Introduction on Inquiry-Based Learning (IBL)

Project Name: weSPOT - Working Environment with Social and Personal Open Tools for inquiry based learning

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Content:

1. Inquiry-based learning (IBL)

Inquiry-based learning is a pedagogic and teaching approach based on the scientific method of inquiry. It is grounded in the constructivist approach to learning, which advocates that each learner follows his own route to build and organize personal knowledge, and that it is more important to know "**how to learn**" than the association and memorizing of information. It is an **active approach** towards learning and teaching that places learners and students at the centre of the learning process and involves self-direction. Students develop knowledge and understanding of scientific ideas as well as an understanding of how scientists study the natural world (Anderson, 2002).

Many terms are used for learning through inquiry, including 'enquiry-based learning', 'guided-inquiry', 'problem-based learning', 'undergraduate research' and 'research-based teaching' (Spronken-Smith & Walker, 2010).

Science learning is not about memorisation of scientific facts and information, but rather is about understanding and applying scientific concepts and methods (Bell, Urhahne, Schanze, & Ploetzner, 2010). Inquiry "refers to the activities of students in which they develop knowledge and understandings of scientific ideas, as well as an understanding of how scientists study the natural world" (NRC, 1996, p. 23). Like real scientists, students can study and investigate the natural world, make their own observations, collect and analyse their own data, and propose explanations based on the evidence of their own work.

Inquiry incorporates the application of scientific methods into studying and investigating problems, topics and areas of interest. Scientific inquiry is more complex than popular conceptions would have it. It is, for instance, a more subtle and demanding process than the simplistic idea of 'making a great many careful observations and then organizing them.' It is far more flexible than the rigid sequence of steps commonly depicted in textbooks as 'the scientific method' (AAAS, 2009).

The National Science Teachers Association (NSTA, 2004) defines scientific inquiry as "a powerful way of understanding science content. Students *learn how to ask questions and use evidence to answer them*. In the process of learning the strategies of scientific inquiry, students learn to conduct an investigation and collect evidence from a variety of sources, develop an explanation from the data, and communicate and defend their conclusions" (p. 1). Scientists observe carefully, classify and analyze their facts, make generalizations, and attempt to develop and test hypotheses to explain their generalizations (Hunt and Colander, 2010).

The steps of the scientific method have been reviewed and outlined in detail and can be summarised as follows: define a question, gather information and resources (observe), form an explanatory hypothesis, test the hypothesis by performing an experiment and collecting data in a reproducible manner, analyze the data, interpret the data and draw conclusions that serve as a starting point for new hypothesis, publish results, and retest (frequently done by other scientists) (Crawford and Stucki, 1990).

According to Conole, et al. (2008) there are four main characteristics of inquiry learning:

- **Questioning and hypothesis**: Learners are engaged by scientifically oriented questions (Grandy & Duschl, 2007). They are asking questions about the world, collecting data, making discoveries and testing those discoveries (de Jong, 2006) or making hypothesis and predictions about natural phenomena (Osborne et al., 2005). **The teacher does not begin with a statement, but with a question.** This allows the students to search for information and learn on their own with the teacher's guidance.
- **Adopting an evidence-based approach:** Evidence collection is set as a priority and allows students to develop and evaluate explanations that address **scientifically oriented questions** (Grandy & Duschl, 2007).
- **Synthesis and metacognition:** Learners synthesising the obtained information, using metacognitive processes[1], to formulate explanations about the task at hand. That will lead to an 'integrated' scientific understanding of scientific concepts, scientific tools and inquiry skills (Edelson, Gordin, & Pea, 1999).
- **The nature of Science:** Learners evaluate their explanations in light of alternative scientific explanations, some times contradicting, and not common or popular beliefs.

Specific learning processes that students engage in during inquiry-learning include:

- Creating their own questions
- Obtaining supporting evidence to answer the questions
- Explaining the collected evidence
- Connecting the explanations to the evidence
- Creating arguments and justifications.

2. Levels of inquiry-based learning

Four types of inquiry-based learning are recognized based on the level of student autonomy in the process.

The simplest level is the **confirmation inquiry** in which students are provided with the question and procedure (method) as well as the results, which are known in advance. Here the teacher guides the inquiry process by providing all the necessary information and tools and the student executes. Teachers provide guidance throughout the whole process and direct the students to the correct decisions and actions.

The next level is called **structured inquiry**. The learning goal here is to introduce students to the experience of conducting investigations or practicing a specific inquiry skill, such as collecting and analysing data. The teacher at this level of inquiry provides the necessary information about the

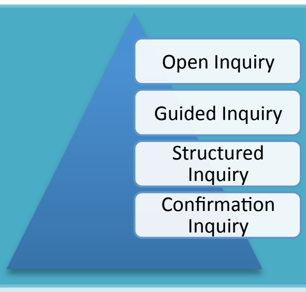
[1] Metacognition is the ability to use prior knowledge to plan a strategy for approaching a learning task, take necessary steps to problem solve, reflect on and evaluate results, and modify one's approach as needed.

problem at hand and the appropriate method and the students work on the solution by collecting and analysing the appropriate data.

The third level of inquiry is called **guided inquiry**. In this inquiry the question and procedure are still provided by the teacher. Students, however, generate an explanation supported by the evidence they have collected. The teacher provides students only with the research question or hypothesis, and students design the procedure (method) to test their question/hypothesis and the resulting explanations with guidance and/or mentoring support.

The most demanding level of inquiry is the **open inquiry**. In an open inquiry students have the opportunity to act like scientists, deriving questions, designing and carrying out investigations as well as communicating their results. This level requires experienced scientific reasoning and domain competences from students. The teacher can provide guidance but the students themselves should decide on the hypothesis, the method, the solution and the communication of the solution.

Table 1. Levels of inquiry according to (Tafoya et al., 1980)



	Main responsibility for:		
Level of inquiry	Problem	Procedure	Solution
Level 4 Open inquiry	Student	Student	Student
Level 3 Guided inquiry	(teacher)	Student	Student
Level 2 Structured inquiry	(teacher)	(teacher)	Student
Level 1 Confirmation/ verification	(teacher)	(teacher)	(teacher)

3. The weSPOT IBL approach

The aim of weSPOT is to provide a learning and research environment for "young researchers" which allows them to explore "scientifically" specific aspects of their physical environment, in the mood of inquiry-based learning within a networked and mobile world. The environment is aimed at supporting informal, self-regulated learning settings as well as formal learning. The learning process can take place independently, or in collaboration with others. It can be self-directed or guided by others (e.g. teachers). The difficult and ambitious aspiration is, to give as much freedom in inquiry based learning as appropriate for the individual and, at the same time, to provide as much guidance and orientation as needed, by smart agents.

weSPOT focuses on scientific inquiry in empirical sciences. Such inquiry answers the question of how phenomena are related: why things do happen. It is about cause-consequence relations, which can principally be tested in experiments. It is not about believes but about empirical evidence. Inquiry-based learning is learning, which starts from a project idea and follows the rules of scientific inquiry. It leads finally to structured knowledge about a domain and to more skills and competences about how to carry out research which is efficient and which can be communicated.

4. Inquiry-based learning and technology

Inquiry-based learning can occur with or without technology. But technology can play a special role in supporting inquiry-based learning and in transforming the learning process. To better understand the context in which technology can support inquiry-based learning, two important distinctions should be noted: technology can be viewed as the subject of instruction or as a tool for instruction, and can serve as an amplifier of traditional practice or as a transforming agent.

ICT technologies are creating new opportunities for students to engage in serious inquiry (Krajcik, Marx, Blumenfeld, Soloway, & Fishman, 2000), to undertake aspects of inquiry that it would be impossible to do otherwise (Novak & Gleason, 2001), such as simulations, and transform the labs from passive teaching areas of science to a dynamic and hands-on, authentic areas of investigation and discovery (Barstow, 2001).

- The World Wide Web and open shared data can provide access to older scientific work in form of reports, data, presentations and articles together with the most recent ones on the same topic, offering the opportunity to explore how scientific data, models and theories are created, modified and refined over time. Computer technology can facilitate the collection of data and manipulation of variables in experiments and models.
- Simulations can support science and its teaching. Teachers can us it to demonstrate the impacts of the choice of variables used in an experiment. Simulated experiments and virtual labs can save time for both teacher and students normally spent on setups, cleanups and other tedious procedures of lab work (Kubicek, 2005).
- Tools such as sensors, mobiles and portable devices, previously only available to scientists, permit students to directly interact with the environment and collect new first-hand data within a practical time- frame.
- Social media and other communication tools such as wikis, blogs, emails etc. can facilitate synchronous and asynchronous communication between learners, teachers and scientists, give access and create communities of practice, which in turn creates added potential to enrich discussions on science and its subjectivity, its social/cultural embeddedness, methods, observations and inferences.

Technology can contribute to a better understanding of abstract concepts, such as atoms or genes, which are difficult to understand because they are unobservable. Such concepts are theoretical constructs based on experimentation, and technology can facilitate their observation and provide the means for experimentation.

Mobile devices and technology has made such tools widely available and, if used within the right context and with the right pedagogical approaches can provide a truly realistic scientific experience. For example, students can use such tools to visit a local area and collect measurements, analyze, compare and discuss the results. They also can record images, video, sound, take notes, use GPS technology and mapping software to record information and use them latter in the class.

However, the answer to the question, "Can technology has significant effect on learning?" is yes as long as one determines the models of teaching and learning that underlie the instruction in the classroom. Pedagogy is the key element in applying the use of technology effectively. Good pedagogy, can be made significantly more effective by appropriate uses of technology.

5. Skills trained with inquiry-based learning

Skills related to weSPOT project considered to be the following. However, this list of skills is not exhausted and will be updated as the project evolves:

- Analytical skills to research a topic, develop a project plan and timeline, and draw conclusions from research results.
- Science skills to break down a complex scientific system into smaller parts, recognize cause and effect relationships, and defend opinions using facts.
- Literacy skills to read and understand non-technical and technical materials.
- Information foraging skills to be able to gather valuable pieces of information from different sources
- Experimentation skills to know the different methodologies and processes required.
- Problem solving skills to overcome obstacles and find solutions
- Mathematic skills for calculations and measurements.
- Attention to detail to follow a standard blueprint, record data accurately, or write instructions.
- Technical skills to troubleshoot the source of a problem repair a machine or debug an operating system, and computer capabilities to stay current on appropriate software and equipment.
- Presentation skills to effectively present information.
- Cooperation skills to listen to others needs or interact with project partners.
- Creative skills/abilities to solve problems and develop new ideas.
- Leadership skills to be able to lead a team.
- Organization skills to keep track of lots of different information.

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