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# weSPOT: A Personal and Social Approach to Inquiry-Based Learning

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**Abstract:** weSPOT is a new European initiative proposing a novel approach for personal and social inquiry-based learning in secondary and higher education. weSPOT aims at enabling students to create their mash-ups out of cloud-based tools and services in order to perform scientific investigations. Students will also be able to share their inquiry accomplishments in social networks and receive feedback from the learning environment and their peers. This paper presents the research framework of the weSPOT project, as well as the initial inquiry-based learning scenarios that will be piloted by the project in real-life educational settings.

**Keywords:** social learning, scientific inquiry, personal learning environment, cloud learning environment, inquiry-based learning.
**Categories:** L.3.0, L.3.4, L.3.6, L.6.2, L.2.2

## 1 Introduction

Seely-Brown and Adler (Seely Brown and Adler, 2008) describe learning as "based on the premise that our understanding of content is socially constructed through conversations about that content and through grounded interactions, especially with others, around problems or actions". In addition, learning is facilitated and triggered

by one's individual interaction with objects in an (real) environment, constructing meaning and testing 'hypothesized' constructs while facing and (re)acting upon unexpected phenomena or problems (Kolb, 1984).

Nonetheless, students in secondary schools and universities assume mostly a passive role within the classroom, whilst the mentoring role is often exclusively held by the teacher. Students are seldom motivated to take initiatives within their learning and extend it outside school settings, motivated by their curiosity. In an Inquiry-Based Learning (IBL) approach learners take the role of an explorer and scientist as they try to solve issues they came across and that made them wonder, thus tapping into their personal feelings of curiosity. IBL supports the meaningful contextualization of scientific concepts by relating them to personal experiences. It leads to structured knowledge about a domain and to more skills and competences about how to carry out efficient and communicable research. Thus, learners learn to investigate, collaborate, be creative, use their personal characteristics and identity to have influence in different environments and at different levels (e.g. me, neighbourhood, society, world).

Learners can go through IBL workflow processes at various levels of autonomy and complexity, consequently with various degrees of support (Tafoya et al., 1980). At the highest level, called 'Open Inquiry' they are only guided by self-reflection, reason and they make sense of phenomena individually or collaboratively, organize and orchestrate their (shared) activities and construct and disseminate knowledge. At the lowest level, they are completely guided by the teacher when defining a problem, choosing a suitable procedure (method) and finding a solution.

Regardless the level of inquiry and the degree of support by teachers, the shift from passive to inquiry-based learning is challenging for both students and teachers. Such a shift requires appropriate methodologies and tools to match students and teachers need at hand. Information and Communication Technologies (ICT) have the potential to contribute positively towards this end (Blumenfeld et al., 1991). Despite this, students are not sufficiently supported by technology for conducting their inquiries and investigations in their everyday environment and in a social and collaborative way. The weSPOT's model aims to provide teachers and learners with the support and the technology tools, so as learners become able to find the optimal level of inquiry to match their needs and be facilitated in the transition from passive towards active learning.

In short, weSPOT will employ a learner-centric approach in secondary and higher education that will enable students to:

1. Personalize their inquiry-based learning environment.
2. Build, share and enact inquiry workflows individually and/or collaboratively with their peers.

Thus, weSPOT aims to lower the threshold for linking everyday life with science teaching in schools by technology.

From the European teachers' perspective, the project will enable teachers as well as students to adopt methodologies for inquiry based science learning based on experiments conducted in a real environment outside schools. Such experiments could be backed-up with computer simulations and 3D images and video, which will enable students to go deep to the science subjects. This in turn will enable new models of

learning and teaching to emerge, bringing students closer to the research, and creating new bridges to business usage of science results.

The remainder of this paper is structured as follows. We first introduce existing IBL models and tools and explain how weSPOT plans to support personal and social inquiry based learning processes. Then we focus on the role of technology and its merit to support these processes and we elaborate on the technologies that will enable the weSPOT IBL approach. Finally, we present the initial IBL scenarios that will be piloted by the project and we conclude with our next steps for implementing our research agenda.

## 2 Inquiry-Based Learning Models and Tools

Inquiry workflows can be described by graphical representations, whose aim is to help users visualize and orchestrate their inquiry projects. These representations are a key to personal as well as social inquiry based learning. Learners can link diverse steps of their investigation and represent their scientific reasoning by integrating graphically their questions, hypothesis, concepts, arguments and data. Inquiry workflows play an important role as visual strategy and mediating tools in scientific reasoning. As a knowledge mapping strategy, they enable users to connect and make their conceptual and procedural knowledge explicit. As a reflective aid, they provide visual guidance for users rethinking and reasoning through their graphical representations. As a visual language, they support users to make their argumentation clear for generating a coherent document outline.

The literature of Inquiry-based Science Education presents several approaches, which can be considered as templates or models for IBL. Based on John Dewey's philosophy that IBL begins with the curiosity of learners, several authors (White and Frederiksen, 1998, Bruce and Bishop, 2002) suggest a 5-step cycle of inquiry, as shown in Figure 1.

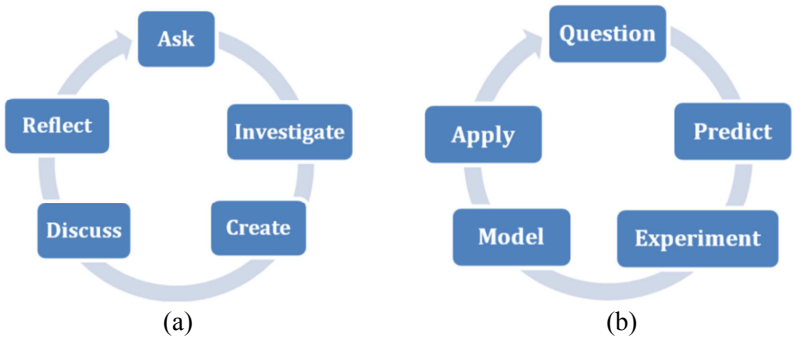


*Figure 1: Five-step models by (a) Bruce & Bishop (2002) and (b) White & Frederiksen (1998)*

These steps comprise a continuous cycle for asking questions and making predictions; investigating solutions through experiments; creating new knowledge and

models; applying/discussing discoveries and experiences; and reflecting on newfound knowledge and/or starting new question.

A slightly different approach proposed by Llewellyn (2004) is a 6-step inquiry cycle (Figure 2): generating a question; brainstorming; stating a hypothesis; choosing a course of action and carrying out the investigation; gathering data for appropriate conclusions; and communicating the findings.

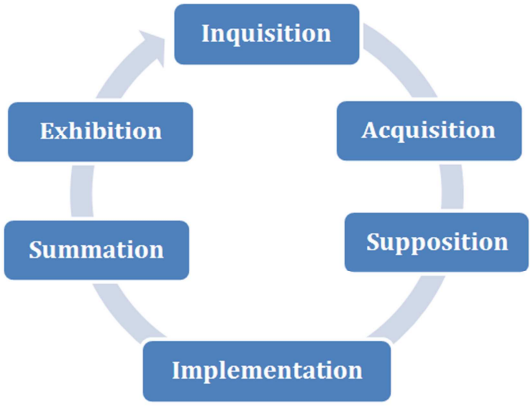


*Figure 2: Six-step model by Llewellyn (2004)*

There is also a significant number of approaches originating from a variety of learning contexts, such as collaborative or individual inquiry; real or simulated environment; curriculum guided or not. Murdoch (2007) proposes 7 steps of inquiry for implementation in groups and integration of investigation to the curriculum (Figure 3).

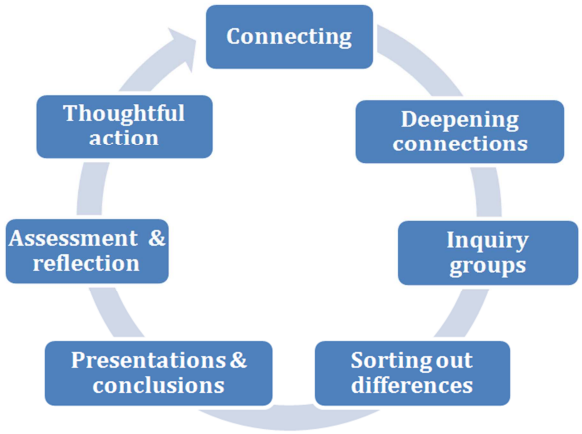


*Figure 3: Seven-step inquiry cycle by Murdoch (2007)*

Mulholland et al. (2012) highlight the inquiry cycle based on an 8-phase model, comprised by initial topic selection, communication of findings and reflection upon the method of inquiry (Figure 4).

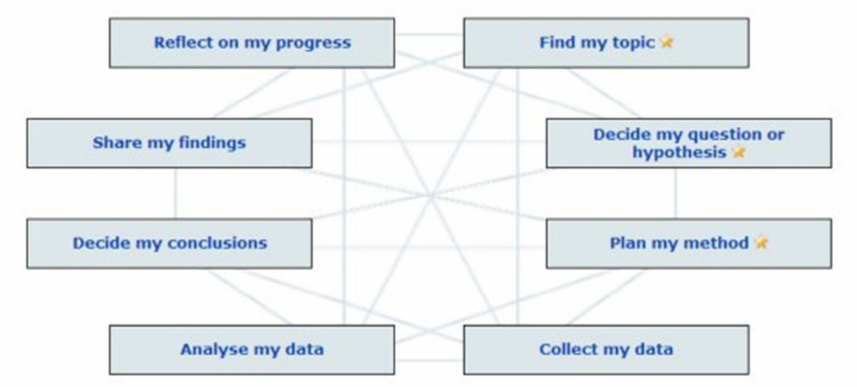


*Figure 4: Eight-phase inquiry model by Mulholland et al (2012)*

All these variations suggest that there is not a specific single representation of inquiry learning workflow that is suitable across every scenario.

There is also a significant number of IBL tools, adopting one or more of the aforementioned IBL models. Table 1 presents the most representative of these tools.

More generic knowledge mapping tools can also be used for creating inquiry workflows. Okada (2009) discusses how mapping techniques and software tools (e.g. Cmap Tools, Nestor Web Cartographer, Compendium and Freemind) can be used by students to connect knowledge during their inquiry projects. In this study, the term "inquiry maps" is introduced, referring to a range of 6 types of knowledge maps that can be applied to scientific inquiry:

1. Research map for designing an inquiry project.
2. Reference map for collecting references in the literature.
3. Reading map for selecting key ideas of papers´ content.
4. Theory map for organising key concepts and definitions from the literature.
5. Fieldwork map for structuring key data from a corpus of documents.
6. Writing map for integrating key arguments for an essay.

## 3 Personal and Social Inquiry in weSPOT

In the view of the IBL models and tools presented above, weSPOT strives to develop a reference model for inquiry skills as well as a diagnostic instrument to measure the individual performance on inquiry skills. The reference model and diagnostic instrument are based on the five inquiry skills areas described by the US National Research Council (National Research Council, 2000):

- engaging by scientifically oriented questions

- giving priority to evidence in responding to questions
- formulating explanations from evidence
- connecting explanations to scientific knowledge
- communicating and justifying scientific explanations to others

| Period and Tool | Description |
|---|---|
| **1996-2012**<br>**WISE**<br>(http://wise.berkeley.edu) | WISE (Web-based inquiry science environment) is a free online science learning environment for students in grades 4-12 created by the team of Marcia C. Linn at University of California, Berkely. |
| **1998**<br>**GenScope learning environment**<br>(http://genscope.concord.org) | GenScope is a learning environment that uses the computer to provide an alternative to text-based science education. It provides teachers and learners with a new tool that enables students to investigate scientific and mathematical concepts through direct manipulation and experimentation. |
| **2001**<br>**The Progress Portfolio**<br>(http://www.progressportfolio.northwestern.edu) | The Progress Portfolio helps students conduct long-term inquiry projects on computers (visualization projects, web-based inquiry projects, explorations, simulations, digital libraries, etc.). It allows students to document and reflect on their work using an integrated suite of screen capture, annotation, organization, and presentation tools. In addition, teachers can use the Progress Portfolio to guide students in their work through the design of prompts and templates that encourage students to think about key issues as they work. It is used by the SIBLE (Supportive IBL Environment) project. |
| **2006-2012**<br>**BGuILE**<br>(http://www.letus.org/bguile/software/Software.html) | BGuILE (Biology Guided Inquiry Learning Environment) brings scientific inquiry into middle school science and high school biology classrooms. The environments consist of computer-based scenarios and associated classroom activities in which students conduct authentic scientific investigations |
| **2007-2010**<br>**nQuire**<br>(http://www.nquire.org.uk) | The nQuire software enables students guided by teachers to design and run science inquiries at school, at home, or outdoors on mobile devices.<br>Students are guided through the inquiry process. Teachers can choose from a set of ready-made inquiries for their students, modifying them as they need, or creating their own new inquiries. They can also monitor their students' progress through inquiries, and give them access to new parts as they complete each stage.<br>Developers can create new inquiries for students and teachers to use, and extend and develop the open source nQuire system to achieve their own goals. |
| **2011-2012**<br>**Evidence Hub**<br>(http://edfutures.evidence-hub.net/) | The Evidence Hub is a collaborative environment for community to pool its ideas, questions, hypothesis data and different kinds of evidence for collective debate. |

*Table 1: Inquiry-based learning tools*

The reference model will define the skills and competence levels in inquiry and these are translated in observable indicators in the diagnostic instrument.

Based on the reference model, inquiry workflows will be defined, which can be build, shared and (en)acted individually or collaboratively. The role of the teacher as well as the peers can vary when a learner follows these workflows, based on the level of support needed by the learner(s), the need to reflect and/or to provide feedback and the need to collaborate to acquire an inquiry competence. So, the instructional strategy will vary, dependent on the learner, the context and the targeted inquiry competence level. However, learners are in most cases stimulated to go through the whole inquiry process, although the level of complexity of the inquiry tasks guiding their activities will vary (Merriënboer and Kirschner, 2007).

## 4 The need for integrating Technology into Inquiry-Based Learning

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 aspects should be considered: technology can be viewed as the subject or tool for instruction, and can transform and enhance traditional practice. This is how technology is seen within the context of the weSPOT project.

To answer the question however, "Will technology has significant effect on learning?" one needs to determine 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. Looking at the interaction between pedagogy and technology so far, one can conclude that traditional pedagogy has not improved much by the addition of technology. Good pedagogy, on the other hand, can be made significantly more effective by appropriate uses of technology.

There is a growing call for inquiry to play an important role in science education (American Association for the Advancement of Science, 1994, National Research Council, 2000). This call for inquiry-based learning is based on the recognition that science is essentially a question-driven, open-ended process and that students must have personal experience with scientific inquiry to understand this fundamental aspect of science (Edelson et al., 1999). At the same time technology receives increased attention from science education. Its potential to support inquiry-based learning is evident from the plethora of projects that explore technology-based inquiry-learning.

Information and Communication Technologies (ICT) can offer significant new opportunities to support inquiry-based learning if used correctly, grounded to the appropriate pedagogy. Technology can contribute towards IBL in several ways according to Blumenfeld et al. (1991). They have identified six contributions that technology can make to the learning process:

- enhancing students interest and motivation;
- providing increased access to information;
- allowing active representations;
- structuring the process with tactical and strategic support;

- diagnosing and correcting errors;
- managing complexity and aiding production.

All of the fundamental properties of ICT technologies can offer benefits for inquiry-based learning. For example, they allow learners to store and manipulate large quantities of data, to present information in a variety of visual and audio formats, to interact with the information in a variety of ways, to perform complex computations, the support for communication, the ability to respond synchronous and/or asynchronous to individuals or groups, and adapt these responses to the learners' needs.

weSPOT is adopting an approach that does not recommend a one-size-fits-all inquiry-based learning model, but it takes the pragmatic view that the optimal level of inquiry is actually variable and it might differ between individual learners or groups. It has to reflect key factors in the learning situation, including the content, context, skill of the student, knowledge of the teacher, and the available educational materials. Students when compared to scientists are novices in scientific inquiry. When their current knowledge of the topic is limited, the intellectual demands of fully open inquiry may not generate effective learning and may even hinder learning by adding intrinsic or extraneous cognitive load. weSPOT's model will provide teachers and learners support and the technology tools to work 'up the ladder' to reach competence, progress and become able to find the optimal inquiry level to match the needs at hand.

## 5 Inquiry-Based Learning and Technology: Related Work

The Personal Learning Environment (PLE) and the Cloud Learning Environment (CLE) have shown evidence of facilitating learning and addressing the current limitations of Learning Management Systems (LMS). Compared to a typical LMS, like Moodle or Sakai, where the learner is restricted by the lack of adaptability and responsiveness of the learning environment, the PLE follows a learner-centric approach. It allows the use of lightweight services and tools that belong to and are controlled by individual learners. Rather than integrating different services into a centralised system, the PLE provides the learner with a variety of services and hands over control to her to select and use these services the way she deems fit (Chatti et al., 2007, Fiedler and Väljataga, 2010, Wilson, 2008).

The Cloud Learning Environment (CLE) extends the PLE by considering the cloud as a large autonomous system not owned by any educational organisation. In this system, the users of cloud-based services are academics or learners, who share the same privileges, including control, choice, and sharing of content on these services. This approach has the potential to enable and facilitate both formal and informal learning for the learner. It also promotes the openness, sharing and reusability of learning resources on the web (Malik, 2009, Mikroyannidis, 2012).

Self-Regulated Learning (SRL) comprises an essential aspect of the PLE and the CLE, as it enables learners to become "metacognitively, motivationally, and behaviourally active participants in their own learning process" (Zimmerman, 1989). SRL is enabled within the PLE and the CLE through the assembly of independent resources in a way that fulfils a specific learning goal. By following this paradigm,

learners are empowered to regulate their own learning, thus greatly enhancing their learning outcomes (Steffens, 2006, Fruhmann et al., 2010).

In weSPOT, we are planning to apply at new level our experience from previous research projects. For example, in the Innovative Didactics for Web-Based Learning - IDWBL (Sendova et al., 2004) project web-based learning comprised five forms: web referral, web quest, web exploration, e-mail project and collaboration. In such a way students were put in a situation to explore new methods and techniques, guided by teachers. They shared their innovative approaches which peers and teachers and in such way they enriched the traditional work in class. The teachers reported an improvement of the thinking process of their students and an increase in their motivation for learning.

In order to apply inquiry-based science education, teachers need to develop new practical methodologies, approaches and tools in their day-to-day practice. To address this need, an useful experience was the I*Teach methodology (Stefanova et al., 2007), which is based on active learning methods, with the student at the centre of the learning process and the teacher as a guide and a partner in project work based on didactic scenarios encouraging the creative thinking of learners (Nikolova et al., 2011). This methodology focuses on the development of specific skills in the context of the ICT education: work on a project, teamwork, presentation skills, and information skills. This methodology was integrated in the TENCompetence pilot project (Nikolova et al., 2009), Share.TEC pilot teachers' training (Stefanova et al., 2011), and in the training of 750 VET teachers in Innovative Methods and New Technologies. It was integrated in the textbook for Information technologies teaching, used actively in the training of teachers for IBSE in Fibonacci project (http://www.fibonacci-project.eu). In 2009 the I*Teach project has been awarded for best products results.

Another useful idea can be borrowed from WebLabs**,** European project focused on the development of a Virtual Learning Environment (VLE) and WebLabs learning model (Mor et al., 2004). The VLE allowed students, teachers and geographically dispersed researchers to be involved in science and math learning and explorations. Students developed an understanding of mathematics as a science through partnerships in research activities. Additionally, students shared their results and collaborated with peers, thus gaining specific social experience (Sendova et al., 2004).

Similarly, the SCY project (Science Created by You; http://www.scy-net.eu) has developed a learning environment called SCY-Lab, where students embark on "missions" that can be completed through constructive and productive learning activities. SCY-Lab provides adaptive support for these activities through pedagogical scaffolds, collaboration facilities, as well as peer assessment and social tagging tools. The artefacts produced by students are saved in a repository and can be reused by other learners (Geraedts et al., 2012).

On the basis of the experiences drawn from these projects, we have formulated the prerequisites for the successful implementation of inquiry-based science education (IBSE) in schools (Nikolova and Stefanova, 2012): change teachers' attitude and provide stronger support to students (at micro level); provide schools management support; enable teachers to share experience and best practices; provide the needed ICT support (at mezzo level); provide constant training for teachers and a rich set of resources based on ICT infrastructure (at macro level).

## 6 Technology facilitating Personal and Social Inquiry in weSPOT

As we have learned from the European project ROLE (Responsive Open Learning Environments; www.role-project.eu), what is often missing from the PLE and the CLE is not the abundance of tools and services, but the means for binding them together in a meaningful way. weSPOT will address this issue by providing ways for the integration of data originating from different inquiry tools and services. Most importantly though, weSPOT will enable the cognitive integration of inquiry tools by connecting them with the student's profile, as well as her social and curricular context. Individual and collaborative student actions taking place within different inquiry tools will update the learning history and learning goals of the student, thus providing them and their tutors with a cohesive learning environment for monitoring their progress.

The Web 2.0 paradigm offers new opportunities for social learning by facilitating interactions with other learners and building a sense of connection that can foster trust and affirmation (Weller, 2009). Social learning, according to Hagel, et al. (Hagel et al., 2010), is dictated by recent shifts in education, which have altered the ways we catalyze learning and innovation. Key ingredients in this evolving landscape are the quality of interpersonal relationships, discourse, personal motivation, as well as tacit over explicit knowledge. Social media offer a variety of collaborative resources and facilities, which can complement and enrich the individual's personal learning space, as shown in Figure 5.

weSPOT will provide students with the ability to build their own inquiry-based learning environment, enriched with social and collaborative features. Smart support tools will be offered for orchestrating inquiry workflows, including mobile apps, learning analytics support, and social collaboration on scientific inquiry. These offerings will allow students to filter inquiry resources and tools according to their own needs and preferences. Students will be able interact to with their peers in order to reflect on their inquiry workflows, receive and provide feedback, mentor each other, thus forming meaningful social connections that will help and motivate them in their learning. From a learner's perspective, this approach will offer them access to personalized bundles of inquiry resources augmented with social media, which they will be able to manage and control from within their personal learning space.

It should be noted though, that there is a significant distinction between the user-centric approach of the Web 2.0 paradigm and the learner-centric approach of weSPOT. This is because a social learning environment is not a just a fun place to hang out with friends, but predominantly a place where learning takes place and it does not take place by chance but because specific pedagogies and learning principles are integrated in the environment. Quite often, what students want is not necessarily what they need, since their grasp of the material and of themselves as learners, is incomplete (Shum and Ferguson, 2010).

In order to transform a Web 2.0 environment into a social learning environment, students need to be constantly challenged and taken out of their comfort zones. This raises the need of providing students with the affirmation and encouragement that will give them the confidence to proceed with their inquiries and investigations beyond their existing knowledge. weSPOT will address this issue through a gamification

approach, by linking the inquiry activities and skills gained by learners with social media. In particular, this approach will define a badge system that will award virtual badges to students upon reaching certain milestones in their inquiry workflows. Students will then be able to display these badges in their preferred social networks. This approach will enhance the visibility and accrediting of personal inquiry efforts, as well as raise motivation, personal interest and curiosity on a mid-term effect.

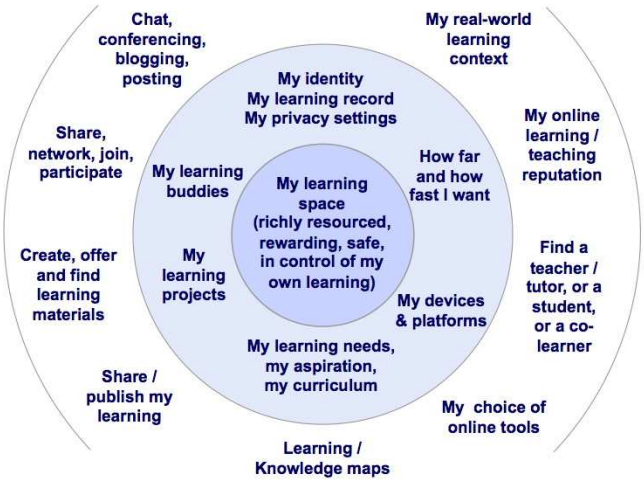


*Figure 5: Personal learning space, resources, and social interactions (Shum and Ferguson, 2010)*

Additionally, mobile technologies will further enable and support the personal and social approach of weSPOT, by integrating scientific inquiry into the everyday life situations of learners. To support their individual or collective inquiry projects, the following mobile services are foreseen within weSPOT:

1. A **mobile personal inquiry manager** supporting a self-directed approach for creating and managing inquiry projects and (the representation of) acquired competences (in badges).
2. A **context-aware notification** system that enables the contextualized sharing and notification of real world experiences. Learners can link inquiry projects to certain locations, physical objects, or combinations of contextual factors, i.e. the weather at a certain location at a specific time of the year. Furthermore, notifications can trigger the collection of data dependent on several parameters (location, time, social context, environment). This enables learners to easily link objects and locations of daily life to inquiry projects.
3. A **mobile data collection system** supports the direct submission of sensor data and manual measurements into the workflow system, to collect data to test a hypothesis. It also supports submission of annotations and multimedia materials, to enable reflection, peer support and collaborative inquiries.

4. A **mobile inquiry coordination interface** supports inquiry coordinators by giving them access to on-going multi-user inquiries and the contributions of all participants. It allows central dispatching of messages and management of tasks and data. In case of formal settings, teachers may use this service to keep an overview and to provide feedback. In informal settings, learners may use it to coordinate their self-initiated collaborative inquiry efforts.

# 7 Inquiry-Based Learning Scenarios in weSPOT

Testing the weSPOT research framework with students and teachers using scenarios from real life is integral for acquiring feedback and requirements from real users. In this section, we present two initial IBL scenarios that are used as pilots in the weSPOT project. These scenarios are concerned with two different domains: microclimates and the energy efficiency of buildings.

## 7.1 The Microclimates Scenario

The first scenario is used within a secondary education context, in order to teach students about microclimates. Microclimates are areas where the normal temperature and conditions are slightly different from the surrounding areas. The aim of this scenario is to find the best place to have a bench at the school. The initial hypothesis is that the best place is the garden site nearest the school entrance because it is sheltered from the wind but south facing, so it is warm and not windy there. Other places to be considered are the car park, the canteen, the games area and the reception.

The scientific questions proposed by the teacher are:

- *Where is the windiest part of the school grounds?*
- *Where is the sunniest part of the school? This is likely to be the warmest.*
- *Where will we find the warmest part of the school grounds?*

Therefore, the inquiry is based on four measurements: speed of wind, sunny periods, temperature and humidity.

The key components of the inquiry (Figure 6) as well as their connections can be identified in the graphical representation of Figure 7, which shows the inquiry overview that has been created by the students. For each possible answer, the students have drawn arguments and counterarguments from the analysis of photos, notes, as well as graphs based on the measurements collected in the location. As shown in Figure 7, the analysis of the 4 measurements has affirmed that the reception is the best place to have a bench at the school because it is very sunny, very warm and not windy.

Previous pilots of this scenario (Okada, 2008) reveal that students have difficulties in writing scientific reasoning in their inquiry projects. It is hard for them to organise ideas, arguments and connect evidence for presenting scientific explanations. In addition, “they did not see writing as particularly enjoyable or central to science”. It is likely that this naive separation between what might be paraphrased as “doing the real science” versus “merely communicating it” is widely shared in the general public, but is directly challenged by the work we briefly reviewed at the start, in which science is constituted by its different discourses.

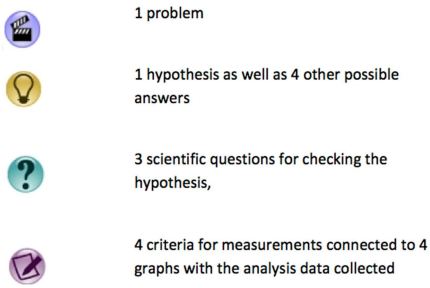


*Figure 6: Key components of the microclimates IBL scenario*

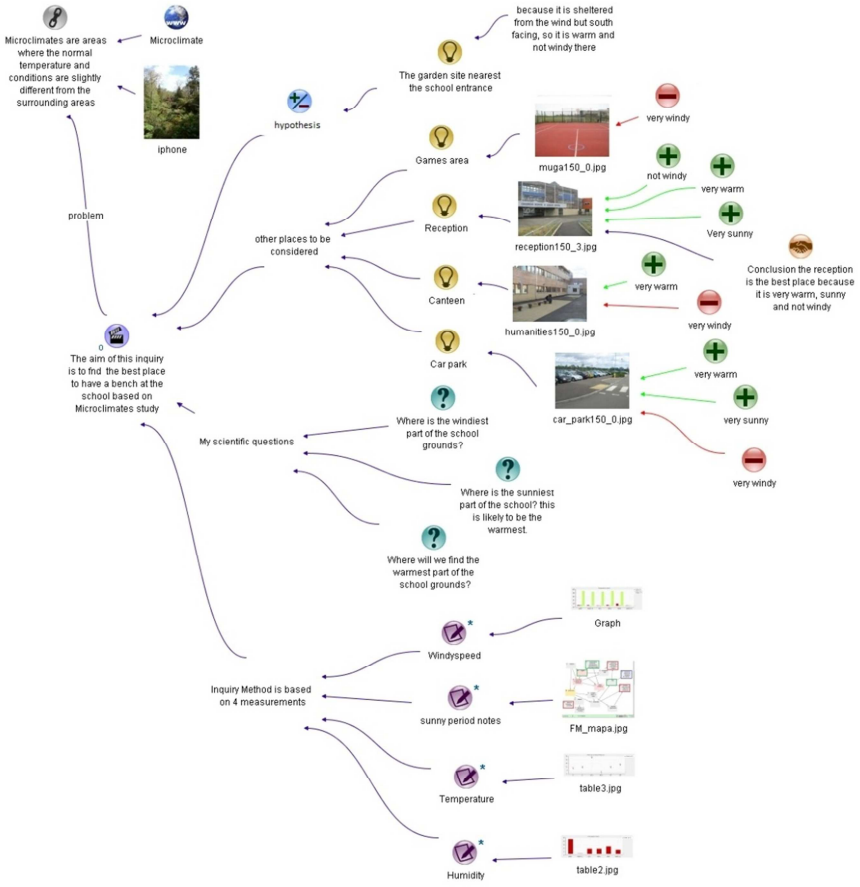


*Figure 7: Knowledge map of the microclimates IBL scenario*

When students are able to get an overview of a good inquiry project, they can then visualise good knowledge and evidence based on data analysis connected to

arguments. Maps can then acts as an inquiry workflow tool for describing their understanding in a coherent and scientific way. As students need to support their position in the map through connections, maps can reveal possible misunderstandings that their writing cannot.

Once pupils, through teachers' feedback, are able to clarify their connections, then they can enrich their argumentation and improve significantly their writing. Then, maps work as a tool for "sorting out their ideas and arguments". Their "arguments are more logical and ordered" and their "points are clearer and easier to understand" (Okada, 2008). Inquiry maps can then be exported to outline view facilitating then the scientific writing. Some students have also had the following comments about this process (Okada, 2008):

- *"You can get down the ideas (scientific information) and link them together, making connections and then edit the same text, which makes the whole thing a lot quicker because you can actually use the notes you make."*
- *"Yes its more fun. I find when it comes to writing up an essay that my argument is more logical and ordered".*

### 7.2 The Buildings Energy Efficiency Scenario

This scenario aims at helping students identify weaknesses of the school buildings from the energy efficiency point of view. The main research question of this scenario is: *"What external factors influence energy consumption and how to act in order to preserve the energy?"* Students try to predict by providing evidences what energy efficiency problems will be faced in the future. Working in a team, they generate ideas for improving the energy efficiency of buildings. Teachers can help them by raising questions such as:

- *Which new building materials, enabling energy-efficient building components should be used?*
- *Which new ecology based technologies will ensure higher quality of the microclimate?*

Students develop inquiry skills for:

- Choosing between given questions and raising new scientific questions.
- Collecting data to prove given hypothesis.
- Formulating explanations to collected data.
- Linking sources and areas of science to clarify the explanations.
- Explaining phenomena using scientific reasoning.

This pilot is situated in the frame of the integrated learning between two subjects: "Man and nature" and "Information technologies" at 6th grade in Bulgarian schools. Participants are 4 teachers (two from each one of the two subjects) and 60 students (age 12-13 years) from the First Private Mathematics Gymnasium. The scenario is organized as a contest between three classes under the title "My classroom is the most energy efficient one". Each class is participating as a team, aiming to measure the energy consumption in the classroom and to propose best ways to preserve the energy without any health risks. Each team is collecting and analysing data. Sub-teams are also formed in order to check different ideas and hypotheses. The winner is the class offering the best and most efficient ideas and measures.

We use the model of the inquiry process consisting of 8 phases, as described by Mulholland et al. (2012) (Figure 4). The inquiry process therefore consists of the following phases:

**Phase 1 - Find my topic.** During this phase, the teacher introduces the problem of energy consumption and presents data related to the quantity and price of the energy consumed by the school during the last several years. After that, the teacher raises the main questions:

- *What measures can be taken to minimize the energy consumption?*
- *Is there a place for alternative energy sources in the classroom?*

**Phase 2 - Decide my question or hypothesis.** Students discuss the main questions and define more specific questions to be answered in advance in order to define their hypothesis. Example specific questions:

- *What are the energy sources in the classroom?*
- *What quantity of energy do they consume?*
- *Is there a relation between external climate and energy consumption?*
- *How long is the air-conditioner working during the day and at what temperature?*
- *What measures could be taken to minimize the energy consumption (e.g. do not open windows, do not leave the door open during breaks, do not switch the light on during the day, etc.).*

After that students prioritize these questions and define their hypothesis. These hypotheses are formulated by different teams in each class and further investigated.

**Phase 3 - Plan my method.** Each team discusses what information they need, how they can collect it and what needs to be measured. In this way, the teams can plan:

- *To measure the temperature inside and outside three times a day (morning, midday and evening).*
- *To compare the temperature in the classroom and outside the building.*
- *To check during the measurement if the window or the door are open.*
- *To watch external climate conditions (sunny, windy, rainy etc.)*
- *To check when the air-conditioner is on and off.*
- *To calculate the energy consumption of the air-conditioner.*
- *To search the web for the most efficient way of use of the air-conditioner they have in the classroom.*
- *To check how often the lights are on and off.*
- *To calculate the energy consumption of the lights.*
- *To check how long the sunlight is enough during the day.*
- *To make informal questionnaires with their parents and relatives about how they save energy.*

**Phase 4 - Collect my data.** Each team collects the data it has chosen to measure. Students make pictures to prove their measurements and collections.

**Phase 5 - Analyse my data.** New teams are formed to analyse the collected data. They generalize data, prepare diagrams and graphics, and identify relations between different factors related to energy consumption (human behaviour, climate, conditions in rooms, etc.).

**Phase 6 - Decide my conclusion.** Students make conclusions related to their hypothesis and discuss different decisions. Each team has to defend their conclusions

and provide the needed arguments. Each student has to make her/his own decision. On the basis of final decisions the class prepares a list with suggestions to the school management. Some possible suggestions:

- *How long to have the lights on and when to switch them on and off depending on different conditions.*
- *How long to have the air-conditioner on and when to switch it on and off depending on different conditions.*
- *What type of woodwork to use.*
- *What type of doors to use and of what material.*
- *What additional energy sources to be used.*

**Phase 7 - Share my findings.** Each team prepares its presentation, conclusions and recommendations, and gives arguments (data, tables, diagrams, pictures). Each team makes its presentation in front of other teams, parents and school management. Each team can ask questions to other teams. The final position of each team is decided from the jury chosen in advance. The decision of the jury will be based on teams arguments and answers to questions.

**Phase 8 - Reflect on my progress.** In the final phase, each class discusses the competition together with the teacher answering questions like:

- *How was our teamwork functioning?*
- *What responsibilities and initiatives did each student take?*
- *Was the communication in the team adequate?*
- *How did students help each other?*

Each individual student has to answer:

- *What were her/his own challenges during this pilot experiment?*
- *What did she/he learn and how?*

The teacher helps the students in answering these questions, as well as in formulating recommendations for future inquiries.

weSPOT will bring this scenario to a level that corresponds to the new technologies that students regularly interact with in their free time. For example, weSPOT will generate animated virtual models featuring the factors that are important for the students' hypotheses.

Figure 8 shows snapshots from a virtual 3D model of a classroom in two different test environments. The left snapshot shows a classroom during a summer sunny day. The outside temperature is 36°C, while it is only 20°C inside the classroom. Unfortunately, the windows and the door are open, so hot air enters the room. The right snapshot in Figure 8 pictures a winter nighttime setup with heavy clouds, snow and winds. The outside temperature is -5°C, but inside the classroom it is much warmer, because the air-conditioner is turned on. Although the door is closed, energy is lost through the open windows. Apart from the air-conditioner, energy is also consumed by the lights, which are turned on because there is no sunlight.

The model is controlled by 15 user-defined parameters (meteorological status – sun, wind, clouds, rain, snow; energy status covering electrical appliances like lights and air-conditioners and options to open or close windows and doors). There are several subsidiary system parameters that control the quality of the virtual model and the animation.

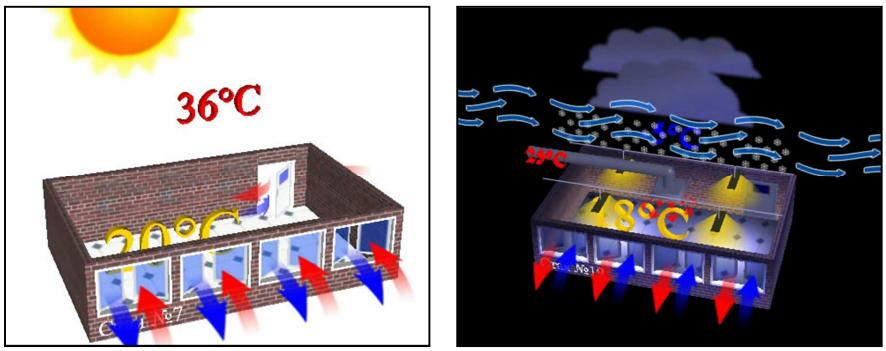


*Figure 8: Snapshots of a virtual 3D model prototype for the buildings energy efficiency scenario*

## 8 Conclusion

The weSPOT project will investigate IBL in secondary and higher education, aiming at supporting students in their scientific investigations through a personal and social inquiry approach. This approach will enable students to build their personalised environments out of cloud-based tools and services and use them collaboratively in order to perform scientific investigations together with their peers. They will also be able to share their inquiry accomplishments in social networks and receive feedback from the learning environment and their peers.

Following the research framework presented in this paper, the project strives to explore technological ways towards lowering the threshold for linking everyday life with science teaching and learning. The specific added value in lowering this threshold will be investigated through a variety of pilots in real-life learning settings within secondary and higher education, starting with the scenarios presented in this paper. By developing a reference model for inquiry skills, as well as a diagnostic instrument to measure the individual performance on inquiry skills, weSPOT will provide teachers and learners efficient support and the technology tools to reach competence, progress and become able to find the optimal inquiry level to match their needs at hand.

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