6.9 Pri-Sci-Net – An FP7 EU funded Project Promoting Inquiry-based Learning in Science at Primary Level of Education

Suzanne Gatt – Malta Council for Science and Technology, Malta
Annette Scheersoi – University of Bonn, Germany
Demetris Koursis – University of Cyprus, Cyprus

The main challenge for Science Education is engaging learners in effective learning which lasts and provides them with knowledge, skills in science coupled with attitudes and values. Learning science from a book has long been recognised as being ineffective in promoting good learning in science, particularly at primary level where children are very curious to explore and learn how the world works. Learning science from books pushes students away from choosing science later on in their educational career choice. Traditional science teaching also does not equip students with the skills and competences necessary to become scientists. The European Commission (2007) has recognized this and advocates inquiry-based learning as the main pedagogy for teaching science. It is for this purpose that the European Commission has invested in supporting so many projects focused on promoting effective science teaching approaches focusing mainly on the use of the inquiry-based approach.

This paper presents the work done by FP7 project Pri-Sci-Net (grant no. 266647) and which aims to promote the uptake of inquiry-based learning approaches at primary level across Europe with children aged 3–11 years. The main project outcomes include developing a shared understanding of inquiry-based learning when relating to young children, helping teachers develop the required pedagogical skills, and to convince them to share their experience and resources with other teachers. The paper share the project partners' vision for inquiry-based learning, pedagogical material produced in inquiry-based learning and which teachers can use when teaching, the initiatives taken at national and international level to train teachers.

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Pri-Sci-Net is an EU funded FP7 Supporting and coordinating action (Call SiS-2010-2.2.1.1) which focused on innovative methods in science education: teacher training on inquiry-based teaching methods on a large scale in Europe. The project is coordinated by the Malta Council for Science and Technology (MCST) from Malta and has 17 partners from 14 countries. The project started in September 2011 and is three years long. It comes to an end on the 31st August 2014.

The project includes initiatives to promote the inquiry-based learning approach to learning science among primary teachers teaching young children in the age range of 3–11 years. The overall aim is to set up a Europe-wide network of professionals and academics in the area of Primary Science Education. The training and professional support to teachers aims to help them use inquiry-based learning in science in schools. This support will be both in the form of national and international training courses as well as in bring together teachers from different countries to share their work. The project also recognizes teachers' and researchers' achievements through a Certificate of Excellence in the implementation of inquiry-based learning in science at primary level. The work of young researchers who focus on children's learning in science through inquiry is also recognised in the form of a Certificate of Excellence for research in inquiry-based learning. Further information about the project's activities can be obtained from: www.prisci.net. The pedagogical material produced can be obtained from www.priscinetwork.wordpress.com.

The project's vision for inquiry-based learning in science

The Pri-Sci-Net team, making up around 30 primary science educators from different European countries have worked together for these three years to develop and promote a vision for inquiry-based learning in science which they belief reflects an effective approach to doing science with young children. This vision was developed and agreed to by the project consortium in the first project meeting, and has been the basis of all the work carried out by the partners in the project.

In this Vision, the Pri-Sci-Net group believes that inquiry-based science at primary level is a *teaching and learning framework* with implications about learning science, learning to do science, and learning about science.

In this framework: *children*

- engage actively in the learning process with emphasis on observations and experiences as sources of evidence;
- tackle authentic and problem-based learning activities where the correctness of an answer is evaluated only with respect to the available evidence and getting to a correct answer may not be the main priority;
- practice and develop the skills of systematic observation, questioning, planning and recording to obtain evidence;
- participate in collaborative group work, interact in a social context, construct discursive argumentation and communicate with others as the main process of learning;
- develop autonomy and self-regulation through experience;

The teacher scaffolds and guides learning by providing a role model of an inquiring learner. The teacher does not function, in the eyes of the children, as the sole bearer of expert knowledge. Instead, the main role of the teacher is to facilitate negotiation of ideas and to highlight criteria for formulating classroom knowledge.

Assessment is mainly formative, providing feedback to the teaching and learning process for all classroom participants. All the activities promoting inquiry-based learning science within this project reflected this understanding on inquiry. As a framework, different specific pedagogical approaches can be adopted. However, each of the science activities used and shared had to reflect this vision.

Criteria for inquiry-based learning in science

Based on the vision, the project partners have developed a set of criteria which ensured that any science activity which was promoted by the project reflected the project's vision of inquiry. This was achieved through ensuring that activities included all the criteria for inquiry-based learning to different degrees. The criteria identified and developed are 8 and include the following:

1) Activities in science should be authentic:

In order for a child to solve a scientific problem, the problem needs to be authentic. This means that the problem needs to become the child's own problem, so that the child has the desire to solve it. The problem needs to have a meaning for the child, and the child has to take part in developing it, to whatever extent possible (Pollen, 2006). Therefore it is wise to choose a content area that falls within the cultural and physical environment of the child and to choose general objectives that are suited to children of the age group under consideration.

2) Stimulate the development of inquiry skills:

The Pri-Sci-Net activities need to stimulate the development of inquiry skills in children. Learning begins with a problem to be solved. In some cases, the activity can begin with a question. In this case the wording of the initial question is important. As all starting situations are intended to lead to the identification of a scientific problem, the problem needs to be posed in such a way that children have to interpret the problem, gather needed information, identify possible solutions, evaluate options and present conclusions. All starting situations are intended to lead to highlighting a problem and to attract attention. Inquiry-based Science Education is a problem-based approach but goes beyond it while also retaining the importance given to the experimental approach.

3) Activities need to stimulate the active engagement of children:

Knowledge and understanding need to be acquired actively. For this to happen children's curiosity must be raised and their interest must be stimulated. Learners must be actively engaged in the learning process. The term 'Actively' indicates that each step in the learning process has a specific purpose aimed at completing an activity or action. 'Actively' can thus refer both to: physical action, e.g. completing practical tasks; but also to cognitive action e.g. mental processes involving strategic thinking and critical reflection. It is not sufficient that learners can work practically during a science activity. In addition to the physical process, children also need to be active in terms of thinking. This aspect is considered vital to the success of any learning experience.

4) Inquiry science involves a strong element of observation:

There are many important science inquiry skills such as asking questions, making predictions, designing investigations, analyzing data and supporting claims with evidence. One of the most important skills, however, is that of being able to observe closely and systematically, as well as determining what it is important to observe. Children observe and react to many things and they also ignore many things just as adults do. In order to "see" something, you need to know what you are looking for. Often, children are simply told to observe something closely. But what does this mean? Many will need guidance to learn to link their observations to their ideas, beliefs or hypothesis. For example, being asked to observe two insects is very different from being asked to observe the insects and note the similarities and differences between them.

5) Inquiry involves considering and using observations as evidence for making arguments:

Observations made are a means of gathering evidence. Based on this evidence, children are to draw conclusions. Inquiry-based learning requires that children draw conclusions from the information which they have gathered and have to build an argument using this evidence. Inquiry activities need to require children, at some point, to consider their observations, whether direct or as a result of research and based on this evidence, to draw their conclusions. As much as possible, conclusions drawn must be presented with the evidence on which they are based.

6) Inquiry can only take place through collaborative group work:

The Pri-Sci-Net activities are designed to stimulate collaborative group work among children. Collaborative group work goes beyond working within a group but also means working effectively with peers. Activities should create opportunities for children to work with each other by taking different roles, dealing with and tolerating different opinions, sharing resources with each other etc., all in order to construct knowledge within a social setting. Whether children are doing experiments, carrying out investigations or discussing scientific issues, they should be working in groups. These situations create opportunities for children develop good social skills involved in collaborative learning. These skills range from expressing personal thoughts, ideas and emotions to the group through to dealing with peers or the teacher/other adults within the school setting.

7) Inquiry promotes discursive argumentation and communication – talking science:

For Pri-Sci-Net, inquiry activities need to stimulate children in talking science. Inquiry-based learning is sometimes understood to mean only hands on activity. In order for direct experience to lead to understanding, students need to read instructions, think about their hands-on work, as well as to discuss it thoughtfully with others, and also to write about it. Students' ideas and theories, predictions, ideas for designing an investigation, conclusions, all need to be made explicit, and shared and debated orally and in writing. In many cases, it is by trying to convey one's viewpoint that one finds answers to one's questions. And, the reverse is true as well. It is often in trying to explain something that one's lack of understanding becomes clear. For many children (and adults as well) talking comes first. Once something has been said, it can be written.

8) Self-regulation:

The Pri-Sci-Net activities, finally, also need to stimulate self-regulation within children. Inquiry promotes self-regulation with children because it stimulates active engagement in the learning process by using cognitive and problem-solving strategies and metacognitive strategies to monitor understanding (Dejonckheere, Van De Keere & Tallir, 2010). Cognitive strategies include a wide variety of individual tactics that students and teachers use to improve learning. Problem-solving strategies are more complex than cognitive strategies and focus on the development of a strategy or heuristic in order to solve a scientific problem (e.g. inquiry circle). Metacognition refers to knowledge of cognition and regulation of cognition (Schraw & Moshman, 1995; Dejonckheere, Van De Keere & Mestdagh, 2009). Knowledge of cognition refers to declarative, procedural and conditional knowledge. Regulation of cognition includes planning, monitoring and evaluation (Schraw, 2006). The level of support during science activities will depend on the experience and intellectual development of the children. As the children develop their skills and confidence they should increasingly carry out their own investigations, taking on the responsibility of learning on themselves. Therefore, in promoting the ability to 'learn how to learn' to inquiry, the teacher needs to:

- Identify the level of the inquiry skills of the children;
- Provide support and strategies to help the children to carry out their own investigations; as well as
- Give opportunities for experienced learners to do their investigations on their own.

For a teacher, opportunities should be created in order to stimulate inquiry skills such as systematic and close observation, questioning, predicting, hypothesis generation, planning, investigating, modelling, interpretation of data, communicating and explaining findings to peers. It is really important for a teacher to help the children learn how to identify and state a problem, as science is built on problems that needs to be solved, and not just on observation alone.

Therefore, overall, teachers should develop inquiry-based activities where they challenge children by asking productive (process) questions in order to promote further learning and by encouraging the children to focus on strategies in order to solve the problem (STIPPS, 2008). The teacher should involve children in planning their science activities where it is appropriate and assists them to regulate their behaviour within learning contexts so that they can gather information and respond effectively. The ultimate goal is to create more autonomy and self-regulation of the learner.

All the science inquiry-based activities promoted by the Pri-Sci-Net project were identified through a rigorous selection process whereby the activities were analysed in terms of how much they include all of these eight criteria just described. It was also ensured that any training organised by the consortium included activities for teachers which reflected all of these eight elements of inquiry. The vision and these criteria ensured that all the consortium partners promoted the same type of inquiry across Europe.

Pri-Sci-Net project outcomes

The project worked to achieve a change in teachers doing primary science through a number of actions aimed primarily at teachers and teacher educators and researchers. These envisaged actions included:

- *Development of 45 science teaching activities* using IBSE in 15 different languages. Based on the vision and on the criteria developed, all the project partners submitted a number of inquiry activities to be within the 45 activities that were to be further developed. A large number of activities which included over 100 examples were evaluated against the criteria and the best 15 for each of the age ranges: 3–5 years; 6–8 years; and 9–11 years were selected. Realising that it is not just a question of translation, the partnership also trialed a number of the activities in the different partner countries in order to identify any particular barriers that may arise in using an inquiry activity developed in one country to be used in another European country. It was only following the trialing in the partner countries that the activities were finalised, professionally designed and then translated. These activities are currently being uploaded in the following website: www.priscinetwork.wordpress.com.
  Table 1 shows the list of activities that have been included within each age subgroup. Teachers are encouraged to access, adapt and use parts of these activities as much as they wish.
- *A database* of primary teachers and researchers in primary science. The partnership have developed a mode of building a database through which they can contact teachers, learn about the project initiatives and to participate in the project's activities. An 'expression of interest' form was developed and used by the project partners to obtain contact details as well as permission by teachers to keep them updated about the project, the pedagogical materials that it has developed and is promoting, and other initiatives in primary science. This approach has been helpful in building a database which now already amounts to over 1 000 primary school teachers from all over Europe. An online newsletter was sent regularly to those teachers who are included in the project database. This ensures that teachers wishing to learn about primary science can have links to where to access relevant educational material;
- *Three international teacher-training courses*. The project also organised three international training courses focusing on promoting inquiry-based learning in science.
  The 1st International training course was held in Ústí nad Labem, Czech Republic, from the 28th January to the 1st February 2013. 25 teachers from eight different countries participated in the training course. The international training course was aiming to attract primary teachers who were interested to learn more about teaching science in the upper grades of the elementary school. The training course tackled Inquiry-based Learning in Science Education (IBSE) and elaborated on various types of teaching and learning approaches that could be utilised in the classroom environment. Furthermore, the course offered specific subject content training in several areas of the primary education curriculum. Participants were also guided to join the Pri-Sci-Net virtual platform for IBSE in primary science and use that to share their work with other teachers. The course included sessions about IBSE and the Pri-Sci-Net project. Also the teachers attended workshops in which they had the opportunity to participate (assuming the role of students) in inquiry-based activities, organized by the science educators involved in the project.

  The 2nd International training course was held in Crete, Greece, from the 1st to the 5th of July 2013. 35 teachers from nine different countries participated in the training course. The second international training was mostly intended to address inquiry-based learning in science education (IBSE) with younger primary students, aged 3 to 7. The training commenced with a general introduction to the Pri-Sci-Net project, followed by a discussion on the meaning of IBSE in the context of primary level education. Next, there was a presentation of the IBSE activities that were developed by the project partners for ages 3 to 7. Finally, participants were given the opportunity to experience some of those activities but also to engage in the process of adapting such activities or even designing their own activities. Emphasis was given to the Pri-Sci-Net teacher platform and its potential to serve as medium that could facilitate interactions and the exchange of ideas and teaching materials among teachers interested in IBSE.

The 3rd international training course was held in Salzburg, Austria from the 17th to the 20th of February 2014. 30 teachers from 12 different European countries participated in the training course. The training course opened with a welcome speech by the Austrian Ministry of

Activities in the age range 3–5 years	Activities in the age range 6–8 years	Activities in the age range 9–11 years
1 Planting seeds	1 Air as matter	1 Winter comes to campus = Chromatography
2 Do plants grow in the dark?	2 Plants' response to changes in orientation	2 Practical exercise from statistics for young scientists
3 Playing with shadows	3 Animal responses to light and humidity	3 Pigment research
4 Soil	4 Sounds	4 Acidic, Neutral or basic?
5 Sky	5 Seed Spinners: exploring air resistance	5 Measurements
6 Snails	6 Magnetic Power	6 Acidic-Neutral-basic: find your indicator from nature
7 Magnets	7 Exercises for health	7 How much weight can paper hold
8 What is a plant	8 Body covering and insulation powers	8 Underwater vulcano
9 Soap bubbles	9 Materials/Change of state	9 the snail that prefers cabbage or lettuce
10 What is colour?	10 Biodiverity/discovering what animals live in	10 Water, icebergs and boats
11 Strong Walls	11 The world around us: shadows, day/night	11 the secret of the human body
12 Water	12 Botany: swelling pressure of seeds	12 Air, more than nothing – characteristics of air
13 Swing game	13 Ants	13 Archimedes Principle II (who is able to build the best boat)
14 Let's float	14 Seeds germination	14 Human Body and Robot Body
15 Flying Balloon	15 Senses and their interaction	15 Animal and Animat

Table 1. List of activities

Education. Then, the Pri-Sci-Net project coordinator, Prof. Suzanne Gatt, welcomed the participants and shared the vision of the project for inquiry-based learning in primary education. The training course involved a series of workshops and presentations about IBSE contributed by project partners. Among the training activities, there was a workshop on colours from Muğla (Turkey) and a workshop on change of state, focusing on water and ice from the University of Southampton (UK). There was also a workshop on how to organise a science fair, a workshop on the nature of science and a world café. Some of these training activities took place in the local science museum in Salzburg.

Figure 1. The 2nd International Pri-Sci-Net training course in Crete (Greece)

Figure 2. The 3rd International Pri-Sci-Net training course in Salzburg (Austria)

- *Two international conferences* in Portugal and in Malta.
  The first conference was held as part of the ESERA conference in Cyprus 2013. The second conference was held 16th–18th July 2014 in Malta. The work of the second year was topped by the first international conference which was organised in Nicosia, Cyprus in September 2013. The conference was particular as it was organised as part of the European Science Education Researchers Association (ESERA) conference. Besides being the first project to be supported by the European Association, the conference provided teachers with the opportunity to share their work with science education researchers from all over the world. In addition, the teachers also had the opportunity to listen to researchers who study in detail and problematise classroom experiences which teachers experience every day. The conference thus placed the Pri-Sci-Net within the international science education community as it was also mentioned in the official conference opening address where the experience was considered as a positive one by ESERA and to be repeated for other projects in the future. Pri-Sci-Net was thus a first in achieving international recognition by ESERA!

The 2nd and the final international conference of the Pri-Sci-Net project was held in Valetta, the capital of Malta, between the 16th and 18th of July, in the historical Building of the Old University. Approximately 100 delegates from different countries of Europe attended the conference and engaged in: a) discussions on the implementation of inquiry based science learning education (IBSE) in primary and pre-primary schools, b) hands-on workshops that can be replicated in the classroom, c) sharing of experiences and best-practices, d) discussion on the amalgamation of informal and formal learning. The end of the conference essentially marked the completion of the Pri-Sci-Net project with the hope and the expectation that what has been achieved during the project could make a significant contribution to the training of teachers with respect of IBSE.

The conference included two keynote lectures by experts in the field. The first lecture by Prof. Constantinos P. Constantinou (President of the European Association for Research on Learning and Instruction – EARLI) was entitled "Do children have any need for science learning? What does existing research tell us?" and the second keynote speech entitled "The Challenge – Keeping

Figure 3. 2nd (and final) international conference of the Pri-Sci-Net project in Valetta (Malta)

IBSE active" was given by Prof. Lady Sue Dale Tunnicliffe (Institute of Education, University of London). An innovation of the conference was the opportunity provided to emerging researchers to present their work as keynote speakers. Also the delegates attended workshops in which they had the opportunity to participate (assuming the role of students) in inquiry-based activities, organized by partners involved in the project. Furthermore during the conference many teachers had the opportunity to present specific IBSE activities they designed and share their experiences with their implementation in the classroom.

In addition, the conference hosted a ceremony for awarding selected educators and young researchers with Certificates of Excellence. This was intended as a means of recognition of those teachers who are working to change the way that science is carried out in their classroom. This number of teachers will hopefully keep on growing with the aim to make it possible to really enhance actual teaching practice in science.

- *Four 20-hour national trainings on IBSE* for teachers and teacher-trainers in each of the 13 partner countries. All the partner countries will provide training to primary school teachers. When one counts the number of hours of training that have been provided by the project partnership this amounts to a minimum of 4 x 13 x 20, these amount to 1 040 hours of training to teachers all over Europe. Some of the partners have also provided more training than that promised and the overall feedback from teachers is that they continue to come back with requests for more training opportunities. Here below are some photos of training groups held.
- *Publication of the Journal 'Inquiry in Primary Science Education – IPSE'*: Another initiative of the project consortium was that of providing space for research on primary science and on inquiry in particular to find its way to publication. One of the project deliverables was the setting up and publication of the IPSE first edition of the Journal *'Inquiry in Primary Science'*. This journal provides space for science educators to publish as well as for teachers to provide inquiry notes where they can share their work and experience in implementing inquiry-based learning in science. The first edition of the journal includes a key paper by Wynne Harlen who is one of the main key actors in primary science at international level. The second edition will be published by the end of August 2014. The Journal can be currently accessed at the following address: www.prisci.net/IPSE

Conclusion

While the project is far from achieving an overall change in the pedagogy of doing science at primary level across Europe, it can be said that some seeds of change have been sown and that a number of teachers have demonstrated enthusiasm and commitment to doing science through inquiry. As the project is nearly at its end, the future of inquiry is now in the hands of those teachers who through their practice will act as the best possible ambassadors for inquiry-based learning in science and who are in the best position to convince other teachers to follow suit.

The project has taught the partners who are mainly science educators, how important it is that the activities promoted by the project need to allow space for teachers to adapt them to their context, to use their available resources and to different levels of children. The teachers have shared how they like to adapt the activities, like the story-telling perspective while keeping the investigation's characteristics close to the original version. Many teachers have shared how they observed a high level of interaction among young children when engaged in inquiry activities. It is the mental pictures of children's enthusiasm and excitement while inquiring that has kept and will keep the project partners working to promote the same vision for learning science even beyond the project!

Figure 4 and 5. Pri-Sci-Net training groups

References

Rocard, M., Csermely, P., Jorde, D., Lenzen, D. Walberg-Henriksson, H., & Hemme, V. (2007). *Science Education now: A renewed Pedagogy for the Future of Europe*, Brussels: European Commission.

Dejonckheere, P. J. N., Van De Keere, K., & Tallir, I. (2011). Are fourth and fifth grade children better scientists through metacognitive learning? *Electronic journal of research in educational psychology, 9(1) – Issue Online 23.*

Dejonckheere, P. J. N., Van de Keere, K., & Mestdagh, N. (2009). Training the scientific thinking circle in pre- and primary school children. *The Journal of Educational Research, 103, 1–16*.

Schraw, G., Crippen, K., & Hartley, K. (2006). Promoting Self-Regulation in Science Education: Metacognition as Part of a Broader Perspective on Learning. *Research in science education, 36*, 111–139.

Schraw, G., & Moshman, D. (1995). Metacognitieve theories. *Educational Psychology Review, 7*(4), 351–371.