon Strategy leaders in Europe have set the target to make Europe 'the most competitive and dynamic knowledge-based economy in the world, capable of sustaining economic growth with more and better jobs and greater social cohesion' [9]. In order to keep up this competitive edge over the rest of the world, one of the specific targets set was to increase the number of graduates in science and technology, hence ensuring future capacity for research and innovation as well as societies of active and informed citizens. This target is still present within the updated EU2020 Strategy [9].

There is currently a gap between the way science education is delivered in classroom and the way it is perceived by society and portrayed through social media. This has led to a drive towards reducing the gap between scientists and citizens understanding of scientific concepts and their impact on the daily life. Furthermore, research has noted that science education is best served through self-discovery and exploration as opposed to knowledge obtained and absorbed, without question from educators.

Education systems have the responsibility of preparing future generations for the world to come, and yet they reflect systems and processes which are adapted only to the past. Researchers know that inquiry-based learning works as it engages students and helps them develop the skills to question and test things. The approach also allows space for students to approach challenges with an open mind and to search for answers which are the best fit and which have been shown to provide the best solution to the problems identified. One such example is a study by Trigwell et al, who compared teacher's approach to teach and student's approach to learning and found that in those classes were teachers were intent on transmitting the curricula required knowledge, students adopted a more surface approach to learning, whereas, in those classes were teachers adopted a more student oriented approach, the latter adopted a deeper approach to learning [2]. These and similar results highlight the importance of improving the quality of student learning and discouraging teacher-focused learning. However, as yet, this pedagogy is far from full implementation in schools across Europe.

Inquiry-learning has faced many hurdles in its implementation in particular as school systems and teachers often have little experience or resources to invest in its successful implementation. In particular, primary science teachers are often expected to teach a variety of subjects and are very often not specialized in science education. In such circumstances, students may pick up teachers' discomfort with the subject and are often not given the space to question scientific concepts but instead instruct to take what is given at face value. As such, PRI-SCI-NET recognizes that the first step towards addressing a change in pedagogy is the empowerment of teachers and teacher-trainers. That is, teachers need to experience inquiry first hand, both to understand what it is and it entails, as well as to gain the required confidence to adopt the approach with the children that they have been entrusted with the responsibility of educating.

Keys and Bryan note that the responsibility of a successful pedagogical reform lies with the teacher and call for transformational models in teacher training [10]. Guskey also identifies the need for Continuous Professional Development (CPD) to enhance teachers' content and pedagogical knowledge; provide adequate time and resources; promote collegial and collaborative professional exchange among teachers; give teachers a chance to evaluate their CPD experience [11]. In addition research observing acquired knowledge and confidence in IBSE amongst teacher trainers who followed an intensive training in IBSE and those who did not have this opportunity highlighted that compared to the traditional university training, the former group were more motivated and cognitively challenged than the latter [12]. However, a key challenge teachers face is implementing IBSE within the strict curriculum framework imposed by the educational system and with the limited resources often available.

Schools also function within the model of a classroom with children sitting at desks, and little room for open spaces. Teachers are required to work within such system, and often experiences great challenges to do things differently to that of reading off books and talking to children as the main way through which they learn. Pri-Sci-Net's objective is to support teachers by providing 45 activities in IBSE for children of different ages between 3 and 11 years, translated in 15 different languages. Furthermore, it provides a networking platform where teachers can share experiences, knowledge and material across Europe. Notably to ensure the material developed was of high quality, the project invested in the trailing of activities to ensure adequate translation in the different languages. This process meant teacher now have available 45 tried and tested inquiry based activities that directly relate Furthermore, the project is investing in teacher by providing them with training in how to engage with students through IBSE, how to support their learning and how to develop future activities for use in the classroom. More poignantly the project is geared towards empowering the teacher to feel confident in adopting IBSE and increasing the amount of science education provided at primary school level. In this regard, research has pointed to the necessity for continuous teacher support programs, that continue to expose and address the advantages and disadvantages of the IBSE pedagogy and that enable the further development and refinement of its implementation in the classroom [13].

3. Method of Evaluation

The 45 activities were chosen through a complex selection process. Using the vision developed by the groups eight criteria: authentic activities; inquiry based activities; active engagement of children; collaborative group work; observation; evidence; discursive argumentation and communication; and self-regulation were identified for each inquiry activity to need to have. From a large number of activities submitted by the consortium, 45, 15 for ages 3-5 years, 15 for the ages 6-8 years and other 15 for the ages 9-11 were selected. This was but just the first step of the process.

It was acknowledged that simple translation into different languages was not enough but there was need to understand those cultural and linguistic issues which need to be taken care of during the translation process. For this reason, 15 out of the 17 partners were to trial at least three activities.

Teachers in schools were identified and research tools for evaluation developed. The research tools involved the following: non-participant observation of the lessons; interviews with four children from the class, and one interview with the teacher. The non-participant observation provided the researcher with an understanding of the context in which the activities was being carried out as well as provided first-hand data on the level of effectiveness of the activity and to identify any difficulties and problems which may arise. The children's interviews probed how much they enjoyed and feel engaged in the activities, identifying anything that they were unfamiliar with or did not understand and how they compared such science with the usual way of doing science. The teacher was asked to reflect on the adaptability of the activities and to indicate any challenges or difficulties which they encountered due to doing things differently.

The activities carried out in Malta were from the age range of 3-5 years and included a trial of 4 activities in five classrooms. The activities were: one about magnets where children had to find ways of determining which of five wrapped objects was a magnet without unwrapping any of them; one focused on walls and testing the different designs for their strength; one on balloons and the best tail to have to make it fly horizontal or vertical when released; and one on floating boxes and how much marbles are necessary to make it sink. The balloons and walls activity was tried out with 5 year olds, the magnets was tried twice, once with 4 and once with 5 year olds; and the one on floating was done with 3 year olds.

4. Results

The observations demonstrated that there was a lot of engagement by the children. This was most evident and structured in the case of the 5 year old children. They understood fully the question or problems posed, and were aware of what they had to find or test in the science activities. The 4 year old children were found to understand what the magnet challenge was about and knew that they had to find which present was the magnet. However, they were less structured in the way they went about trying to find the magnet, and collaborated less than observed by the 5 year olds. The three year old activity was less structured and it was difficult at times to move them away from playing to focusing on what happens when you put objects in water and when you put marbles into a floating container. However, when interviewed, the children none the less were still able to articulate what the activity was about.

A number of challenges were however identified at different levels. One challenge was at system level where typical school curricula tend to emphasise written activities and more traditional modes. Although not impossible, it could easily be that such IBSE activities to end up excluded from the syllabi as they tend to promote more cognitive thinking and inquiry skills rather than content. The education value of inquiry may not be valued. This was stated by the teacher despite a recent policy document published in Malta which commits to have inquiry-based learning in science as the main pedagogy for doing science.

The teacher, however, expressed greater challenges in changing her approach to the pedagogy. The inquiry activities within Pri-Sci-Net place great emphasis on children asking questions, gathering evidence and basing their conclusions on the evidence gained. The teacher thus has to continually challenge the children on their statements asking questions such as ‘why do you say that?’, ‘what did you observe to be able to say that?’. She has said that on trialling out three activities in three consecutive weeks that she has realised that she has experiences a shift in the way she teaches. The increase in questions arising and focus on evidence was observed in this teacher's third activity on balloons where she skilfully created space for the children to design the way in which they were to test their balloon's tail. It is amazing that 5 year old children were able to realise that the best way to test their balloon was through blowing it up and releasing it to see how it flies, this with no help at all from the teacher. The teacher stated that now she often finds herself asking questions like those mentioned above in other areas of the curriculum. She shared her experience on how challenging she found it at first to refrain from telling and to elicit reflection and focus on the observations during the investigation. She acknowledged that obtaining a culture shift among teachers in Malta in order to change the way they approach science thinking, is a major challenge and needs time, training and reflection, as well as the motivation by teachers to change their current pedagogical approaches.

One other challenge is possibly that of teachers re-thinking about what children can achieve. It has to be said that the 3 and 4 year old children were surprising. Even if not all the children engaged at the same level, it can be noted that both teachers stated that some children demonstrated levels of engagement and learning which were not what they expects. In the case of the 3 year olds, at one point, one child took a cup and saucer and managed to make them float. Seeing this, she then took the cup, filled it with water and placed it back on the floating saucer. This instance shows how this particular girl managed to transfer and apply successfully the concepts being studied in the box and marble experiment. Similar instances were observed in the magnet activities. Many of the four year olds were capable of identifying the magnet by testing which one stick of the cupboard. They were able to use their knowledge about the properties of magnets to solve their problem.

It has to be said that no particular linguistic difficulties were encountered. This could mainly be the case because most of the teaching in the schools involved takes place in the English language and the activities were originally in the English language.

There were some different challenges experienced in some of the partner countries. Experiences from the United Kingdom demonstrated how children struggled with the new forms of communication, particularly in the worksheet which the IBSE activity trialled required. In Greece problems arose due to system structures and expectations about schooling. These highlighted the threats that established curricula can pose to IBSE pedagogies. Children suffered in being expected to do and learn science in a different way. In France children struggled to hypothesise which is the basis of inquiry in science.

5. Discussion of Results

In general, the potential of the IBSE approach was highly appreciated both by pupils and educators The empirical approach of IBSE activities enabled teachers to capitalize on children's previously acquired competences although it was noted that more time is needed in order to become familiar with the many of the aspects of the IBSE approach (e.g. hypothesis making and testing, workgroup, discussion). In particular, the hypothesis structure raised some problems. At primary age children are still not familiar with hypothesis making, neither with the hypothesis structure itself. The high number of learning objectives in each activity and the high number of children in classrooms could be problematic for adopting IBSE activities in school curricula as in the case of France.

A first analysis of the data collected (interview with teachers, interview with children, proofreading, observation schedules, and demographic sheets) has led us to point out several questions that are of pertinence for implementing of IBSE approach in schools. It is to be acknowledged that bringing about a change in the way that science is taught and done in primary schools is to require changes and adaptation at system, teacher and learner level. The education system needs to change to be able to acknowledge the skills developed through doing inquiry. There should also be recognition that inquiry needs more time and thus needs to be allocated a bigger chunk of the timetable. Teachers need to go through a complete re-culturisation about how learning should take place and what type of pedagogies they have to use. This takes training and time as teachers gain skills and confidence through practice of doing inquiry with children in class. Children also need to be nurtured into doing inquiry. Many children develop expectations about what they are supposed to do and what types of knowledge they are required to reproduce at school. Children need to be given time and space to express their opinion, try and find answers and to use their inquiry skills. Only with a change in regular practice will children really be able to develop the inquiry skills which we would like that compulsory education system to nurture in our future generations. Last and not least, there needs to be a change also in the mode of assessment. Any form of summative assessment fails to capture the full capabilities of inquiry that children have developed and this aspect still needs to be researched. So far a formative approach is what supports inquiry most.

6. Conclusions

This paper addressed pedagogical challenges in current science education and methods of addressing change in teaching and teacher support strategies. The results of show that the, when support structures were available, the IBSE approach was appreciated both by students and teachers as it allowed them to capitalize on the learning experience. Findings confirm the need for continuous forms of teacher support, and the more formal recognition of inquiry based learning that is support by school curricula and time-tables. It was noted that children also need to be nurtured into adopting the inquiry based process, particularly if it marks a significant change from the current method of instruction. Nevertheless it is possible to conclude that successful IBSE can pave the way for increased interest in and engagement with science, resulting in more informed citizens and more research and innovation in the field.

7. References

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