University of Leicester

The Fibonacci Project

INQUIRY BASED SCIENCE & MATHEMATICS EDUCATION

Bridging the gap between education research and practice

26 – 27 April 2012

Disseminating Inquiry-based Science and Mathematics Education in Europe

WITH THE SUPPORT OF

EUROPEAN COMMISION

SEVENTH FRAMEWORK PROGRAMME

The Fibonacci Project

The ambition of the Fibonacci Project is to contribute to the dissemination of inquiry-based science and mathematics education throughout the European Union, in ways that fit with national or local practice. It has developed a process of dissemination and sharing expertise between 12 Reference Centres and 25 Twin Centres, based on quality and a global approach. This is done through the pairing of Reference Centres selected for their expertise, extensive school coverage and capacities for transfer of inquiry-based science and mathematics education (IBSME) with 12 Twin Centres 1 and 13 Twin Centres 2, considered as Reference Centres-in-progress.

Started on 1st January 2010 for a duration of 3 years, the project is coordinated by the French *La main à la pâte* programme, with a shared scientific coordination with the University of Bayreuth (Germany).

www.fibonacci-project.eu

This project has received funding from the European Union's Seventh Framework Programme

EUROPEAN COMMISION

SEVENTH FRAMEWORK PROGRAMME

The Fibonacci Project – Second European Conference

Inquiry Based Science & Mathematics Education:
Bridging the gap between education research and practice

26 - 27th April 2012
University of Leicester, UK

This Conference aims to disseminate and explore strategies for improving inquiry-based science and mathematics through research and evaluation of innovative practice. Sessions include the innovative work being undertaken through the Fibonacci Project in over 30 organisations in more than 20 European countries as well as presenting other projects focused on research and/or developing high quality inquiry-based practice.

Its objectives are to:

- Review the meaning of inquiry in mathematics and science education (IBMSE),
- Present research and practice of IBSME,
- Bridge the gap between IBSME theory, research and practice,
- Consider strategies for integrating scientific and mathematical inquiry and other curricula,
- Consider how the external environment of the school can be used to promote IBSME,
- Explore methods for carrying out evaluation and research in schools and classrooms in IBSME, and to
- Promote networks of cooperation for inquiry-based mathematics and science education.

The conference is organised by the School of Education, University of Leicester www.le.ac.uk in cooperation with the Fibonacci European coordination team (*La main à la pâte* – French Academy of Sciences, École Normale Supérieure Lyon, École Normale Supérieure Paris).

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The Fibonacci Project: Second European Conference

Inquiry Based Science & Mathematics Education:
Bridging the gap between education research and practice

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Gilbert Murray Conference Hall

Introduction and welcome

Professor Martin Barstow
Pro Vice Chancellor and Head of the College of Science and Engineering

The Fibonacci Project and its Principles

David Jasmin
Director of the La main à la pâte Foundation

The 3-year Fibonacci project started in January 2010. It aims to enhance large dissemination of inquiry-based science and mathematics education (IBSME) in Europe through the tutoring of different institutions including universities, teachers' training centres and research institutions (Twin Centres) by institutions with particular expertise in science and/or mathematics education (Reference Centres).The activities cover all levels of education, from preschool to middle school as well as a few upper secondary schools. At local or regional level, the project is implemented using different strategies and models with regard to the coordination of the activities; the professional development and follow up of teachers; the development of resources; and the community involvement. At a European level, the collaboration between the Reference Centres and the Twin Centres also takes different forms to suit local needs and are typically characterised by peer learning. As a result, the Twin Centres have been able to develop or improve the professional development of their teachers. Common work among the partners through the five major topics on IBSE and IBME has lead to five European training sessions organised between September 2011 and March 2012. In 2012, the project involved 36 higher education organizations and more than 50,000 pupils. During his presentation, David Jasmin will present the main principles, results and perspectives of the project.

10.00am – 11.00am

Gilbert Murray Conference Hall

Keynote: Developmental Research in Inquiry-Based Mathematics Teaching

Professor Barbara Jaworski
Loughborough University, United Kingdom

Barbara Jaworski is Professor of Mathematics Education in the Mathematics Education Centre at Loughborough University. She has been Chair of the British Society for Research into Learning Mathematics (BSRLM) and President of the European Society for Research in Mathematics Education (ERME), and she was, for six years, Editor-in-chief of the Journal of Mathematics Teacher Education (JMTE). Her main research interest concerns the ways in which mathematics teaching develops, particularly through critical inquiry in which teachers and educators engage together in research. This has involved collaboration to form inquiry communities with teachers at all levels of schooling, most recently in projects in Norway. She is currently engaged in exploring the teaching of mathematics at university level.

11.30am – 1.00pm

Rothley & Oakham Suite, John Foster Hall

Dialogic learning: From an educational concept to the actual classroom

Peter Gallin, Markus Jetzer and Mike Rohr
University of Zurich, Switzerland

In Switzerland, Prof. Dr. Urs Ruf and Prof. Dr. Peter Gallin (Institute for Education, University of Zurich, Switzerland) together developed a general teaching concept that they call 'dialogic learning'. It is applicable at all levels of learning and has met with a satisfying response in German-speaking countries, especially in the areas of German and mathematics.

The core concept is concerned with students' self-controlled learning and their keeping track of their progress in journals, which are a basis for the dialogue between the teacher, the contributing student and the entire class. The core focus is, thus, closely related to the goals of Fibonacci IBME. This session will elaborate Prof Gallin's theoretical work with illustrative practical classroom examples.

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Ruf, Urs & Gallin, Peter (2005): *Dialogisches Lernen in Sprache und Mathematik. Austausch unter Ungleichen*. Grundzüge einer interaktiven und fächerübergreifenden Didaktik (vol. 1) and Spuren legen – Spuren lesen. Unterricht mit Kernideen und Reisetagebüchern (vol. 2). 3rd revised edition of the 1st edition 1998. Seelze-Velber: Kallmeyer.

Using ICT to support active graphing in the primary classroom

Matthew Law and Rob Salt
Cossington Church of England Primary School, Leicestershire

An involvement in the Fibonacci project, well resourced ICT facilities and a commitment to developing innovative practice has allowed us as a team to develop children's independent use of software in order to collect and critically evaluate data in science investigations. The practice was carried out by two teachers working with 60 children aged between 7 and 11 in a small village primary school in Leicestershire. Using practical investigations suggested at Fibonacci meetings, the explicit use of laptop computers to collect and represent data, as part of an ongoing and evolving investigative approach, was developed with the children.

The instant nature of graphing on laptops, the ease with which these can be shared with whole classes and the growing skills of the children to use ICT has allowed us to encourage children aged 8-11 to question results and follow their own lines of enquiry during science investigations. This in itself helped children to create the important link between skills in science and mathematics. It also encouraged us as professionals to consider ways of teaching and developing skills from both subjects in a cross curricular way that gave these skills relevance and importance, supporting other key learning in lessons.

As well as developing and consolidating key skills in ICT, children also developed their critical thinking when analysing data. This in turn allowed the children to challenge and question their own scientific understanding, with an opportunity to respond to data and make changes to an investigation during the course of a single lesson.

As with all good teaching, using active graphing requires a patient, whole school approach and clear scaffolding, encouraging children to develop independence as they become more confident with ICT and the skills to challenge the data they produce. However, the impact of using active graphing and the 'mini-plenaries' can lend themselves to powerful learning opportunities in practical investigations. They also place objectives from the mathematics data handling curriculum at the heart of investigative science skills, allowing teachers to support children in developing these skills and their growing understanding of the need to be critical thinkers.

Teaching children how to talk: Raising attainment in science and mathematics

Rory McGrath
Medway Community Primary School, Leicester

My research set out to explore whether teaching children how to speak and work collaboratively would increase their attainment in Science and Mathematics. The focus on speech was based in the context of my school, which has a significantly high number of students who speak English as their second language. The research literature that underpinned my work was Mercer (2004) and (2006) along with Monaghan (2005) and Cohen (2007).

I worked with two groups of older primary children. The main activities were based on small group sessions for 40 minutes. I used a modified action research model to structure my research. The first teaching session established the rules for talk that the children would use throughout the following sessions. In the next few sessions children had a science or mathematics activity to discuss and a problem to solve. This was closely linked to improving their language through the activities they were doing. After the first cycle of intervention I reviewed and then moderated my practice and then carried out a further set of teaching with a new group of children.

The children's progress was being assessed constantly through a number of different methods, most notably a USB microphone and a modified assessment grid. A pre and post assessment was carried out and the children's speech development was clear from the transcribed sessions.

Progress was broadly satisfactory, but one child was a particular disappointment whereas another was a particular success. There were contextual reasons for this which will be explored in greater detail in the presentation. The children all developed their language use, in the academic setting, whilst 90% of them developed their understanding of mathematical and scientific concepts.

If other practitioners were to follow this as a means to improve science and maths in their classrooms I would suggest giving the intervention longer to run. I was working on a restricted time scale which meant that the children did not have as long as I would have liked to develop their language. I would also suggest that the teacher who performs the intervention, is also the class teacher of the group. This is because the impact of the work and the progress of the children will be greatly increased if the class teacher is able to reinforce what is done in the small group, across the daily teaching.

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Tilton & Swithland Suite, John Foster Hall

Concept Cartoons research into practice: Does Dennis still want a good argument?

Stuart Naylor and Brenda Keogh
Millgate House Education

Concept Cartoons were created in the UK approximately 20 years ago. They were developed as an innovative response to the challenges of taking learners' ideas into account in science inquiry in elementary and high school classrooms. Initial research into the approach indicated that Concept Cartoons encouraged learners to engage positively in science lessons, providing a bridge between learners discussing their ideas and subsequent learner-led inquiry (Keogh and Naylor, 1999). Typifying the response of learners is a quote from a high school student, aged 12:

There are lots of naughty children in this class, but we are busy and better behaved… even Dennis, the naughtiest boy in our class, wanted to stay in at playtime and carry on discussing.

Since their creation, Concept Cartoons have become a commonly-used strategy for many teachers, both in the UK and in several other countries for supporting teaching in science. They are used in a wide variety of learning settings, and they have been created in other subjects, including mathematics. For some years Keogh and Naylor's research provided the only evidence into the impact of Concept Cartoons in the classroom. More recently a wide range of researchers, many of them from outside the UK, have added to that research base, using evidence from school students, university students and practising teachers (e.g. Chin and Teou, 2009; Sexton, Gervasoni and Brandenburg, 2009)

This paper attempts to summarise that research base. It sets out what appear to be the major developments in the nature and format of Concept Cartoons, and identifies some of the significant implications of using them for teaching and learning. This includes their potential for promoting cognitive conflict and argumentation, enabling peer and self-assessment to take place, and challenging misconceptions. It considers how these features can provide a positive driver for inquiry-based science and mathematics teaching and learning. The paper also addresses some significant aspects of teachers' professional learning that have arisen out of the research, including how constructivist approaches might be implemented in the classroom and promoting change in teachers' professional practice. Some future developments in Concept Cartoons are also suggested. The paper reflects on whether Concept Cartoons can engage the modern Dennis and his friends, and what insights they have to offer to inquiry-based science and mathematics education 20 years on.

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Getting children to design experiments through Concept Cartoons

Patricia Kruit, Fanny Wu and Ed van den Berg
Hogeschool van Amsterdam and Vrije Universiteit Amsterdam

Concept cartoons (Keogh & Naylor, 1999; Naylor et al, 2007) are a popular means to stimulate reasoning with science concepts among students from the age of 8 – 18. However, the concept cartoons also provide a very natural context for students to design their own experiments. Show children a concept cartoon, have some discussion, and then ask them to design an experiment to provide evidence for or against one of the statements in the cartoon, and the children feel confident that they can do this. They rush off to set up an experiment. They get into the activity so quickly that the teacher even has to slow them down and force them to think through their ideas a bit more carefully. This is where the challenge is, to get them to think and to reason and yet maintain the enthusiasm. At present we are experimenting with concept cartoons and inquiry in different schools and at different age levels (8 – 12). We are trying to measure progress in inquiry and reasoning skills using video and notebooks with emphasis on reasoning with concepts and evidence (Klentschy, 2008). Using the research we are developing guidelines for how to use the concept cartoons productively to develop reasoning and research skills (Hardy et al, 2010). These guidelines, data, and some video materials will be available for sharing at the time of the conference.

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Seminar Room 1, Gilbert Murray Hall

Science on Stage Europe: Development and dissemination of inquiry-based teaching projects

Stefanie Schlunk and Elena Luehrs
Science on Stage Europe

The development of innovative teaching material and the dissemination of concepts and ideas for a more attractive science teaching is a crucial aspect for the improvement of science education on a large scale within Europe. Science on Stage Europe (SonSEu) offers European teachers opportunities to meet, share and exchange teaching ideas and experiences. The association believes that a good way to encourage school children to become scientifically literate citizens or consider a career in science or engineering is to motivate and educate their teachers. With its activities, SonSEu reaches approximately 42,000 teachers in Europe.

When mentioning an attractive science teaching approach, for SonSEu, this has perpetually meant promoting the teacher's role as a moderator rather than as an instructor. This way, the association pushes the development and dissemination of inquiry-based practice. Through experiencing and exploring for themselves, students get physically and emotionally involved and can more easily develop a passion for scientific subjects and contents. This is connected to the theory of multiple intelligences, which implies that people (in this context, more precisely: students) learn and process information in different ways. By focusing on teachers, SonSEu promotes the development and the dissemination of teaching projects, which are based on these learning concepts.

SonSEu consists of National Steering Committees (NSCs) in 26 European countries and Canada; their representatives are active and competent educators. All NSCs are responsible for organising pre-selection processes before and follow-up activities after the Science on Stage festivals, which take place every two years.

This Science on Stage education conference is designed as a huge bazaar at which approximately 350 European teachers present their innovative ideas and projects for the classroom, primarily based on an inquiry-based teaching approach. At these conferences, teachers and educators are the main actors and experts – and the ones receiving inspiration for their own teaching at the same time.

After each festival, SonSEu organises follow-up activities to deepen the contacts made at the conference and to help teachers get inspired by science teaching methods in other countries. The follow-up activities are geared towards sustainability, including teacher-training programmes, teacher exchange scholarships and long-term workshops. The latter are usually over two years during which interdisciplinary groups of European science teachers develop teaching material.

The next Science on Stage festival will take place in April 2013 as Polish-German cooperation in Słubice – Frankfurt (Oder); its motto is "Crossing Borders in Science Teaching". Inquiry-based learning will again be one of its guiding themes.

Training trainers for expanding IBSE in Colombia

Mauricio Duque-Escobar, Margarita Gómez-Sarmiento, Adry Manrique-Lagos
Pequeños Científicos Program, Universidad de los Andes, Colombia

Since the year 2000, Inquiry-based Science Education (IBSE) has been promoted in Colombia, by the national Colombian ISBE program called Pequeños Científicos®. The program has evolved as an alliance between different organizations and local universities. It is currently led by Los Andes University and involves close to 100,000 students in IBSE classes over 10 years. From the beginning, the Pequeños Científicos® program has focused on situated professional development for in-service science teachers based on tutoring and hands-on workshops based on ECBI. As the program has been growing in the country it has been shown that it is necessary to have a system to train teacher-trainers in order to multiply the professional development scheme in other parts of Colombia, raising coverage and getting into more schools. The aim of the program has always been to make practicing teachers become trainers and guide novice peers to implement IBSE.

While we have developed a good understanding of the knowledge and skills necessary for teachers to implement IBSE classes, the program doesn't have enough information about the knowledge and skills necessary for a teacher to become an IBSE trainer of teachers. It is clear that the basic training used with novice teachers is not enough to be an effective trainer and to multiply the strategy, and that's why Pequeños Científicos® has been offering additional trainers training schemes since 2005.

First approaches to trainers' training were conducted by deepening the basic workshops, but this showed to be ineffective because teachers didn't get enough understanding of IBSE in order to guide accurately novice teachers. To get a better training it was decided to involve teachers in a master degree course from Los Andes University. The course focuses on inquiry science education. Academic development was complemented with workshops about leadership and inquiry learning methodology. During 2010-2011, a process of trainers' training has been implemented based in coaching and follow up to future trainers. This process is more time-demanding but has proved to be more effective in getting teachers to appropriate understanding of IBSE and to develop sufficient skills to guide novice teachers to implement IBSE. This process is complemented with online modules oriented to design IBSE units and portfolios.

The main purpose of this work was to systematize and assess the strategies used by Pequeños Científicos® program to train IBSE trainers. We believe that this learning could be used to help professional development schemes and to increase local capacity expanding IBSE in Colombia.

Using moodle for inquiry-based activities: Tracing changing classroom practices

Kathrin Otrel-Cass, Elaine Khoo, Bronwen Cowie, John Williams, Kathy Saunders, Simon Taylor
University of Waikato, New Zealand and University of Aalborg, Denmark

Teaching science can be challenging, particularly if it involves teachers wanting to develop their students' explorative attitudes and habits for inquiry learning approaches. In this presentation we focus on a case study of a New Zealand secondary school teacher's use of Moodle to facilitate students' sharing and co-constructing of scientific understandings. This investigation is part of an ongoing New Zealand Teaching and Learning Initiative funded project to explore the nature of e-networked collaborations in secondary science classrooms.

The nature of scientific inquiry involves multifaceted activities that encourage one to explore and understand what can be observed in the world. Such knowledge is not developed from scratch but rather is developed by those engaged in inquiry-based activities on what they already know (Harlen, 2004). Collaboration, sharing ideas and co-construction of ideas and understandings requires changing teaching and learning practices that allow pupils to learn how to collaborate ‘inquiry style’. Online learning environments can provide spaces for learners to collaborate beyond the confines of the classroom’s physical space and time. We used the Communities of Inquiry model (Garrison, Anderson & Archer, 2000) to understand how teaching, learning and social factors play together and impact on students’ developing understanding in text-based, asynchronous online inquiry environments.

In this study the teacher used the discussion forum in Moodle to encourage his students to share and develop their science ideas. Building on experiences of how to use Moodle shared by another colleague and responding to his students’ online interactions and exchanges, he was able to change attitudes and habits regarding inquiring in science from task oriented and providing safe answers to being explorative, critical and creative. Asynchronous online environments such as Moodle provide complementary learning environments that can break with established classroom traditions and ways of engagement to support inquiry-based activities but require careful planning and orchestration of teaching strategies (teaching presence), and an understanding of students’ learning (cognitive presence) and ways of social collaboration (social presence).

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Seminar Room 2/3, Gilbert Murray Hall

Research Workshop – Clarifying your research question and designing your research methods

Professor Hilary Burgess
University of Leicester

This session will focus upon:

- How a research question needs to accurately reflect the topic under investigation
- How the design of a project is influenced by the research question chosen
- The appropriateness of different research methods to investigate a research question
- Issues of validity in research
- A consideration of ethical issues in the research process

There will be opportunities for discussion of participants' research projects in this workshop.

2.00pm – 2.45pm

Hospitality Lounge

Acceptance of IBSE method among children, teachers and students on the university and society

Dragana Milićić[1],Marija Bošnjak[2],Stanko Cvjetićanin[2], Biljana Jovanov[3],Tatjana Marković – Topalović[4] Ljiljana Jokić[5], Dušanka Obadović[6] and Stevan Jokić[7]
[1]Faculty for Biology, [2] Pedagogical Faculty-Sombor, [3]Primary School- Zrenjanin, [4]High Medical School-Šabac, [5]AKM Edukacija, [6]Faculty of Natural Science-University od Novi Sad , [7]Vinča Institu-University of Belgrade

Having in mind how science is presented in Serbian schools and the bad results of our students on the PISA test, we have tried to change this situation by introducing hands-on and now IBSE methods in science education, by developing, in 2001, individually and by support of the Serbian Physical Society and collaboration with French Academy of Sciences. We have taken account of the experience of: *USA with Hands-on, France with La main à la pâte, Sweden with NCF, China Learning by doing, England with XXI Century Science* etc., The academicians Pierre Léna and Yves Quéré, and French team "La main à la pâte" have been of particular help.

In 2003, the Serbian Ministry of Education decided to put forward an optional course *"Hands on - Discovering the World"* for children from 6 to 8 years old. Approximately 7-10 % schools, *i.e.* 300 classes, 6 000 to 8 000 children and 300 teachers are involved. Our strategy was, in the first place, scientific literacy for all children by creation of different resources for teachers. This idea in Serbia was a new one and we did not have, at the beginning, strong support. For that reason we have decided to translate as many of the books as possible for teachers and parents created by the *La main à la pâte* team. Thus we fulfilled two minimum conditions: by translation, we have started communication among French and Serbian scientific-educational community; and are developing good scientific and educational material. About 20 books have been translated.

The website http://rukautestu.vinca.rs, the semi-mirror of the French one (www.inrp.fr/lamap), in use (in Serbian) from the end of 2008, contains about 2 500 pages. Teachers can find many important resources such as *By the Foots of Eratosthenes, European discoveries, Greenwave-the signs of spring;* pedagogical documents about bridging from elementary to low secondary school such as *Integral teaching of science.* The pedagogical projects make the interdisciplinary approach possible as well as participation of our teachers and students in different internationals activities.

Over the past five years we have completed workshops (8h) with about 3 000 preschool and primary school teachers all over Serbia. We have also created specific resources for the classroom, including material kits and guidelines for teachers. At the end of 2010, 15 "Experimental Rooms" all over Serbia were supplied with kits which give teachers a model of research and enable inquiry-based processes to be implemented in a convenient place with convenient tools.

Five years after the optional subject *Hands-on Discovering of the World* had been introduced in our educational system, an analysis was carried out in order to determine the extent and the way this subject was taught by the 137 teachers from 16 schools of one District. The questionnaire showed that 13% of teachers used to teach or still teach this optional subject; that about 21% of parents and 13% of pupils are interested in it. The analysis shows that this subject is not present enough in teaching practice because parents and pupils are poorly informed and mostly uninterested but also because of the widespread erroneous view that this subject requires special equipment and laboratories. The results also show that a large percentage of teachers, parents and pupils of this District are not familiar with basic principles and the way of teaching this optional subject (http://rukautestu.vin.bg.ac.rs/handson4/knjiga4/5_Bosnjak_M.2007.pdf). A further questionnaire in 2010, in another District (where 25% of teachers have participated in workshops), with a sample of 230 teachers from 32 elementary schools, confirmed the hypothesis that poor information and methodical competence of teachers had a very significant impact on students' interest in this subject.

We conclude that teacher training, better equipped schools and more active influence of Ministry of Education and society will significantly affect the higher percentage of cases in which this subject will be used.

Coaching more than a thousand teachers in IBSME with four teacher coaches: methods and strategies

Wim Peeters, Miranda De Neef, Lutgard Neels and Ria Van Huffel
DKO vzw

DKO vzw is an organisation that structurally supports more than 130 secondary and some 350 primary schools as organisations in all their processes. Heads of schools, administrative personnel, teachers and in general everybody working in a school can ask for support in the form of coaching.

The four authors of this paper are responsible for coaching secondary school teachers in mathematics and all natural sciences (The courses are in biology, chemistry, physics and sciences). The job of teacher coach spans a wide range of very diverse activities and responsibilities. One of them is curriculum development, giving information on new curricula, as well as advice on strategies and methods to implement them in the classroom. In addition it is possible and useful to organise teacher training on the use of language in science classes, active teaching methods, new experiments and so on. Apart from that, schools can ask for assistance in helping teacher groups to work together, to develop a coherent school policy on certain matters like evaluation, research competences and cross discipline cooperation. Networking is organised to bring together teachers of different schools to tackle common problems or interests.

Recently, driven by some negative reports from the inspectorate, schools are paying more attention to “research competences” in all disciplines, including modern languages, economics, human sciences and also, of course, mathematics and natural sciences. We show how our team of four coaches deals with this issue and how it tries to use Fibonacci input in their coaching. We will introduce specific tools that are used and discuss with the people present whether and how these could be transferred to other settings.

Disseminating inquiry-based science education in Italy: The Program "Scientiam Inquirendo Discere" (SID)

A. Alfano, P. Bortolon, G. Forni, A. Lepre, I. Marini, S. Zanetti and A. Pascucci
ANISN, National Association of Natural Science Teachers

The program *Scientiam Inquirendo Discere* started in 2011 as a collaborative National Program between the Accademia dei Lincei and the National Association of Natural Science - ANISN, supported for three years by the Ministry of Education. It aims to introduce the IBSE approach in Italy in collaboration with the project *La main à la pâte*. It represents the development at national level the results and participation of ANISN as TC2 in the Fibonacci Project and a progressively stronger connection between the Accademia dei Lincei and the French Academie des sciences.

This program can achieve important strategic objectives: enhancing and profiting from previous experiences and initiatives developed in Italy, strengthening international collaboration and providing a sophisticated tool for implementing and evaluating the National Guidelines for the curriculum.

The main targets of the program are teachers and students of elementary and middle schools. During the school year 2011/2012 35 trainers, 115 teachers and 4300 students will be involved. The program has a multilevel organization structure of both national advisory and operational structures with local operational nuclei called "pilot centres" to provide partnerships with networks of schools and promotion of community practices in science. There are three pilot centres in: Naples at Stazione zoologica Anton Dohrn, Venice at the Istituto Veneto di Scienze ed arti; and Pisa at the Scuola Normale Superiore. The institutional and operational headquarters of the national coordinating structure is in Rome at the Accademia dei Lincei. The operational steps of the program are:

Year 1 Organization of advisory and operational national structures and organization of the school and teachers networks. Training of the trainers. Setting up of the Web site www.linceieistruzione.it . Development of didactic resources and experimental materials.

Year 2 Implemention of the organization and activity of pilot centres. Further development of didactic resources and experimental materials.

Year 3 Evaluation and implementation and widespread diffusion of the project to other students, teachers and pilot centres .

How do teachers engage pupils in group talk which develops their scientific understanding?

Liz Hewitt
University of Leicester

The teaching of science can be tricky; learners arrive in the classroom with misconceptions that are sometimes difficult to shift. Using group talk is a useful tool which can enable children to work on their understandings, sort through their ideas, organising and clarifying them with their peers. Pupil-pupil interaction and discussion can be a rich site for conceptual change (Howe, Tolmie, Duchak-Tanner & Rattray, 2000). Through it children are able to talk their way to new understandings. It is a place where scientific knowledge is socially constructed, validated and communicated, a more symmetrical arena than teacher-pupil dialogue. Peer group talk can enable the children to develop inquiry skills, as they question, reason, hypothesise and use evidence (Mercer, Dawes, Wegerif & Sams, 2004). The role of the teacher is vital in encouraging this reflective, exploratory talk but this is not often studied (Webb et al., 2009). This project therefore aims to identify the teacher strategies which lead to the most effective talk for developing pupils' scientific understanding. Researching experienced teacher's routines and practices and the thinking behind them can enhance understanding of teaching and learning and can lead to the development of effective teaching approaches (Lijnse, 2000).

This presentation reports on the work of the second year of a four year doctoral research project. An ethnographic case study methodology is being employed, in order to attempt to gain access to a full understanding of how the teacher plans for and organises talk in science. A reflective cycle is being used to enable teachers to focus their thinking, over the period of study, on strategies for group talk. Sociocultural Discourse Analysis of productive talk sequences should lead to a deeper understanding of the linguistic mechanisms present that enable the children to learn well. This evidence can then be analysed alongside the observed teaching strategies, in order to identify and understand how practitioners can effectively engage and support their pupils in talk for thinking and learning in science.

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How to implement IBSE in Italian secondary schools?

Maria Angela Fontechiari
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The Rocard report strongly supported Inquiry-based Science Education (IBSE). However, its spread in Europe is still quite limited and it has mainly involved primary schools. Considering the low achievement and poor interest in science shown by Italian students in the PISA tests, IBSE could be effective in reversing this trend. IBSE engages students in a multifaceted activity which reproduces scientific inquiry (NRC, 2000), allowing for creativity, considering alternative approaches and using evidence for the explanation. The essence of IBSE is to reflect on the ongoing process, which allows students to think about what they are doing, and how and why they are doing it. This higher level metacognitive activity can lead students to understand the nature of science (NoS). Some conditions are needed to implement IBSE: to go beyond thinking of science simply as a body of knowledge, to avoid believing that traditional "cookbook" labs promote inquiry-based learning and to overcome the distorted view that identifies the scientific method as the only way to carry out the scientific process.

Furthermore, as teachers play a key role in IBSE, they have to understand NoS and be able to teach it. However the pre-service training of most Italian teachers has been focused on purely academic content and epistemologically based on the outdated paradigm of modern science (Fiorentini, 2000). This is a critical point since the previous learning experiences of teachers serve as models for their own teaching (Akerson & Hanuscin, 2007). Therefore, the implementation of IBSE first requires supporting teachers through professional development which is itself inquiry-based: teachers will understand IBSE better through experiencing it rather than having it described (Harlen & Allende, 2008). Also, simply engaging in scientific inquiry activities is not enough to develop teachers' understanding of NoS but an explicit reflective approach is needed (Akerson & Abd-El-Khalick, 2003). To become familiar with IBSE, teachers can adapt existing activities making them more inquiry oriented with strategic changes (Llewellyn, 2005). This gradual shift can continue moving across the different "levels of inquiry" by increasing the degree of learners' responsibility (NRC, 2000).

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Implementing Pedagogical Content Knowledge through partnership and relating this to the planning and assessment of practical activities

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Pedagogical Content Knowledge (PCK) was introduced by Shulman (1986) as relating the professional understanding of the content of science subject knowledge to pedagogical knowledge (classroom management, educational aims and related teaching strategies) and context (school, students). Teachers themselves construct the knowledge which guides their actions in practice when they teach about particular science issues or topics.

In this project a series of twilight Continuing Professional Development (CPD) sessions organised by the Science Learning Centre East Midlands and the coordinator of postgraduate Secondary Science course for student teachers from the University of Leicester were run across an academic year with a group of secondary teachers and the student teachers they were mentoring. Participants were introduced to PCK and the PCK toolkit (a series of worksheets to guide the planning, implementing and reflection of PCK in the classroom) and, in a subsequent session, encouraged to share, discuss and reflect on their experience of PCK. The toolkit was based on two models of CPD and PCK (Berry & Loughram, 2010; Windschitl et al, 2010) as presented at the Research and Development Conference at the National Science Learning Centre.

Alongside the teacher CPD, the secondary science student teachers were introduced to PCK through their taught sessions at the University of Leicester.

A range of materials has been both developed and collected from the project including completed PCK frameworks, samples of marked work, learning journals, video footage and interviews. Some of the findings and the benefits of collaboration between the Science Learning Centre, the tutors, student teachers and their teacher mentors from the partnership schools will be presented, as well as the implementation of PCK related to planning and assessing practical activities according to a modified framework developed by Millar and Abrahams (2009) with a new cohort of Science student teachers.

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In-service teacher training to take the IBSE approach into Earth Sciences teaching in Italian secondary schools

Barbara Scapellato
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In the last few years a great number of surveys have shown that students don't like studying science and do not reach true understanding of what they have studied. Several studies on science education in Europe suggest using the Inquiry-Based Science Education approach (IBSE) to reverse the decline in interest of young people in science and develop in all future citizens the *scientific literacy* they need for the world beyond the school. The dissemination of this approach in Italian schools is limited by a number of factors, among which is the large amount of time necessary to plan and then implement the activities in class, compared to the time available in relation to the curriculum as well as the demands of student assessment. Increasingly large class sizes and the lack of laboratories and equipment are additional issues. The purpose of this research project is to promote the use of IBSE into Earth Science teaching in Italian secondary schools through the formulation of an effective model of training for trainers. A pilot teacher training course to implement inquiry-based activities in classes will be set up. The effectiveness on students' learning and the feasibility of this approach will be assessed. This study will gather data about: the effectiveness of IBSE on students' learning and motivation to study through tests (pre-test/post-test design). Students will come from first forms from Academic secondary schools. The beliefs of Earth Science teachers about the feasibility of this approach and the training course model will be evaluated by means of questionnaires and/or interviews before and after a pilot training course and the implementation of inquiry-based activities in classes. The expected outcomes are: to elaborate an innovative and effective model of training for in-service teacher trainers; to evaluate whether this kind of teacher training course can also encourage a positive perception towards IBSE and hence its use in the teaching of Earth sciences; to collect data on effectiveness of IBSE on learning and Italian students' motivation to study Earth science; to set up Earth Science inquiry-oriented, "ready for use" activities and guidelines for further design of new activities. Up to now this type of research has never been carried out on this topic in Italy. This is one of the first projects dealing with the teaching of Earth sciences which we hope will contribute positively in the approach towards these disciplines in Italian schools.

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Modelling science and mathematics integration at second-level in Ireland: Taking an inquiry-based approach to learning

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This doctoral research was developed at the invitation of a regional Development Partnership in Ireland. The Partnership is investing in methods that could stimulate economic growth through supporting science and mathematics education in local schools. Five secondary schools in the region are taking part in the overall initiative. A science and mathematics integration focus could permit the development of an inquiry-based and problem-solving approach in science and mathematics education in these schools (Wilhelm & Walters, 2006). In addition, the new Irish mathematics syllabus, Project Maths, places greater emphasis on applications, and on a contextualised mathematics that draws on real-life data and problems. It was therefore felt that investigating a model for science and mathematics integration would now be useful and timely.

The literature on science and mathematics integration indicates that, although it is often recommended, science and mathematics integration research has floundered to some extent possibly because of a lack of a clear definition (Hurley, 2001). Models of integration vary considerably (Pang & Good, 2000). Much of the research has been carried out in countries where teachers have considerable scope to develop their own curricula, and so is not directly applicable to the Irish context.

In order to design an appropriate model, the teachers of science- and mathematics-related subjects in the five schools were surveyed. The survey found that teachers believe that integration is beneficial for student learning, but have varied views about what it entails. In addition, integration currently occurs predominantly at the level of referring to other syllabi as it is relevant, and is concentrated on a few isolated topics and techniques. A number of teachers said they would find a teaching sequence for integration and a list of suitable topics useful. Hence the next step will be to map the areas of overlap between the syllabuses in both disciplines. Based on this, a Teaching and Learning Sequence will be developed that both science and mathematics teachers could refer to when developing their own schemes, and a series of critical integrated skills activities will be developed for teachers to utilise or adapt in their teaching.

The poster will present an overview of the research as outlined above, and will give further detail on the Teaching and Learning Sequence and Critical Integrated Skills Resource for teachers.

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STEM Workforce preparation program aligned with New Jersey's 21st century life and career skills standard

Anders Hedberg[1], Frederick Egenolf and Donna Beccaria[2]
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The past twenty-five years have brought dramatic transformation of learning and teaching to schools across the US, Europe, Asia and Latin America through inquiry-based science education (IBSE). Outcomes data demonstrate increased student achievement in terms of science and mathematics content and process learning, bridging of the achievement gap, and validation of IBSE as an effective practice (references given below). Thus, a critical foundation is being laid for workforce preparation. While significant contributions have been made by the STEM-based industry to support IBSE, little attention has been given to the development of skills and behaviours related to the use of STEM content knowledge in the workplace. Tomorrow's STEM workforce needs to understand and learn these skills while still in their K-12 classrooms in order to secure employment and develop their careers, years from now.

Supported by a corporate mission of strategic philanthropy, Bristol-Myers Squibb (BMS) developed a program curriculum which demonstrates how R&D success is grounded in interdisciplinary use of science, mathematics, engineering, technology, ethics and communication. The program *R_xeSEARCH: An Educational Journey* engages high school students in project planning, analysis, active problem solving and decision making to research and develop a new medicine. A fictitious story describes the emergence of a new infectious disease, High School Syndrome, and guides students toward a successful treatment ready for commercialization. This program was donated by BMS to the National Science Resources Center (NSRC) under the Smithsonian Institution.

In response to New Jersey's implementation of a new core curriculum content standard 9 (NJ CCCS9: 21st Century Life and Career Skills), BMS developed a unique tool kit for teachers, introducing them to the practical application of each of six standard elements in the R&D efforts demonstrated by this program: 1. Creativity and Innovation; 2. Critical Thinking and Problem Solving; 3. Collaboration, Teamwork and Leadership; 4. Cross-Cultural Understanding and Interpersonal Communication; 5. Communication & Media Fluency; 6. Accountability, Productivity and Ethics.

Pilot Teacher Professional Development using this *Teachers Guide: Practicing Workplace Skills* and engaging corporate and R&D professionals in active teacher PD, resulted in a significant increase in teachers' understanding of NJ CCCS9, recognition and use of the corresponding workplace skills and contributed to their ability to access expertise and tools to teach in accordance with the standard.

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The inquiry-based sciences education at a Brazilian science centre

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University of São Paulo

Our work aims at incorporating two different approaches towards Science Diffusion that complement each other without, however, losing their own specificity. Whereas the first focuses on activities such as exhibitions, experiments (kits) and the Olympics of Science, the second was discovered by us in 2001 with the French Project "La Main à La Pâte"and is a more specific inquiry-based proposal. The latter was used to broaden our more multi-tasked national programme. The Proposed National Curriculum of the Ministry of Education of Brazil embodies the ideas of science education through research. We need more practical suggestions for this curriculum.

The main purpose of the Centre for Scientific and Cultural Diffusion (CDCC) at the University of São Paulo is to show the scientific work produced by the University which is of interest to the people in general. There are various exhibitions including astronomy, biology and ecology. At the CDCC there are also 70 kits of 1st to 9th year of the elementary school and 39 kits for the high school. The production began in 1984 and now they are present in science centres all over the country. The Science Olympics have been held since 1999 for the 9th year of the Elementary School. Most of the schools in and around São Carlos take part. Every year different subjects are treated. In 2011 the subject was "Forests". There is also support for hands-on projects. The issues or situations may arise from the students themselves during the day-to-day practice in the classroom, or be suggested by the teacher. In the latter case, it is important not only that there is clarity about the aims they want to reach, but also that the questions are meaningful to the students, and are consistent with their level of cognitive development, thus allowing the generation of more appropriate responses. This way, discovery will occur and will elicit the delivery of responses through investigative activities. Students seek to answer the questions posing their hypotheses on the matter and verifying these hypotheses with the procedures specified in each activity. The identification of hypotheses relating to experiments is one of the great difficulties of our teachers.

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Training teacher students in IBSE

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Inquiry-Based Science Education appears suitable to teach natural scientific contents and skills (Hof, 2010). Nevertheless, inquiry learning is rarely adopted in German schools (S-TEAM, 2010). Therefore, teacher students should be well prepared for the implementation as well as for the problem areas of this method. Currently, only a few references concerning necessary course content (Mayer & Ziemek, 2006) or possible problem areas in German university teacher training exist (Hilfert-Rüppel et al., 2009).

For this reason, the aim of the research project is to develop an IBSE-course for teacher students of biology classes. Accordingly, the suitable course content has to be determined and the problem areas have to be explored.

The determination of the course content will be based on the current German literature (e. g. Bylebyl et al., 2010, Mayer & Ziemek, 2006). Semi-structured interviews with experts are expected to reveal further content. Open questionnaires, videography (Saltiel & Delclaux, in press) and guideline-based interviews, should lead to potential problem areas of the teacher students. Finally, the results obtained will be included in this course.

With the results of the pilot survey it is already possible to draw conclusions about basic problem areas and about problems during the application of inquiry learning in classes.

This IBSE-course for teacher students strives to raise the quality of education by preparing the students to apply Inquiry-Based Science Education.

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Working towards responsive in-service teacher education

Christina Siry and Andrea Teuchert
University of Luxembourg

In this poster, we will present an overview of our work at the University of Luxembourg that seeks to facilitate in-service teacher education that is responsive to teachers' needs and contexts.

In alignment with the conference theme, the poster will illustrate an evolving teacher education program that seeks to "bridge the gap" from research to practice. Grounded in sociocultural theoretical perspectives (e.g., Vygotsky, 1978), the research we are undertaking highlights the relationship between the individual and the collective. Through a dialectical perspective, these are inseparable and each changes with the other. Thus, the teacher education we envisage for our participants emerges from their specific needs and contexts and is developed through a collective process in which teachers are supported in working together to learn in a professional learning community. The research approach incorporates video-based ethnography and seeks to move towards research that "works with" participants (e.g., Siry & Zawatski, 2011).

Through a semester-long series of field visits in several classrooms, university researchers began to engage in ongoing dialogue with teacher participants in the Fibonacci project. As a group, the teachers and the researchers recognized the need for teacher education workshops that connected closely with the teachers' existing challenges and successes working towards adopting a new approach to teaching science (through inquiry) in their multilingual classrooms. We intend to share the methods that we have been developing by working with our teachers to co-develop science units that are relevant to their contexts and responsive to their needs. This is an ongoing focus for the Fibonacci project in Luxembourg, and our major claim is that through a spiralling process of theoretical input and praxis-inputs, the curriculum is emerging; both the curriculum for the workshops themselves as well as the curriculum the teachers are developing. The implication of this work is that, connected to our theoretical frameworks, we find a greater need to coordinate the individual as well as collective components in professional development. To that end, in the coming term we plan to incorporate individual coaching along with ongoing workshops and curriculum development.

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3.00pm – 4.00pm

Rothley & Oakham Suite, John Foster Hall

Teaching about the Nature of Science through inquiry: Insights and developments of a two-year professional development programme

Cliona Murphy, Janet Varley, Siobhan Treacy and Anne McMorrough
St Patrick's College, Dublin

The focus of the Fibonacci Project in Dublin, Ireland, is to develop practising teachers' conceptual and pedagogical knowledge of the Nature of Science (NoS) using an innovative professional development (PD) programme. Educational research literature indicates that when explicit approaches to teaching about the Nature of Science are employed while implementing science curricula, teachers are: more confident and enthusiastic about teaching science; employ more hands-on inquiry-based approaches; and afford their pupils more opportunities for discussion and reflection in science class (Murphy, Murphy and Kilfeather, 2010: Murphy, 2008; Murphy, Kilfeather and Murphy, 2007). Furthermore, it would appear that pupils who engage with activities that relate to different aspects of NoS reveal more interest in school science (Murphy et al, 2010). Guided by the findings of the international research literature the Fibonacci project in Dublin is exploring new possibilities for teachers' professional development. It provides opportunities for 22 participating primary teachers to develop:

- an on-going and collaborative professional culture;
- regular links with teaching colleagues in other schools;
- greater NoS pedagogical expertise and deeper NoS subject knowledge; and
- the skill of reflective practice in a supportive and safe environment.

It is anticipated that by the end of the two year project, not only would these Dublin based teachers have the confidence and competence to teach about NoS as an integral component of the primary science curriculum, they would also have the expertise to facilitate the dissemination of these innovative inquiry-based approaches within their schools and to other schools nationally.

In this presentation an overview of the type of professional development that these Dublin teachers are engaging in over the course of the project will be presented and exemplars from the workshops provided. Experiences from the Fibonacci Project in Dublin will be co-presented by participating teachers and researchers, which will include video clips of teaching and learning about the Nature of Science in the Dublin primary classrooms.

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Tilton & Swithland Suite, John Foster Hall

Continuous professional development for raising teachers' self-sufficiency in IBSE

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The Reference Centre (RC) of Nantes (France) built a network of teacher trainers and scientists, in charge of supporting primary and middle school teachers for developing IBSE in their classrooms. Each activity which is undertaken in RC Nantes is aimed at focusing on helping teachers to become self-sufficient in IBSE within 3 years.

Improvement of self-sufficiency is supposed to be a natural consequence of raising teachers' self-confidence and ability in IBSE. Given the assumptions that:

- both of these professional qualities are strongly related to individually acquired experience;
- acquiring new scientific knowledge takes more time than teachers have (within time devoted to formal Continuous Professional Development – CPD); and
- discovery of IBSE good practices should be associated with positive emotional experience.

All supported activities are deliberately focused on peer-to-peer supported self-experience and practice. A permanent theoretical background is simultaneously provided by the RC's staff.

This presentation aims at describing, first, how the activities are being carried out with teachers and pupils:

- During in-service training sessions: beginning with ready-to-use units (year 1, training day 1), that make the teachers feel secure, then rising progressively to self-developed or self-adapted units (years 2 and 3), through Inquiry-based workshops and common work (about skills and assessment) with both primary and secondary school teachers.
- In the classroom, mostly during the 2 first years, teachers work with engineering or PhD student coaches who may bring basic literacy and scientific safety into the classroom and may also report to the Fibonacci staff.
- Permanent follow up of each school by a scientist with expertise in IBSE. When needed, the scientists may help teachers to analyse in their lessons to identify whether the standard steps of inquiry were missing or present.

In the second part, the presentation will report on the analysis of teachers' response and developing practice over 2 or 3 years.

In conclusion, the presentation will also point out what could be the main feature of a positive learning process: teachers' CPD, itself, has to follow the steps of inquiry-based learning. The challenge is to organize these steps on an informal and individual way over 2 or 3 years. In addition individual and peer-to-peer collaboration between teachers and scientists greatly benefits both of them.

WITH THE SUPPORT OF

Seminar Room 1, Gilbert Murray Hall

How 16-18 year-old pupils from four European countries experience activities during a four day visit to a research institute

Maarten Tas and Frankie McKeon
University of Leicester

The REStARTS project emerged from a concern about the motivation of young people in Europe toward sciences in general and aeronautics in particular, the reduction in the number of pupils interested in aeronautical research and the consequent decrease in number of young people with the necessary level of specialism. The project aimed to develop the pupils' awareness of a scientific technological industry and of its research in three steps:

- Activities in school;
- Activities at local research institutes; and
- A four day visit for a limited number of pupils from 4 countries at a school lab in a research institute.

This study focuses on the last step, in which 4-5 pupils work in mixed nationality groups on several activities which were led by either German secondary school teachers or researchers.

Visits to science centres promote positive attitudes and cognitive learning may also occur (Rennie & McClafferty, 1996). From a constructivist perspective learning may be enhanced by the social interaction involved with practical activities relating to the real world (Jarvis & Pell, 2005). Building on school based activities to broaden pupils' experiences has been reported as important for successful visits (Finson & Enochs, 1987). The purpose of this study was to explore how the visit to the research institute was experienced by the pupils from the different countries. Methodology included group interviews with pupils and semi structured interviews with teachers and researchers from each country.

Overall the pupils had positive attitudes towards aeronautics and science. However, this is not surprising as they had been selected to attend this visit as high achieving students at their schools. Learning appeared to be restricted depending on related prior experiences, the nature of the activities undertaken during the visit and the confidence within the international groupings. The use of English as a common language throughout the visit was a variable factor for the pupils and the leaders of the activities.

Whilst many of the key factors identified by the pupils mirror those in the literature for school visits to science centres and museums, they appeared to have been magnified during a residential visit in an international setting, in which the language of communication was not their first language.

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Investigating honey: Informal science laboratories as places where pre-service teachers and pupils learn together

Petra Skiebe-Corrette,
Freie Universität Berlin

Informal science laboratories were founded in response to the declining number of students electing to study the "hard" sciences such as chemistry, physics and mathematics. The first of these laboratories was founded in the beginning of the 90s; today there are about 120 within Germany (Dähnhardt et al.). The aim of these laboratories is to increase children's interest in science by providing hands-on activities in an authentic environment thus giving a realistic and modern view of science. Most of them are located at universities and research institutions, but they can also be found in science centres, museums or industry.

Some of the informal science laboratories at universities are also used to train pre-service teachers, like the three informal science laboratories at the Freie Universität Berlin. Within a laboratory, content, pedagogical and pedagogical content knowledge can be acquired. For example, with one group of 29 pre-service primary teachers, we developed a set of experiments concerning honey for use in our informal science laboratory.

In order to gain content knowledge, we visited a research institution (Länderinstitut für Bienenkunde Hohen Neuendorf e.V.) that focuses on honeybee research and offers services to bee keepers. If a bee keeper wants to mark a honey as linden honey, the honey has to meet specific standards. The honey has to pass a sensory analysis: it has to taste, smell, feel and look like linden honey. In addition, 20% of its pollen has to be from linden trees. The honey has to meet other standards, including a water content below 20%, a conductivity below 0.8 mS/cm and lie in a particular pH range. We visited the laboratory where these parameters are investigated and talked to experts.

Pedagogical content knowledge had to be applied when the students designed five experiments for children grades 4 to 6 that would allow the children to test the following parameters: pH, water content, conductivity, pollen content and sensory experience. The students developed word cards for the sensory station that would help children with language difficulties to find the right vocabulary. They also learned to develop and optimise an experiment, and to overcome obstacles when an experiment did not seem to work.

Pedagogical knowledge was acquired by the students when they supervised different children from different primary grades and different school districts. This contact led to multiple revisions of the different stations and to a reflection of their teaching practices. It also led to questioning their own content knowledge. As seen in this example informal science laboratories can offer valuable experiences for pre- service teachers.

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Seminar Room 2/3, Gilbert Murray Hall

Research Workshop – Handling qualitative data: Part 1

Professor David Pedder
University of Leicester

This workshop will provide practical hands-on opportunities to work with qualitative data using inductive and deductive approaches. The data examples are drawn from research with (a) beginning science teachers and (b) experienced science teachers who consult their pupils about the helpfulness of their teaching.

As we compare inductive and deductive approaches to data analysis, we shall focus on key aspects of the collection, management, interpretation and reporting of qualitative data, looking in particular at how decisions in these areas connect with research aims and questions.

4.30pm – 5.30pm

Rothley & Oakham Suite, John Foster Hall

Practice in Leicester Fibonacci schools

Frankie McKeon and Leicester Project Teachers
University of Leicester

The Leicester Fibonacci Project aims to develop a more integrated approach to science and mathematics education for teachers to enhance the scientific and mathematical practice of pupils in the 4-13 age range.

Pairs of teachers with mathematical and scientific expertise have been collaborating in their primary and secondary schools to develop an investigative approach to facilitate this more integrated approach to science and mathematics.

University based sessions, each with an integrated science and mathematics content, introduce a progression of activities from which teachers choose to try for themselves. Sessions have included focus on: Instruments and measuring, Averages and sample size, Active graphing, Shape, Area, Perimeter, Volume and Surface Area. Scientific concepts have included Forces, Materials and Change, Earth in Space and Life Processes and Living Things. At all stages the aim is to focus on both mathematics and science concepts.

Teachers select activities to try in their classrooms between sessions, and are encouraged to develop their own approaches and ideas. Tutors visit schools to observe teaching, talk to children, discuss practice and provide support.

Project teachers will illustrate the approaches they have adopted in their schools and present examples of work they have undertaken with children in their own classes and across their schools. They will provide some insights to the variety of strategies they have adopted for developing links between mathematics and science and also to the organisation employed to facilitate these links.

Tilton & Swithland Suite, John Foster Hall

How can inquiry-based learning in science and mathematics be assessed properly and fairly?

Ian Jones
Mathematics Education Centre, University of Loughborough

"Assessment is usually focused on knowledge, facts and problem solving, and rarely includes the competences IBSME is aiming at: creativity, critical thinking, language abilities, and experimental skills." (Fibonacci Scientific Committee, 2010, p.12)

Inquiry-based science and mathematics education (ISBME) and traditional tests lack compatibility. ISBME emphasises learning through authentic and collaborative problem-solving that requires and develops conceptual understanding of scientific and mathematical ideas. Assessment of such learning can only be proper and fair if it is based on authentic evidence of students engaging in such activities. Conversely, traditional tests draw on individual students' responses to short items and so "often tend to assess memorised facts" (Fibonacci Scientific Committee, 2010, p.4). As such, traditional tests do not and cannot capture the authentic evidence required to assess what students achieve and learn when engaged in ISBME.

Instead, the assessment of ISBME should be based on observations of students working collaboratively in authentic problem-solving contexts. Such evidence might, for example, take the form of movies of students working together, or digital portfolios collated by students over the course of a project. This could then be assessed by experts – usually subject-specialist teachers – who would be required to judge the achievement and learning of each student based on the evidence available. The outcome of such assessment could be used for formative or summative purposes as required.

The problem with this approach is that expert judgement is highly subjective. This is unacceptable, particularly for high-stakes summative purposes, because each student's outcome would be partly dependent on the preferences and biases of whoever happened to make the judgement. Fortunately, a new method is emerging that puts expert judgement at the heart of assessment but also ensures a high reliability, surpassing even that of traditional tests. The method – called Adaptive Comparative Judgement – achieves this by presenting experts with pairs of students' work and asking them to decide which student is the more able "scientist" or "mathematician". The underlying principle is that while people are poor at making *absolute* judgements of single stimuli, they are very good at making *relative* judgements of paired stimuli (Thurstone, 1927). The outcomes of many such pairings presented to several experts can be used to construct a rank order of students that has shown to be highly robust and reliable.

In the presentation I will explain in detail and demonstrate Adaptive Comparative Judgement, and show how it can be used to assess authentic evidence of ISBME properly and fairly. Towards the end of the session participants will be invited to try the system for themselves.

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Seminar Room 1, Gilbert Murray Hall

Does it make us think? Inquiry-based learning in science and engineering: Aligning research, policy and practice

Louise Hayward, George MacBride and Ernest Spencer
University of Glasgow, School of Education

Scottish education policy is committed to developing inquiry-based learning in all curricular areas, including science and engineering. However Scotland is dropping down the PISA science tables and national surveys of science education provide further negative findings. This presentation examines how research, policy and practice can be better aligned to enhance young people's achievement in science and engineering in Scotland.

The Scottish Survey of Achievement made clear how far science education has been failing both to engage young people and to develop their understanding of science, while teachers and learners have very different perceptions about the extent to which inquiry-based methods are used. The consequent Scottish Government (2009) strategy included development of a major online science, engineering and technology resource.

There is, therefore, recognition of the need for transformational change in science and engineering education in Scotland. Research in Scottish education argues that any sustainable innovation which can be scaled up must address several dimensions of integrity: educational, personal and professional, and systemic (Harlen & Hayward 2010, Hayward & Spencer 2010).

In the context of major educational change (Curriculum for Excellence) the University of Glasgow Fibonacci project made use of research on transformational change and on inquiry-based learning in science and engineering to develop a model for engineering education in primary school based on five pillars:

- Building capacity to enable people to learn from one another: teachers working together and teachers and engineers working together
- Learners extending their understanding of engineering: what it is and why it matters
- Learners accessing world leading research in engineering in Scotland and underpinning concepts
- Learners building links between their learning in school and the world of engineering
- Learners understanding what a career in engineering might be like

This presentation will illustrate ways in which the project has sought to grow ideas across Scotland. Critical consideration of the curriculum specification and of these teaching resources suggests that there may be unarticulated tensions among understanding of the big ideas of science (Harlen 2010), curriculum specification, and the relationship of ideas to life beyond the classroom. The presentation will explore these issues through the lenses of socio-constructivist models of learning, concept development and models of pedagogy (Cobern et al 2010, Kapelari et al 2011).

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Seminar Room 2/3, Gilbert Murray Hall

Research Workshop continued – Handling qualitative data: Part 2

Professor David Pedder

6.30pm – 11.30pm

Conference Dinner: National Space Centre

Conference dinner will be at the National Space Centre. During the evening there will be an opportunity to see a ‘Space Show’ and have private access to the whole of the Centre.

Buses will collect delegates outside of John Foster Hall at 6.30. Delegates will leave the National Space Centre at 11.00 to return to John Foster Hall.

Friday 27th April 2012

9.30 – 11.00am **Presentations**

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- *Designing and measuring the impact of whole school primary science continuing professional development* (30 mins) – Sue Bull and Phil Hingley
- *A new model for inquiry-based, academic pre-service teacher education* (30 mins) – Maaike van den Herik, Welmoet Damsma, Ineke Schaveling and Ed van den Berg
- *What can we learn about current practice in inquiry based science teaching and learning in England from the Primary Science Quality Mark award programme?* (30 mins) – Jane Turner, Steve Marshall and Adam Farley

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- *Students investigate 2D shapes in a dynamic computer environment* (30mins) – Susan Forsythe
- *Developing teaching efficacy for inquiry-based learning* (30 mins) – Steven Watson
- *IBSME in the Czech republic* (30 mins) – Libuse Samkova

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- *Mind the Gap: How (or how not) is inquiry-based learning integrated German Biology school lessons?* (1 hour) – Stefan Nessler, Philipp Krämer, Hans Edelmann and Kirsten Schlüter
- *The SECURE project researches science curricula and teachers' and learners' opinions on science education* (30 mins) – Wim Peters

Seminar Room 2/3, Gilbert Murray	Page 53

- e-Mission-Operation Monteserrat – *Video Conference Simulation Managing a Natural Disaster: Part 1*

Conference Hall, Gilbert Murray	Page 54

- Research Workshop – *External evaluation of MST projects as a contribution to quality assurance, to dissemination and to sustainability* – Yves Beernaert and Magda Kirsch

11.00 – 11.30am Tea/coffee
Hospitality Suite, Gilbert Murray Hall

11.30am – 1.00pm **Presentations**

Rothley & Oakham Suite, John Foster Hall	Page 55

- *Nanoscience and nanotechnology at high school: A Hands-on inquiry-based approach* (30 mins) – Annamaria Lisotti, Guido Goldoni and Valentina De Renzi
- *Inquiry in education for sustainable development – Research on juvenile lifestyles including students as research partners* (30 mins) – Christain Bertsch and Anja Christanell
- *Developing a relevant science education together with students and their teachers* (30 mins) – Anders Jidesjö and Ulrika Johansson

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- *IT distance learning and assessment for teachers training on IBSE* (30 mins) – Adelina Sporea and Dan Sporea
- *An IBSME approach to teaching in in-service education* (30 mins) – Antonia Trompeta, Renata Carvalho, Claus Auning and Ida Guldager
- *Development of a student self-evaluation instrument to evaluate accuracy, reliability and validity in inquiry* (30 mins) – Saskia van der Jagt, Lisette van Rens, Herman Schalk, Albert Pilot and Jos Beishuizen

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- *Free translation on demand of IBSME resources - needed and available but unbelievable and misunderstood* (30 mins) – Àgueda Gras-Velázquez, Eloïse Gérard and Přemysl Velek
- *Continuing professional development in inquiry-based pedagogies: From a transitional to a transformative model* (30 mins) – Fco. Javier Garcia, Geoff Wake, Katja Maass and Michiel Doorman
- *What was the question? S-TEAM and the future of inquiry-based science teaching* (30mins) – Peter Gray and Zozan Kaya Ashaug

Seminar Room 2/3, Gilbert Murray	Page 64

- e-Mission-Operation Monteserrat – *Video Conference Simulation Managing a Natural Disaster: Part 2*

Conference Hall, Gilbert Murray	Page 65

- *Initiating inquiry-based science education in outdoor learning sites: Issues and Challenges* (1 hour) – Suzanne Kapelari, Elaine Regan, Justin Dillon, Doris Elster, Julia Willison, Asimina Vergou, and Gail Bromley
- *Taking the plunge: inquiry-based teaching material to support inquiry-based learning in biology classrooms* (30 mins) – Kirsten Schlüter, Kathrin Bylebyl, Katharina Freund and Stefan Nessler

1.00 – 2.00pm Buffet lunch
John Foster Hall

2.00 – 3.00pm **Presentations**

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- *IBSE and assessment for Learning: A Socio-cultural perspective* (1 hour) – Cristina Carulla

Tilton & Swithland Suite, John Foster Hall Page 69

- *Teacher collaboration on the integration of science and mathematics education through an inquiry-based approach* (30 mins) – Frankie McKeon, Tina Jarvis and Janet Ainley
- *Facing the challenges for IBSE implementation* (30 mins) – Marta Ariza, Antonio Armenteros, Ana Abril and Francisco Garcia

Seminar Room 1, Gilbert Murray Page 71

- *Understanding the European policy context: from globalising to glocalising pedagogy* (1 hour) – Geoff Wake

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- *Developing a tool for evaluating inquiry-based science education (IBSE) in Europe: Building a bridge between research and practice* (1 hour) – Susana Borda Carulla

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3.15 – 4.15pm Key Note – *Design based research as a framework for promoting research-informed adoptions of inquiry orientated science teaching* – Professor Costas Constantinou

4.15 – 4.45pm *Conference Conclusions* – Professor Sir Robert Burgess, Vice-Chancellor and Professor Janet Ainley, University of Leicester.

5.00 – 5.30pm Tea/Coffee
Hospitality Suite, Gilbert Murray Hall

5.00 – 6.00pm Visit to the University of Leicester Botanic Garden
How outside space can stimulate learning – Ruth Godfrey

8.00pm Dinner at John Foster Hall: A Taste of Leicester

9.30am – 11.00am

Rothley & Oakham Suite, John Foster Hall

Designing and measuring the impact of whole school primary science continuing professional development

Sue Bull and Phil Hingley
Science Learning Centre East Midlands, University of Leicester

The Science Learning Centre East Midlands is part of the national network of Science Learning Centres funded by the Department for Education. The remit of the Centre is to provide high quality continuing professional development (CPD) for all those involved in science education including the design and development of tailor made bespoke CPD for schools.

During the academic year 2010-2011 the Science Learning Centre East Midlands delivered 5 bespoke versions of a 'Creative Cross Curricular' primary course to schools across the region. These were unusual in that they explored relating science to several different areas of the curriculum. Their bespoke nature also meant that the content of the course was designed for the specific needs of each school.

The courses were delivered to primary schools in counties throughout the Midlands: Derbyshire, Nottinghamshire, Leicestershire, Leicester City and Northamptonshire to a total of 93 teachers and teaching assistants and were described as being 'whole school' CPD episodes as all staff attended. The 'whole school' approach involved everyone in the school: headteacher, senior management, teachers and classroom assistants. It is rare in England to be able to provide CPD to more than 1 or 2 teachers from a school at any one time. Four of the schools had never engaged with the Centre prior to the bespoke CPD episode and the fifth had only engaged once before, five years previously.

Several months after the CPD intervention, schools were revisited to research and identify the impacts of the 'whole school' CPD through questionnaires and interviews focussing on the following questions:

- What was the main driver for engaging in bespoke science CPD?
- Why was a whole school approach taken? What were the benefits of this approach?
- Has a whole school approach to science CPD aided pupils' learning?

In the session some of the findings and the benefits of a 'whole school' approach to CPD will be discussed, as well as how the episodes were designed, developed and delivered. How each school implemented aspects of the CPD within their teaching schemes and the effects on pupils' learning will also be covered.

A new model for inquiry-based, academic pre-service teacher education

Maaike van den Herik[1], Welmoet Damsma[2], Ineke Schaveling[1] and Ed van den Berg[2]
[1] University of Amsterdam
[2] Hogeschool van Amsterdam

In the Netherlands elementary teacher education traditionally has been part of vocational higher education and not of university education. Over the past few years several Dutch universities have set up university level elementary teacher education programmes jointly with teacher colleges. The purpose is to attract talented students with a strong academic background to the teaching profession. The University of Amsterdam and the Hogeschool of Amsterdam have a joint program in which students obtain elementary school teacher certification and a university Bachelor degree in Pedagogy. Students are highly motivated and put in 50 hours or more per week. In the third semester of study students fulfill an internship in an elementary school and design, try out, and evaluate a series of 4 science lessons which meet criteria for inquiry learning. Students use a 7-step model of inquiry-based teaching and learning from Van Graft and Kemmers (2007) which is similar to the more familiar 5E (Engage, Explore, Explain, Elaborate, Evaluate) model of Bybee (1997). Apart from designing the lessons, the students also develop their own evaluation instrument to investigate the effectiveness of the lessons and the learning output. The design process is monitored through student blogs, guidance sessions, and video. Instructors from the University use the student blogs to provide students with feedback during the process of testing their lessons. Both university and school-based generalist teacher educators and cooperating teachers are involved in the monitoring process which is led by a science educator. Students also consult with scientists and other specialists. This part of the program is evaluated with a survey completed by students and cooperating teachers, and interviews with scientists, university and school-based generalist teacher educators.

Some lesson series have a community component such as archeology in which various ethnic groups are interviewed by the children about death rituals. Through this process pre-service students as well as the generalist teachers and teacher educators have an intense encounter with inquiry-based science. The intention is that the inquiry orientation will permeate the whole academic programme of these pre-service teachers. At the time of this abstract the teaching had just been completed. The lessons were creative and motivating. Children and pre-service students were very enthusiastic. Lessons met inquiry criteria to various degrees, but pre-service students are well aware of the shortcomings. More evaluation data will be coming in and will be presented at the conference.

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What can we learn about current practice in inquiry-based science teaching and learning in England from the Primary Science Quality Mark award programme?

Jane Turner, Steve Marshall and Adam Farley
Science Learning Centre East of England, University of Hertfordshire

The Primary Science Quality Mark (PSQM) is a national programme that aims to:

- Ensure that all pupils are actively engaged in inquiry-based science; independently making decisions, answering their own questions and solving real problems
- Raise the profile of science in primary schools
- Provide a framework for evaluating, planning and developing the quality of science teaching and learning
- Celebrate a commitment to excellence in primary science teaching and learning in primary schools

External evaluation from both the commissioned external evaluation[1] and Ofsted[2] clearly demonstrates that the PSQM is meeting these aims. Uniquely, compared to other quality marks, the PSQM programme is developmental and supported by CPD. It takes a year for schools to complete the PSQM process at the end of which they submit reflections with supporting evidence against 13 different criteria covering all aspects of primary science leadership, teaching and learning. These submissions form a unique, rich and significant evidence base of current practice in primary schools in England which can provide valuable insights into inquiry-based science.

Using a typology of terms devised by an expert advisory team following the Delphic iterative model to reach a consensus, grounded theory methodology has been used to code a substantial sample of the submissions. Data analysis has addressed the following questions:

- What do teachers understand by the term science inquiry and how to they plan and organise for it in their schools?
- Which pedagogic strategies in inquiry-based science are used and to what effect?
- What models of science curriculum planning are used for science, how are they devised and selected and what is their impact?
- How do teachers assess children's progress in primary science inquiry?
- What barriers to inquiry-based science do primary teachers perceive?

This presentation will discuss the findings and consider the implications for inquiry-based science at two levels: firstly for the Primary Science Quality Mark award programme internal processes and CPD programme; secondly for policy makers, teachers and wider stakeholders.

Notes

1.http://www.psqm.org.uk/about_psqm/PlannedNationalRollout.html
2. Ofsted *Successful Science* Jan 2011 p 49-50

Tilton & Swithland Suite, John Foster Hall

Students investigate 2D shapes in a dynamic computer environment

Susan K. Forsythe
School of Education, University of Leicester

Investigative activity is an important element of learning in mathematics. Working with Dynamic Geometry Software (DGS) can be an effective medium in which pupils investigate geometrical figures and their properties thus developing mathematical thinking. The main features of DGS are the tools for creating the basic elements of Euclidean Geometry (points, lines and circles) with the means to construct geometric relations between objects (Laborde, 1993). The dynamic nature of the software allows objects on the screen to be dragged (moved on the screen) whilst keeping constructed properties constant. I have developed a task in the Geometers Sketchpad (Jackiw, 2001), a DGS program, designed to encourage pupils to develop understanding of the properties of 2D shapes. A generic quadrilateral on the screen has internal 'bars' of fixed length and orientation. Dragging the bars inside the shape generates a number of different triangles and quadrilaterals.

Pairs of students working on the task were asked to 'drag the bars and investigate what shapes you can make'. When the students thought they had made specific shapes they were encouraged to use the measuring facility of the software to check properties of equal sides and angles. During the sessions, the on-screen activity and the dialogue between students and researcher were recorded. The data was analysed using a constant comparison method to identify themes in the dialogue and the dragging strategies used by the students. Van Hiele's work on levels of geometrical reasoning was used as the theoretical framework in the analysis of the students' conceptualisation of the shapes (Van Hiele, 1986).

An important theme that emerged was the way that the students appeared to use symmetry in order to position the bars and to identify equal sides and angles in the resultant shape. It was often the case that when they checked the measurements, expected equal sides and angles were not exactly equal. The students then typically made small dragging movements, which I have named 'refinement dragging' in order to make 'equal' measurements as close as possible. Often the measures could be got very close to within 0.1 centimetres and the students appeared to accept this as evidence that it would be possible to make an accurate shape with the bars in that position.

After having recorded sessions where pairs of students worked on the task, I took the task into two schools and worked with whole classes. Whilst it was not possible to observe the students in whole classes as closely as pairs of students, there was evidence that they a) used the same kinds of dragging strategies, and b) were able to observe the properties of the bars inside the shape. Some of them were able to use what they had learned to construct squares which retained their properties even when dragged.

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Developing teaching efficacy for inquiry-based learning

Steven Watson
University of Nottingham

This paper concerns professional development (PD) materials that were designed to encourage teachers' use of inquiry-based learning in mathematics. It includes a description of the design and theory behind the professional development and an evaluation of its effectiveness in mathematics departments in three English secondary schools with thirty teachers. The research question was, to what extent do the PD materials promote teachers' use of inquiry-based learning? The evaluation draws upon *self-efficacy* (Bandura, 1997) as a theoretical framework for professional learning. This study suggests a strong relationship between teaching efficacy and the extent to which teachers adopt inquiry-based practices in their teaching. This has important implications for the design and development of PD for inquiry-based learning. Bandura's study suggests that in order to be successful, PD should be designed to develop teachers' self-efficacy in inquiry-based learning pedagogies.

The professional development materials originally accompanied the Bowland mathematics case studies (Bowland Charitable Trust, 2008). These are a series of learning activities that involve problem solving and inquiry-based learning. They consist of seven modules which include classroom activities and tasks, videos of example lessons and teachers discussing the issues as well as explanations of relevant research. There are modules on how to work with unstructured tasks promoting effective discussion amongst students, teachers' questioning and formative assessment.

An ethnographic approach combined with quantitative measures based on a standard teaching self-efficacy instrument (Tschannen-Moran & Woolfolk Hoy, 2001) indicated that teachers with high levels of teaching self-efficacy were more likely to implement the aims of the professional development. There was also some indication that the PD materials may have had some effect on teachers' self-efficacy specific to the PD. I conclude that developing efficacy should be an important aspect of PD design and employment and that further work is needed on developing teaching efficacy instruments that reflect the implementation of inquiry-based learning.

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IBSME in Czech republic

Libuse Samkova
University of South Bohemia

The University of South Bohemia joined the Fibonacci project very recently in September 2011. This 'Twin Centre' (TC) will focus on the role of mathematics in science and mathematics investigative work. This session will provide an overview of the process of how this new centre identified the needs of their teachers, what action should then take place and an evaluation of the initial 6 months of work.

It was decided to concentrate on lower and upper secondary schools where there are skilled educators who have already been cooperating with the university for a long time. Czech teachers know almost nothing about IBSME, but some of them have used the methods of IBSME in their teaching for years. These “natural IBSME” teachers had priority when building the Fibonacci team. It is expected that these teachers will provide considerable assistance, since they have already gained classroom-based experience. All the Fibonacci teachers teach mathematics plus one or two other subjects such as biology, descriptive geometry, IT, chemistry, etc.

The intention is to take advantage of this multidisciplinary background, to develop two different tasks where the teachers will review:

- Their non-mathematical subjects, to identify where mathematics is used as a tool. They will then be guided to suggest how to link the two subjects. The objective is that students will understand the mathematical ideas in a form and context that is useful for the non-mathematical subject.
- Their mathematical activities to identify when investigative procedures and activities can be applied.

In both cases, the Fibonacci teachers (with help of the TC staff) will create learning environments, and test them in their classes. It is intended that these learning environments will help other teachers to have a better understanding of the multidisciplinary importance of mathematics, as well as the inquiry-based approach to teaching mathematics. Moreover, these environments will help teachers to understand the role of mathematics also in subjects which are not familiar to them.

In addition to this multidisciplinary approach, the TC Centre will develop a particular learning environment on the very important topic of “Improving financial literacy”. This topic is essentially new. As a subject it is partly a component of mathematics lessons with the other part in social science. As the topic is very new, Czech secondary schools teachers lack textbooks or learning environments so are motivated to develop materials. The TC Centre also believes that the topic is very suitable for IBSME.

The session will report on the work during the first 6 months with an evaluation, commenting on the progress, successes and problems.

Seminar Room 1, Gilbert Murray Hall

Mind the gap: How (or how not) is inquiry-based learning integrated in German biology school lessons?

Stefan Nessler, Philipp Krämer, Hans Edelman and Kirsten Schlüter
University of Cologne

International and national educational standards (e.g. NRC 1996, KMK 2004) emphasize the importance of teaching knowledge of basic scientific skills as well as teaching scientific literacy. In order to address these aims, European projects, such as the 7th Framework Programme (http://cordis.europa.eu/fp7/home_en.html), featuring e.g. Fibonacci and Pathways, suggest that inquiry-based teaching can be a key method to reach these goals. In Germany, this idea is additionally supported by national projects like SINUS (Prenzel et al. 2009) and Biologie im Kontext (Bayrhuber et al. 2007). These projects are designed to promote inquiry-based teaching in the context of teacher training and teaching material.

However, studies (PISA 2006, S-Team 2010) illustrate that inquiry-based teaching in Germany is still lacking as an integral part of school lessons. This suggests that despite international and national efforts inquiry-based teaching methods have not yet reached the target audience, namely schools, teachers, and pupils. This situation applies to other countries as well (S-Team 2010).

Hence, we will give a critical review of literature dealing with inquiry-based learning in Germany with the focus on biology classes. We will address this topic by covering issues such as i) academic contributions to the distribution and appliance of inquiry-based teaching in schools and ii) how inquiry-based teaching is communicated to pre-service and professional teachers. We will also consider on-going projects in different federal states, such as the “Pollen”-project coordinated by the University of Berlin. Here, a differentiated view is important, because in Germany not all federal states support such projects, resulting in a differing distribution of success in inquiry-based learning.

We will conclude our talk by discussing the role of infrastructure in schools, such as size of classes and availability of equipment in schools, which can support or inhibit inquiry-based teaching. Finally, we will consider how the above mentioned aspects contribute to (or counteract) the distribution of inquiry-based learning and teaching in Germany. We regard our discussion as important since these problems might also be relevant to other countries in Europe.

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The SECURE project researches science curricula and teachers' and learners' opinions on science education

Wim Peeters
DKO vzw, Belgium

Based on scientific research, the SECURE consortium will make a number of recommendations to policy makers who have an impact on curriculum development as well as on teacher education. These recommendations address the question of how the interest in Mathematics, Science, Technology and ICT (MST) can be enhanced among youngsters and in particular their future teachers, whilst at the same time optimizing the preparatory learning of those pupils.

The specific objective of the SECURE project is to provide relevant and rigorous research data and translate them with recommendations that contribute to the debate among policy makers on science curricula and their objectives, balancing the needs between training future scientists and broader societal needs. The SECURE research focuses on 5, 8, 11 and 13 year-old learners, their science curriculum and their teachers. These ages bridge the gaps between kindergarten, primary school and middle school. The target group for results are all people bearing responsibility for science education, including Fibonacci participants, since the ages match the target learners of the Fibonacci project perfectly.

The SECURE project provides scientific research results to enhance the debate among policy makers on the purpose of school MST education, whether this purpose is being addressed in practice through school curricula, and what perceptions both learners and teachers have on science. Big European projects can benefit from the outcomes of the SECURE project. They could adapt their strategy and implementation methods to take account of the research results.

The authors will present the research strategy, including criteria for comparison of curricula, questionnaires and interview formats for teachers as well for all four age categories. Preliminary results will be available for discussion.

People present will get an in-depth view of the project and will be invited to consider their participation in the project as external experts or international policy makers.

Seminar Room 2/3, Gilbert Murray Hall

e-Mission-Operation Montserrat: Video Conference Simulation Managing a Natural Disaster: Part 1

This is a simulation of managing a natural disaster based on a hurricane and volcano on the island of Montserrat showing the application of mathematics and science. It is run via video conference link from the National Space Centre. It requires handling of data about the hurricane and volcano to make decisions concerning whether and how to evacuate the island population.

Conference Hall, Gilbert Murray Hall

Research Workshop – External evaluation of MST projects as a contribution to quality assurance, to dissemination and to sustainability

Yves Beernaert and Magda Kirsch
Edu.Consult

The workshop will focus on how to set up and implement an external evaluation taking into account the nature of the project, the objectives, the partnership, the activities, the deliverables and the foreseen outcomes. Special attention will be given to formative and summative evaluation both at the level of the pedagogical contents of the project and at the level of the organization and management of it. Information will be shared on how the external evaluation can be implemented making use of various tools and methods integrated in a protocol of evaluation. Sharing information and giving support throughout the project and in the final report will be focused upon.

The possible roles of external evaluators and the possible forms of external evaluation will be expanded upon. Internal evaluation will also be brought into the picture.

Comparisons will be made between evaluating a large project such as Fibonacci over several years and smaller projects over short periods such as INSPIRE and SPICE, two Comenius European projects focusing on MST and IBSME.

Finally information will be shared on the elements the evaluators of the Commission look at when evaluating an application for a new project. Thus some guidelines will be given to help those who are already thinking of some follow-up projects to Fibonacci.

It is hoped that those who attend the workshop will bring in their expertise to the discussion of project evaluation in general and the evaluation of their Fibonacci activities in particular.

11.30am – 1.00pm

Rothley & Oakham Suite, John Foster Hall

Nanoscience and nanotechnology at high school: A hands-on inquiry-based approach

Annamaria Lisotti, Guido Goldoni and Valentina De Renzi
University of Modena

An inquiry-based approach to science is now discussed throughout the world as one of the keys to the development of pupils' interest and effective teaching. However getting down to practice and comparing outcomes at different school levels, the upper secondary sector seems to show more resistance to implementation, with fewer examples of best practice and a shared opinion from many teachers that curricula requests and time constraints are impossible obstacles.

In this presentation we will illustrate the experience in Modena (Italy) which brought together high school teachers and students, researchers and last but not least industry representatives to collaborate in educational training.

In spite of the falling interest in traditional curricula in Physics and Science, young students are nonetheless fascinated with the latest research and its technological outputs. Many properties of matter (such as conductivity, colour and pliability) which can be appreciated at the macroscale even in a school lab are actually determined at the nanoscale and can be envisaged as the effects of quantum physics at work. Nanosciences and nanotechnologies are therefore an ideal playground to introduce cutting edge research topics and the basics of modern physics at high school. Many nano-materials have only recently been designed and most of their applications are still in the development stage. This means that students are able to use them in schools sometimes even before they have found their way into many commercial products which is in itself motivating. In some cases the material's behaviour is not yet fully understood and the investigation that students can perform really reflects the kind of research that is now being done in laboratories around the world. This is a great way to complement and sometimes even challenge pupils' "school" Physics knowledge, compelling them to refine their design and experimental skills directly "in the field": predicting, designing and implementing new experiments, collecting and interpreting data, looking for more to support such interpretations, visualizing new possible applications. In such a picture the role of the teachers too undergoes a dramatic change compelling them, in a non artificial way, to focus more on experimental methods and research skills.

Nanosciences and nanotechnologies rather than a self standing module were introduced in the initial stages as a theme across the curricula, integrating interdisciplinary research and technology with traditional science concepts.

An initial teachers' professional development course was held in autumn 2011 in Modena and more are planned for the future. While most of the materials used in the experiments are quite cheap, they are not ordinary or easily accessible, particularly with regard to nano-material samples. There is also a plan to implement a toolbox with consumables for teachers to experiment further with their classes.

WITH THE SUPPORT OF

Inquiry in education for sustainable development: Research on juvenile lifestyles including students as research partners

Christian Bertsch[1] and Anja Christanell[2]
[1]University of Education, Vienna , [2]Austrian Institute for Sustainable Development, Vienna

Reform efforts around the world stress the importance of developing images of science that are consistent with current scientific practices. Students should develop an understanding of what science is, what science is not, what science can and cannot do, and how science contributes to culture (Schwartz et al. 2004). However, many inquiry activities found in schools fail to capture important characteristics of authentic scientific inquiry and transport a naive vision of the activities that scientists engage in while conducting their research (Chinn and Malhotra 2002). Authentic inquiry bears little resemblance to the cookbook experiments found in many science classrooms or to the very simple forms of inquiry found in many textbooks. One way to address the lack of authentic inquiry in the classrooms is Research-Education-Collaborations (REC). REC are transdisciplinary research projects involving schools as active partners in the research process.

Over the last two years we involved grade 10 students in a research project on sustainable lifestyles and youth culture. Based on diaries about their own consumption behaviour the students developed - with the help of social scientists – a questionnaire and acquired basic knowledge on questionnaire development and descriptive statistics. The questionnaires were answered by 1000 Austrian students, translated and then sent to partner schools in the Cameroon and Japan and analysed looking closerly at gender and intercultural differences. Based on their own research, impulse films, presentations and discussions with experts on sustainability issues, the pupils explored the ecological and social consequences of their lifestyles. They spread their research findings via presentations at the Vienna University of Economics and Business and in their schools. Additionally they used their own communication channels and created blogs and designed postcards and T-Shirts with sustainable consumption related motifs.

Working in an REC for two years we also focused our research on the potential benefits and challenges of such cooperation. To identify a set of core challenges and potentials we used participative observation, informal talks and individual in-depth interviews with participating researchers, teachers and students. The transcribed interviews were analysed following a grounded theory approach. All partners described the projects as very enriching. Teachers and students reported an increase of their own understanding of the nature of scientific inquiry in social science. However, Research-Education-Collaborations face, like many transdisciplinary approaches, different challenges that might limit the broader implementation and deeper integration of such projects in the education and research system. Challenges include the time-consuming interface management when bringing together two different systems (education and research), the methodological challenge associated with the satisfying integration of the projects on both sides, the limited academic recognition accorded to REC (publish or perish culture in science) and the still very inflexible structures in most schools to conduct project work.

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Developing a relevant science education together with students and their teachers

Anders Jidesjö and Ulrika Johansson
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It is well documented that many students experience trouble in finding science in school relevant (Lyons, 2006; Osborne & Collins, 2001). Studies have used different methodologies and the results are sometimes hard to interpret and implement in schools (Jenkins, 2006). Several studies point to the quality of teaching and ways that students are being involved (Osborne, Simon & Collins, 2003). One way is to start discussions of relevance from the perspective of the students and their teachers where they are seen as part of the solution instead of part of the problem (Watts, Alsop, Gould and Walsh, 1997; Maskill & Pedrosa de Jesus, 1997). To become learner sensitive is also a critical aspect in inquiry-based instruction (Brown & Melear, 2005).

In Linköping there was a desire to develop science instruction. Project groups were organized with people from one school district, the university, municipal employees and politicians. The work started from students' and their teachers' perspectives and was supported in different ways and by different people during the process. The results indicate that if teachers are supposed to change and develop their science teaching it is important that the challenges originate in classroom realities. We report on ways that this was done. Attention was also paid to learners' and teachers' needs, experiences and expressed problems with science using focus group methodology. The results indicate that both students and teachers were positive to develop science education. Teachers were mainly aware of students' interest but indicated problems relating to lack of leadership, content that must be covered, working conditions and teaching methods. Students pointed more to the importance of connections with society, nature and working life. They wanted attention on ways they experience science outside school and asked for more learning opportunities with reflection, discussion, real problems and challenging work. The results are discussed in relation to the general problems with establishing a modern science education.

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Tilton & Swithland Suite, John Foster Hall

IT distance learning and assessment for teachers training in IBSE

Adelina Sporea and Dan Sporea
National Institute for Laser, Plasma and Radiation Physics, Center for Science Education and Training

The Center for Science Education and Training – CSET (http://education.inflpr.ro/) was established six years ago at the National Institute for Laser, Plasma and Radiation Physics in Bucharest. Its main goal is to support science education at pre-university level, from kindergarten to high school. As part of our science education activities we focused recently on the professional development of science teachers. We are aware that a true reform of the educational system has to start with the way science is taught in school. This is why our professional development program which is accredited by the Romanian Ministry of Education has a target group of school science teachers to introduce them in the use of IBSE methods. In the beginning, we started by assisting elementary school teachers and after that we addressed the middle-school science needs. In order to provide a broader access to information and to deliver a richer content, we designed an e-learning platform (http://teachscience.moodlehub.com/).

Dealing with the professional development of elementary and middle school science teachers, we faced the following challenges:

- In Romania training sessions for teachers are organized ONLY in the classical, face-to-face format.
- Teachers do not extensively use the Internet and electronic resources in preparing their lesson plans.
- There is a great demand for professional development courses on science teaching.
- Today courses are more or less formal and there is no means to see and to evaluate the way teachers apply in the classroom what they were trained on.
- Romanian teachers use the classical methods for transmitting knowledge, they do not coach students to acquire and use competences.

In order to overcome these drawbacks of the Romanian educational system we devised a modern, revolutionary course set-up. Our teachers' professional development program on IBSE includes:

- A traditional, face-to-face course delivered in schools or at our facility. Such a course includes theory background presentation, demo sessions, hands-on practice, participants' surveys, and covers up to 25 % of the overall training program.
- A distance learning module, extended over 65 % of the program time. This distance learning facility offers unlimited access, for the course duration, to an e-learning platform and to a videoconference server. On the platform teachers can find learning units they have to use in practising IBSE methods.
- Several assessment steps (10 % of the program), run during both the face-to-face course and as final evaluation which consists of a project developed in the classroom by each course attendee.

An IBSME approach to teaching in in-service education

Antonia Trompeta[1], Renata Carvalho[2], Claus Auning[3] and Ida Guldager[3]
[1] University of Alicante, Spain, [2] Ciência Viva, Portugal, [3] University College South Denmark

We have developed an IBSME unit, films and a generic guide to develop didactical skills and knowledge [1] which we have introduced on in-service workshops in Spain, Portugal, Germany and Denmark. In the implementation process we focus on helping the teacher in the process of designing his or her own approach to the unit – taking into account the learning abilities and preconceptions of her or his students and considering that 'learning in science is not a step-by-step progression through a predetermined hierarchy of activities and skills'[2].

Through working with the unit the teachers become familiar with an IBSME approach to teaching and a range of didactical methods which can be included in an IBSME teaching sequence including:-

- the creation of a learning environment that encourages questions and at the same time ensures focus on the concepts in science and mathematics that the teacher wants the students to learn;
- the gathering and handling of data in a way that supports the students' modelling competences;
- the dissemination of ideas, data, results etc. supporting students' use of scientific and mathematical language; and
- the practical and experimental work of students both in cooperation and alone.

We are in an ongoing process of reediting the unit taking into account response from teachers participating in in-service workshops and feedback from teachers implementing the unit in class.

We will present the systemized experiences from our in-service education workshops in an oral presentation, and comment on national variations due to differences in curricula and teachers' educational backgrounds.

Notes

1. The ships unit: http://www.fibonacci-project.dk/in-english/materials/units
   Inspired by Learning Science through Inquiry; Produced by Thirteen/WNET New York in collaboration with the Education Development Center (EDC). 2000.
   http://www.learner.org/resources/series129.html?pop=yesπd=1452
2. Wendy Saul and Jeanne Reardon (1996) *Beyond the science kit. Inquiry in Action*. Heinemann, Portsmouth p 24.

Development of a student self-evaluation instrument to evaluate accuracy, reliability and validity in inquiry

Saskia van der Jagt[1], Lisette van Rens[1], Herman Schalk[1], Albert Pilot[2] and Jos Beishuizen[1]
[1]Department of Research and Theory in Education, VU University Amsterdam, The Netherlands
[2]Freudenthal Institute, Utrecht University, The Netherlands

At secondary schools learning to inquire is becoming a more important part of the science education curriculum during the last decades (Abd-El-Khalick, BouJaoude, Duschl, Lederman, Mamlok-Naaman, & Hofstein, 2004). A formative instrument with qualitative descriptions of performance criteria seems to have the potential of promoting learning of students when the objective of an inquiry is learning how to ensure accuracy, reliability and validity. Rubrics, within the instrument, support learning by making performance criteria explicit, which makes it easier to give feedback to students and to let them perform a self-evaluation of their work (Jonsson & Svingby, 2007).

This design study aims at developing a set of rubrics that enables students to evaluate the accuracy, reliability and validity in an inquiry, during the time they plan, conduct and handle the data in that inquiry. The main research question of this study is: Which characteristics in a self-evaluation instrument or which set of rubrics are feasible for upper secondary science students to interpret the accuracy, reliability and validity during the enactment of an inquiry in science subjects?

The design of this self-evaluation instrument was based on thirteen design characteristics. These were converted from a draft of 22 rubrics, based on five levels in the Structure of Observed Learning Outcomes (SOLO) taxonomy (e.g. Biggs & Tang, 2007) and the concepts of an evidence model (Van der Jagt, Schalk, & Van Rens, 2011). The draft instrument was tested with 16 pre-university secondary science teachers, 23 student-teachers and two students, using a student inquiry report. Next, to determine the feasibility of the instrument, 24 pre-university students and two science teachers used the rubrics in class in three successive – general science, biology and physics – inquiry modules. Data were obtained from written documents, audiotapes, questionnaires and interviews.

It is concluded that the set of rubrics is feasible to use as an instrument for self-evaluation in class. However, the use of rubrics in the inquiry modules seemed quite time-consuming. When re-designing the rubrics for the second test round the number of rubrics should be reduced and each rubric should contain an example to improve the feasibility.

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Seminar Room 1, Gilbert Murray Hall

Free translation on demand of IBSME resources – needed and available but unbelievable and misunderstood.

Àgueda Gras-Velázquez, Eloïse Gérard and Přemysl Velek
European Schoolnet

The Scientix project of DG Research and Innovation aims to encourage networking between the different stakeholders in Science education: teachers, projects and researchers. To do so it launched a portal in May 2010, organized a European conference in May 2011 and is continuously organizing workshops and online courses.

Besides information on public funded projects, like the Fibonacci FP7 project, and the usual sections: forums, chats, news and newsletters; the Scientix portal has a repository of materials including lesson guides, animations, simulations, reports, videos, etc from different projects which teachers can use in their classes.

The key difference of the Scientix repository compared with other similar repositories is the possibility for teachers to request the translation of the materials to any of the 23 official languages of the Commission. This translation is carried out by official translators and is completely financed by the European Commission.

Many studies show that one of the conditions for teachers to use any material in their classes is that it is available in their native language. Or at least, in English. Over 240 resources have already been added to the Scientix repository so far from over 70 projects. Of these resources, 167 are available for translation on demand, thanks to their Creative commons – derivatives allowed license. Teachers registered in the portal (open to all) may request the translation of any "translatable" material they think will be useful for them from any of the 23 EU languages into any other of these languages.

After 1.5 years of the launch of this service, less than 5% of the possible translations have been requested. Causes include: projects not believing that their resources can be included and translated for free (upon request from teachers), teachers not being used to having access to these type of services and the low probability of several teachers requesting exactly the same translation.

At the Fibonacci conference we will present the changes in the use of the 'translation on demand of resources' of the Scientix portal after the introduction of features like tagging and ratings as well as the advantages and problems for the dissemination of IBSME resources.

Continuing professional development in inquiry-based pedagogies: From a transitional to a transformative model

Fco. Javier García, Geoff Wake, Katja Maass and Michiel Doorman
University of Jaén, The University of Nottingham, University of Education Freiburg, Utrecht University

PRIMAS is a project funded under the European 7th Framework Program, aiming at a wider uptake of inquiry-based learning methodologies in participating countries and beyond. The project is undertaking a programme of actions that address a wide range of different target groups, including teachers, parents, students and policy makers. The most important of these concerns teachers and involves the design and implementation of a continuing professional development program. Here we emphasize two of the major challenges this intervention faces: scaling up to ensure large-scale implementation and dealing with different national contexts.

First, we will reflect on the professional development model that underpins the PRIMAS initiative. Based on literature, we will introduce some clarifications and classifications of different models and strategies for teachers' professional development. Particularly, we will use the classification of professional development models as being either *transmissive, transitional* or *transformative* (Kennedy, 2005). This classification focuses on the potential of a professional development strategy to have a real impact on teachers' pedagogies, and will be used as a theoretical background to analyse the continuing professional development strategy adopted by PRIMAS.

Secondly, we will briefly explain the design of PRIMAS professional development program which is based on materials that were initiated within the Bowland Maths project. Our analysis suggests that the professional development program has basically the characteristics of a transitional model, but it should and could be implemented in a way that evolves into a transformative one. Our analysis is supported by illustrative cases from different countries that are already implementing the program with our understanding enhanced by an analysis of the different national contexts. This used the scale of levels of didactical determination from Anthropological Theory of Didactics (Chevallard, 2002) and identified the source and origin of constraints and conditions for implementation of the project.

Finally, we will draw some conclusions about strategies and principles for a transformative professional development of mathematics and science teachers that might take account of the challenges of large-scale implementation and the nature of the different cultural backgrounds in which we are required to operate.

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What was the question? S-TEAM and the future of inquiry-based science teaching

Peter Gray and Zozan Kaya Asphaug
Norwegian University of Science and Technology (NTNU)

In 2008, S-TEAM followed on from the Mind The Gap project in addressing a call from the European Commission, regarding widespread dissemination of inquiry-based science teaching (IBST) across Europe. Since then, several other calls in the same vein have resulted in further IBST projects in STEM (Science, Technology, Engineering, Mathematics), but a lack of overall coordination has meant that these projects tend to work in isolation. The ProCoNet group (Project Coordinators' Network) has addressed this problem informally, and has produced a joint report (1). There is, however, a need for informed reflection on the relationship between educators, national governments and EU policy in this area. There appears to be a perception that educators can produce a 'magic bullet', which will solve macro-economic problems at minimal cost. Education is, arguably, the only area of research and development capable of producing such a solution, but the current system, metaphorically, is like engaging a dozen or so construction gangs to build a house, without plans and without speaking to each other about what they are doing.

In this paper and presentation, I will argue that passive interaction between educators and EU funding systems is no longer satisfactory. In other words, we, as educators, need to shake the tree. I will support this assertion through analysis of the official discourse of the EU/EC system and of the current 'field' of EU funded projects in FP7. I will suggest that even a relatively small effort to increase collaboration between the EC and ongoing projects could produce disproportionate increases in the effectiveness of these projects, at all levels – policy, practice and theory.

The paper will report on an ongoing project at NTNU to research flows of knowledge and power within the EC system as it applies to STEM education. This is not in order to subvert the system but to provide constructive suggestions as to the way forward, from the everyday concerns of pedagogy, curriculum and assessment familiar to science educators, to the esoteric considerations of calls and work programmes.

1. see: www.proconet-education.eu.

Seminar Room 2/3, Gilbert Murray Hall

e-Mission-Operation Montserrat: Video Conference Simulation Managing a Natural Disaster: Part 2

Conference Hall, Gilbert Murray Hall

Initiating inquiry-based science education in outdoor learning sites: Issues and challenges

Suzanne Kapelari[1], Elaine Regan, Justin Dillon [2], Doris Elster[3], Julia Willison, Asimina Vergou [4] and Gail Bromley[5]
[1] University of Innsbruck, AUT; [2] King's College London, UK; [3]University of Bremen, BRD; [4] Botanic Garden Conservation International, UK;[5] Royal Botanic Gardens Kew, UK.

Education authorities are increasingly worried about the low level of student interest in school science. Although much of the concern focuses on attitudes towards chemistry and physics, plants are the basis for all life on earth and botany has almost disappeared from school science textbooks as well as from young people's minds (Link-Perez, Dollo, Weber, & Schussler, 2010, Uno 2009). Teachers play a crucial role in the development of students' interest in science (Osborne & Dillon 2008). Although some science educators argue that pedagogical practices based on inquiry-based science education (IBSE) methods are more effective than 'traditional' teaching approaches (Rocard 2007), for various reasons, this type of teaching is not practised in most European classrooms.

The EU 7th framework SiS INQUIRE project aims to support novel pedagogies by developing and delivering a one-year garden-based IBSE teacher training course in 11 European countries. The course is run through 14 botanic gardens and natural history museums – including some of Europe's most inspirational cultural and learning institutions. These centres act as catalysts, training and supporting teachers and educators to develop their teaching proficiency. To bridge the gap between education research and practice, teachers, botanic garden educators and science education researchers are working together in learning communities to transform the simplistic and under-theorised model of IBSE into actual teaching and learning units and activities addressing the topics "biodiversity loss and climate change". The teachers and botanic garden educators participating in INQUIRE are supported in engaging in reflective practice through undertaking their own classroom-based practitioner research.

This presentation will report on various approaches that demonstrate how communities of practice are facilitated in the INQUIRE project and how engaging practitioners in their own IBSE research can be supported.

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WITH THE SUPPORT OF

Taking the plunge: Inquiry-based teaching material to support inquiry-based learning in biology classrooms

Kirsten Schlüter[1], Kathrin Bylebyl[2], Katharina Freund[2] and Stefan Nessler[1]
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It is widely accepted that inquiry-based teaching is a good means to promote scientific thinking in pupils as well as teaching scientific knowledge and scientific literacy (Rocard-Report 2007). However, teachers may find inquiry-based teaching challenging because this kind of education is contradictory to traditional ex-cathedra teaching in which teachers are able to control what happens during a lesson (Lotter et al. 2007). This may be because they have to i) decide whether a school student's question and/or hypothesis is scientifically oriented, ii) judge a designed experiment during the lesson whether it is appropriate to answer the question or iii) evaluate a conclusion in the light of given results, which are possibly different from pre-defined expectations (Crawford 1999). These reasons may contribute to the circumstance that the use of inquiry-based teaching is still variable between different countries (S-Team 2010).

In order to attend to these problems, we designed working material for biology classes that is intended to encourage teachers to include inquiry-based teaching in their lessons by addressing the above mentioned problems (Bylebyl et al. 2010). We generated material which follows the scientific way of gaining knowledge and was evaluated in the classroom. Thus, with our material we are able to give comprehensive advice for teaching these examples, since we could elucidate possible pitfalls that may occur during lessons. Accordingly, advice for each example is given in the form of how to i) distinguish between a scientific and non-scientific hypothesis, ii) plan, judge, and analyse the experiment, and iii) how to write a scientific protocol. Finally, it is demonstrated how the scientific protocol can be analysed to distinguish between well and ill-conceived phases of the research process. We will exemplify the outline of our material by presenting two examples: i) modelling a water strider and ii) plant seed propagation in water.

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2.00pm – 3.00pm

Rothley & Oakham Suite, John Foster Hall

IBSE and assessment for learning: A socio-cultural perspective

Cristina Carulla
Aalborg University

The research takes place in the field of assessment for learning in Inquiry-Based Science Education (IBSE) (Shavelson, et al. 2008). I studied an existing discourse within an IBSE network growing in different cultures, social environments and continents supported on learning sequences that have been constructed by different experts and practitioners in different countries. This research considers assessment for learning and Inquiry-based Science Education as historically constructed discourses in a process of social interaction among researchers, teacher educators and teachers. Discourses are the formulations in written and spoken language that repeatedly express and construct the actions and values confirming educational practices (Gee & Green, 1998). The educational discourses of the IBSE Network are influenced by discourses about how learning happens and should happen based on developmental psychology, cognitive learning theories, educational assessment and science education research. It seems problematic that ideal discourses about inquiry-based teaching, learning and assessment do not consider the classroom practice as social and cultural phenomena. The ideal activities of teachers and learners are devoid of social and cultural elements that shape learning in classrooms. The theoretical research was guided by three aims: to denaturalize dominant discourses of assessment for learning in IBSE, to make visible their assumptions about learning, and to formulate a new proposal for assessment for learning in IBSE from the point of view of socio-cultural learning theories.

I assume a critical research perspective inspired by Skovsmose and Borba's (2004) methodology. I distinguish two different educational discourses: the *individualistic,* based on Jean Piaget's genetic epistemology, and the *socio-cultural,* supported by Lev Vygotsky's cultural-historical psychology. I characterize the dominant discourse on assessment for learning research within the IBSE Network, and I show that it follows an individualistic perspective that does not pay attention to the socio-cultural forces driving learning. I make visible some tensions around the relation between human beings, language and the natural and made worlds, focusing my attention on *reality, experience* and *phenomena* as historically, socially and culturally determined. I delimit a classroom discourse using the relationship between the social environment and assessment inspired by the research experience in a Colombian school. I formulate a new discourse for assessment for learning in IBSE, moving from the individualistic dominant discourse towards a socio-cultural approach.

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Tilton & Swithland Suite, John Foster Hall

Teacher collaboration on the integration of science and mathematics education through an inquiry-based approach

Frankie McKeon, Tina Jarvis and Janet Ainley
University of Leicester

Pairs of teachers from schools with pupils in the 4-13 age range have been collaborating to integrate science and mathematics teaching as part of a project using an inquiry-based approach which aims to enhance pupils' scientific and mathematical practice. Offer and Vasquez-Mireles (2009) report teachers' beliefs that integration of mathematics and science teaching might strengthen content knowledge, promote flexibility in problem-solving and enhance pupil motivation. However teachers' classroom practice is likely to be influenced by their individual views of the nature of science and mathematics, teaching and the process of learning in both subjects (Abd-El-Khalick & Lederman, 2000). Beliefs about the role of inquiry-based approaches (Harlen and Allende, 2009) and teachers' substantive understanding and pedagogical content knowledge in both mathematics and science may also impact on planning and practice in the classroom. This study addresses the questions

- What are teachers' responses to the Fibonacci project with respect to their understanding, own practice and teaching?
- How have teachers' collaborations supported the integration of mathematics and science?

A case study methodology has been adopted using: field notes on observations and discussions with teachers involving review and analysis of informal reports about their work with children and semi-structured interviews. Teachers' collaborations are reviewed using types of collegiality and collaboration including 'sharing' and 'joint work' proposed by Little (1990). Differing developmental stages of changing practice as outlined by Jarvis, Pell & Hingley (2011) appear to influence the quality of collaboration. Factors inhibiting and supporting uptake of the project approach are also explored.

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Facing the challenges for IBSE implementation

Marta Ariza, Antonio Armenteros, Ana Gallego and Francisco García
University of Jaén

There is enough research evidence showing the effects of IBSE on students' interest in learning science, on the development of inquiry skills and on the acquisition of conceptual understanding of science topics (Minner et al, 2010). Moreover, current educational policies are trying to promote IBSME (European Commission, 2008; European Commission, 2011). Then why is IBSE not used more widely?

There are different factors that teachers consider as problematic when trying to implement IBSE (Colburn, 2000; Walker, 2007). They can be classified into problems related to the school system, the individual teacher and to resources. Teachers point out that curriculum content full of concepts and theories to cover, the allotted time for instruction and the predominant assessment practices inhibit implementation. The second group of aspects hindering IBSE uptake are related to teachers' beliefs and attitudes. They do not feel confident with rethinking their role and worry about the possibility of discipline problems, exorbitant preparation requirements, and their lack of knowledge in a wide range of topics. The last group of factors is related to the availability of learning resources. Although a wide range of IBL teaching materials can be found, they do not always fulfil teachers' expectations. Some of them are interesting proposals designed as long projects to be carried out by students. However, usually teachers would prefer not to completely replace their daily practice by a project teaching approach, but prefer to have short inquiry activities to enrich their classes and to add other activities to cope with the rest of the science curriculum content.

The present work starts from the study of the main barriers hindering IBSE implementation and then focuses on one of them: providing teachers with appropriate training and teaching materials to promote not just inquiry skills in students, but also conceptual understanding of science ideas.

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Seminar Room 1, Gilbert Murray Hall

Understanding the European policy landscape: From globalising to glocalising in pedagogy

Geoff Wake
University of Nottingham

The project PRIMAS (Promoting Inquiry in Mathematics and Science Education across Europe) is evidence of the European Union's attempts to influence the globalisation of education policy. From a sociological perspective, education has a particularly important role to play as nations respond to emergent trends across the world in economic, political, cultural and social aspects of life (Ball, 2008). In recent years a key driver has been the idea of the 'knowledge economy' with much policy activity predicated on the assumptions that across the European Union (i) we require citizens and workers better educated in science, technology, engineering and mathematics (STEM) (EU, 2000) and consequently (ii) our schools need to provide inquiry-based learning that will motivate young people so that they are more highly disposed to undertake further study of, and future work in, STEM (Rocard, 2007). Through funding of a range of initiatives, therefore, the European Union has provided the catalyst for a globalising movement that intends to stimulate substantive change in pedagogic practices in its pursuit of a pan-European STEM based knowledge economy.

PRIMAS is working to understand the policy context at a European level and how policy priorities may, or may not, be localised within the nations of the partnership. The cultural and historical development of the education systems of partnership nations mean that any attempt at imposing a global uniformity in educational change is not possible. Rather, systems, structures and most importantly people (teachers, educators, policy-makers) react differently to policy imperatives because of 'local' contexts resulting in what Robertson (1995) has termed glocalisation. In a first phase of work in this field PRIMAS, therefore, asks how do globalising intentions interact with national contexts to result in glocalised outcomes? We provide systematic analysis of data collected using a common framework across the partnership of: (a) priorities in maths and science education and the professional development of teachers, (b) how systems and structures mediate/manage policy implementation; and (c) the processes of providing data and evidence that inform policy decisions. Potential affordances and constraints to the overall European aims of increasing its maths / science educated skills base are therefore identified with key issues and recommendations presented.

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Conference Hall, Gilbert Murray Hall

Developing a tool for evaluating inquiry-based science education (IBSE) in Europe: Building a bridge between research and practice

Susana Borda Carulla
La main à la pâte, École Normale Supérieure (ENS), Paris

In the framework of the Fibonacci Project, a team of six partners from different European countries (France, Greece, Luxemburg, Slovakia, Sweden, and United Kingdom), have been reflecting on the following question: how does scientific inquiry in natural sciences translate into observable classroom practices? In order to better define the essence of inquiry-based science teaching and learning practices, the team created a common European Inquiry-Based Science Education (IBSE) evaluation instrument. Building an evaluation instrument means passing from theoretical inquiry guidelines to concrete, observable, assessable practices in the classroom context.

The process of making this instrument has involved researchers in science education, science teacher trainers, science teachers, and students from the above mentioned countries, either directly or indirectly. The activities leading to the making of the instrument have included 1) a review of bibliography on IBSE and on class observation instruments; 2) regular working meetings among the team members; 3) three different tests in at least five different classes in each country involved, at three different stages of development of the instrument.

This paper will first present the main issues that came up throughout the process of building the instrument and how the team tackled them:

- What are the essential, determinant components of inquiry in terms of teaching and learning practices, regardless of contextual factors or pupils' age, which distinguish it from other good practices in science education?
- What are the advantages and disadvantages of using evaluation scales in this context?
- Does the fact that evaluation is carried out for summative or formative purposes have an effect on the structure or presentation of the instrument?
- Does the user of the instrument (teacher or teacher trainer) have an effect on the structure or presentation of the instrument)?

Not only the tool as a finished product, but also the process of building it, has been a way to ensure a fruitful back-and-forth dialogue between research on inquiry-based science education and actual classroom practice. The instrument itself has come to be conceived by the team as a formative tool for triggering reflection among the different actors within the educational system, more than as a finished product.

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Conference Hall, Gilbert Murray Hall

3.15pm – 4.15pm

Keynote: Design based research as a framework for promoting research-informed adoptions of inquiry oriented science teaching

Professor Costas Constantinou
Learning in Science Group, University of Cyprus

Costas Constantinou is a Professor in Science Education and Director of the Learning in Science Group at the University of Cyprus. He has a PhD in Physics from the University of Cambridge and has worked as a Postdoctoral Research Associate at Washington State University and as a Visiting Professor at the University of Washington. He is a member of the editorial board of the *International Journal of Science Education* and the *Educational Research Review* and he is serving as a reviewer in other international research journals including *Learning and Instruction* and the *Journal of Research in Science Teaching*. His research interests focus on the learning and teaching of science as a process of inquiry and the use of educational technologies as a tool for promoting critical evidence-based thinking. The Learning in Science Group uses the results of this research in the development of online and conventional learning environments, such as the STOCHASMOS platform, and research-based teaching-learning sequences to promote conceptual understanding and scientific thinking. Dr. Constantinou has co-ordinated a number of projects funded by the European Commission and the Cyprus Research Promotion Foundation. He has participated in the High Level Working Group that authored the report *Europe needs more Scientists!* in 2004; he was the Rapporteur in a group of experts that carried out the mid-term evaluation of the EC Science in Society program in FP6 and he currently participates in an expert panel reflecting on the educational outreach programme of the European Space Agency and its future evolution. Finally, he has served as a member of the Board of the European Association for Research on Learning and Instruction (EARLI) and of the European Association of Science Education Researchers (ESERA).

4.15pm – 4.45pm

Conference Conclusions

Professor Sir Robert Burgess
Vice Chancellor, University of Leicester

Professor Janet Ainley
Director, School of Education, University of Leicester

5.00pm – 6.00pm

Visit to University of Leicester Botanic Garden

How outside space can stimulate learning

Ruth Godfrey
University of Leicester

The University of Leicester Botanic Garden is very close to John Foster hall. The plant collections and landscape features make the garden one of the most diverse in the region. In addition there are two Fibonacci pavements and a hopscotch showing the Fibonacci mathematical sequence.

The Botanic Garden and the associated Attenborough Arboretum hosts over 11,000 children and adults annually on booked education visits. The experimental hands-on approach programmes cover a wide range of subject areas from 4 year olds to adult. In 2011 the quality of the education work was recognised by the award of the Learning Outside the Classroom Quality Badge and the Growing Schools Award.

Ruth Godfrey the Botanic Garden Education officer will give delegates the opportunity to visit the site and see how an outside space can be used to stimulate learning and in particular Science and Mathematics.

Delegates who wish to take part in the guided visit should meet at the Reception Desk in Gilbert Murray.

The Fibonacci Project
Second European Conference

Inquiry Based Science & Mathematics Education: Bridging the gap between education research and practice

26 – 27 April 2012, University of Leicester, United Kingdom

Local organisers

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