User-driven Development of an Inquiry-Based Learning Platform: Formative Evaluations in weSPOT

Michael A. Bedek[1], Olga Firssova[2], Eliza P. Stefanova[3], Fleur Prinsen[2], Foteini Chaimala[4]

[1] Knowledge Technologies Institute, Graz University of Technology, Inffeldgasse 13, 8010 Graz, Austria
[2] Welten-Institute for Learning, Teaching and Technology, Open University Netherlands, Valkenburgerweg 177, 6419 AT, Heerlen, Netherlands
[3] Faculty of Mathematics and Informatics, Sofia University "St. Kl. Ohridski", 5 James Bourchier, 1164 Sofia, Bulgaria
[4] Foundation for Research and Technology Hellas, Nikolaou Plastira 100, Vasilika Vouton, Heraklion, 70013, Crete, Greece
michael.bedek@tugraz.at, {Olga.Firssova, Fleur.Prinsen}@ou.nl, eliza@fmi.uni-sofia.bg, haimala@iacm.forth.gr

Abstract. This paper describes the formative evaluation activities that were designed and implemented during the development of the weSPOT[1] inquiry based learning platform. With the ambition to provide a platform that supports a broad range of inquiry activities in accordance with end-users needs, an agile software development approach was followed as a process of co-design between practitioners, researchers and developers. The paper focuses on the design of end-user centric evaluation activities for fully exploiting the potential of agile development. A detailed overview of several case studies is presented to demonstrate how implementing a continuous evaluation cycle allowed to pinpoint and help resolve arising issues in a process of collaboration between technology development and pedagogy.

Keywords: Inquiry-based learning, Qualitative Evaluation, Cognitive Walkthrough, User-centric, weSPOT

1 Introduction

Inquiry-based approaches to science learning are gaining popularity worldwide. Such approaches combine science knowledge with practicing skills that are generally accepted as the skills of the XXI century, such as critical thinking, creativity, digital literacy and problem-solving [1]. The development of these skills is considered as an ongoing process that is fed by formal school learning and by informal learning through knowledge-rich tasks and activities in both, real and virtual worlds. With the availability of ubiquitous web-based and mobile tools and technologies, learning can take place anywhere and anytime, with or without monitoring and supervision of teachers. However, it is the task and responsibility of teachers, educational experts

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and developers of advanced educational technologies to support learners in their learning process.

In a European research project called weSPOT, educational researchers and software developers from eleven countries are developing a theoretical framework and a corresponding multimedia toolkit that can support learners throughout the inquiry process, both at school and in the outside world. “weSPOT” stands for *W*orking *E*nvironment with *S*ocial and *P*ersonal *O*pen *T*ools for Inquiry Based learning. The project started in October 2012 and lasts for three years. Speaking generally, the project´s ambition is to develop an integrated weSPOT toolkit that can be effectively used for inquiry-based learning in a broad range of domains. This toolkit should be usable in both formal and informal learning with different age groups and in different learning cultures. For this purpose, the weSPOT toolkit includes a variety of components, which serve their separate functions (as development strands operating in parallel), but are actually interdependent and interoperable.

This ambition is simultaneously a strong point and a potential weakness of the project, as developing for multiple functionalities and uses can be very challenging and might broaden the scope beyond of what is feasible to accomplish within the timespan of a single project.

Aiming to provide a broad range of practical and scientifically supported functionalities necessitates a process of co-design between practitioners, researchers and developers. Since pedagogical design and software design are both trades of their own, the mutual design practices need to be bridged. An iterative process of co-design, in which communication is the key, seems best suited for this task. Educational technology projects in the past have shown that teacher and learner needs might only become apparent with use of (intermediate) products, so a priori needs analysis (understanding the whole problem before attempting to produce a solution) would not suffice [2].

Thus, technological design needs to be interwoven with the development of inquiry-based learning in practice, because even the content and pedagogical experts might not know what is possible or necessary. In a sense, the practitioners and developers are formulating (and incrementally reformulating) a ‘common’ problem. When teachers formulate design specifications, they may use language which is not directly translatable into technical requirements and technology development projects always need to deal with the fact that every change might evoke other problems to emerge.

One approach to deal with the complexity of this technology development process is ‘agile’ development [3], which has been followed within the project. Such an approach allows for iteration in design, constant feedback loops and version control. However, in order to fully exploit the potential of such an agile development, end-user centric evaluation activities have to be carried out. A major methodological challenge is to design the evaluation activities in a way that elicits valuable feedback from participants who might be unfamiliar with usability studies. ‘Valuable’ in this context means that the concrete responses from participants can be easily translated into new requirements for developers. This can be hardly achieved by quantitative methods, such as asking for (numerical) ratings by means of Likert-scales. Qualitative methods, such as focus groups or semi-structured interviews with an open-response format are much more suitable to reach this aim.

This paper describes how such qualitative evaluation activities have been carried out in a rather early phase of weSPOT´s agile software development. It starts with a provision of background information on the project and continues with the description of the planned methodology (which has been considered as a blueprint for all qualitative evaluation activities in weSPOT). This is followed by a description on how this blueprint has been applied in practice on a representative subset of three out of 12 case studies. Afterwards, the obtained results are presented and an outline is given on how these results have been further processed and how they had an impact on the iterative development activities. It concludes with a critical reflection on the suggested procedures, as well as an outlook on future evaluation activities.

2 Background

The work reported in this paper was conducted in the frame of the weSPOT project, which produces software components for supporting inquiry-based learning. The weSPOT framework of inquiry-based learning regards inquiries as learning experiences, in which students develop understandings of scientific ideas by engaging in research activities. The underlying assumptions of this approach are:

- Everyday experiences feed natural curiosity of young learners and can enhance formal classroom learning in which knowledge of scientific concepts is developed.
- Personal experiences and insights can help learners to understand theoretical concepts taught in the classroom.
- Development of inquiry skills by doing inquiries should mirror the process of systematic scientific observation and experimentation as well as consistent and critical reasoning that became standard in scientific communities [4].

The weSPOT approach does not prescribe how inquiry-based learning should take place. Rather than that, it offers flexibility in designing and organizing inquiries ranging from highly structured and teacher-guided classroom learning inquiries to open ones that can take place anywhere. While in the structured inquiries, the teacher designs and orchestrates the learning process and determines the outcomes, in the open inquiries learners take the initiative to start an inquiry, to conduct it guided by curiosity and their personal quest for knowledge [5].

Based on the principles described above and in conjunction with the state-of-the-art literature on inquiry-based learning, a first instantiation of the weSPOT pedagogical model was developed. This model presents an inquiry as a process that encompasses six distinct though interconnected phases: *Question/Hypothesis*, *Operationalization*, *Data Collection, Data Analysis, Interpretation/Discussion and Communication*. Each phase includes a range of activities and tasks that require specific inquiry skills and support further development of these skills [4].

Thus, the weSPOT inquiry model supports the learner from setting inquiry goals, formulating questions and hypotheses for investigation up to data collection and analysis, to interpreting and sharing the results. The weSPOT model is elaborate in terms of the specific tasks that learners do when conducting inquiry, by providing meticulous descriptions of the whole inquiry process and its phases. It also includes a number of innovative characteristics that aim to help learners when conducting their own inquiries, such as: continuous relating of the inquiry process to the context (referring to the physical or theoretical settings of the whole inquiry process); flexibility for tailored and adapted scientific inquiry, depending on the needs of the curriculum and the expertise and knowledge of the learners; and finally, reflection at the centre of each inquiry phase. Thus, reflection is seen as an integrated process throughout the inquiry activity, and not as an independent phase that comes at the end of the process [4].

In order to support learners performing inquiry related activities as well as to allow monitoring of these activities by teachers, the weSPOT project team developed a toolkit in which web-based and personal mobile tools are integrated based on the principles of open social learning [6]. The basic weSPOT toolkit includes four core components: a web-based Inquiry Space engine (WIE), a domain knowledge representation component (FCA), a learning analytics component (LARAe) and a mobile component, PIM. A detailed description of these four components is provided in Table 1.

Table 1. Components of the basic toolkit for inquiry-based learning

Tool	Description
weSpot Inquiry space engine (WIE)	WIE is a web-based platform (a hub) developed by re-using and extending the open-source social networking framework Elgg[2]. WIE allows teachers and students to set up an inquiry project, organize and structure it according to their needs by activating selected components (widgets) from a broad range of those available per inquiry phase. Examples of widgets are: A Question widget, a Mind Map widget, a File upload widget, a Page widget, a Discussion Forum widget, etc. Next to widgets that are activated for a single phase, several tools are available throughout the whole inquiry, such as FCA and LARAe.
Formal Concept Analysis tool (FCA)	FCA is a domain representation and domain visualisation tool integrated in WIE. FCA allows structuring the learning domain using objects (i.e., files uploaded into the platform), attributes and learning resources (URLs).
Learning Analytics Reflection and Awareness environment (LARAe)	LARAe is a learning analytics tool integrated in WIE. LARAe provides an overview of all users' activities in a particular inquiry and shows generated content at individual and group level
Personal Inquiry Manager (PIM)	PIM is a mobile app that enables mobile access to the personal inquiry space in WIE. With this app, users can manage inquiries on a mobile device and add data as text or images to their personal inquiry spaces in WIE. PIM supports data collection through web-services of ARLearn, a toolkit for designing mobile and location-based learning games [7]. At the time of the formative evaluations PIM was available as a mock-up. However, the users could try out the functionalities of PIM through an ARLearn application.

In the course of the weSPOT project the basic toolkit was expected to be expanded with an open badge system integrated in the Inquiry space, a mobile tool for monitoring learner's activities and a diagnostic instrument for measuring inquiry skill development by performing activities in weSPOT. However, during the project phase reported in this paper these tools were yet in the conceptual phase and were not the object of the evaluation. The tools and components listed in Table 1 were at a prototype level of development before the evaluation activities described in the following section had started.

[2] http://elgg.org/

3 Method

The software developed within weSPOT is based on an agile software development methodology SCRUM, an approach that was selected to deal with the complexity of a process of co-design between practitioners, researchers and software developers. Since developers need to be able to flexibly react to emerging demands from practitioners, the agile method within the project worked with iterative 'sprints' of development, in which developers provided updates to already designed elements and could appropriate new requirements they think were manageable within the given time period for the next sprint (they might do rapid prototyping, create mock-ups or near-full solutions). At regularly scheduled 'sprint-meetings', developers as well as non-technical members of the project prioritised work depending on urgency, blocking issues, and on the basic understanding of how promising a new idea seems and how much time it might take to find a solution.

In order to fully exploit the potential of such an agile development, end-user centric evaluation activities were also carried out. Evaluation activities were designed to gain feedback from end users that could be easily translated into new requirements for developers. Qualitative methods, such as focus groups or semi-structured interviews with an open-response format were considered suitable for this aim.

When planning the evaluation activities in weSPOT, we had two main questions in mind which we wanted to address: i) *Are the current* weSPOT functionalities *in accordance with the end-users, i.e. the teacher´s and student´s needs*?, and ii) *how usable is the* weSPOT *platform, with four basic components, as a whole?*

To address these questions at an early stage of the toolkit development, qualitative formative evaluations were held when the first version of the pedagogical model was released. We conducted workshops together with teachers and students, and applied methods which were mainly qualitative. In this we followed the representative design tradition [8] which suggests exhaustively observing a small number of subjects.

3.1 Participants

weSPOT project members from eleven European countries conducted qualitative formative evaluations with one to ten potential users of the weSPOT toolkit. Overall, 12 workshops with 32 teachers, around 20 students and 2 school principals were conducted in eight European countries as well as in Brazil. In the following, a more detailed description of the Dutch, the Greek and the Bulgarian cases will be provided. These cases were selected, because they are representative and can illustrate both the common issues and possible differences, with respect to the agile software development across countries and cultures.

Dutch case: 1 teacher, 1 school. In the Netherlands, the evaluation was conducted in March 2014 with one participant as a one person face-to-face workshop. The workshop was conducted by a researcher affiliated to the Open University Netherlands (a weSPOT project member).

The participant (JH), male, 50 years old, is a teacher of Chemistry and Nutrition at a junior technical-vocational secondary school (VMBO in Dutch). JH has 30 years of teaching experience. He is co-responsible for curriculum design and is granted responsibility to try out and implement new pedagogical approaches and tools with students in his area of expertise. JH is an experienced ICT-user, he has designed several modules in electronic learning environment of the school (Blackboard ©), is well-red in Educational Theory, Educational Design and Educational Research Methodology as he is momentarily completing a Master of Science in Educational Science.

The school in which JH works and where a weSPOT implementation was subsequently planned is a four year junior technical vocational school for students in lower educational tracks of the Dutch educational system.

Greek case: 1 teacher, 1 school. In Greece, the evaluation activities (workshop) were conducted in August 2014, with one participant and included a cognitive walkthrough and a hands-on session. The workshop was conducted by a researcher from the Foundation of Research and Technology Hellas (FORTH), as a weSPOT project member.

The participant (IK), male, 45 years old, is a lower secondary physics teacher at the Experimental School of Heraklion. He has currently 6 years of experience as a secondary teacher, and before that, additional 6 years of experience in teaching University Physics students. He holds a PhD in Physics and is highly motived in using innovative teaching methods with a view to facilitate students' science learning. He is an experienced user of ICT in teaching practice and has a sound background in inquiry based learning. He has a good experience in using the project-based approach both in the frame of regular classes, and in extra curriculum activities (participating in the school's Science Club, collaborating with FORTH educational group in a number of European projects).

The school that IK is currently working at has a long tradition in running innovative teaching interventions and a culture of experimentation in teaching and learning pedagogies and methodologies. The school is empowered by highly qualified teaching staff, while students enter the school according to their achievement in examinations.

Bulgarian case: 7 teachers, 2 schools. In Bulgaria the evaluation was conducted in the beginning of March 2014, as a face-to-face meeting and included a cognitive walkthrough, a focus group and a hands-on session. The workshop was conducted by 3 interviewers from at Faculty of Mathematics and Informatics, Sofia University (weSPOT project partners) supported by 2 PhD students.

Seven teachers, all females, took part in the workshop. 3 teachers represented the First Private School of Mathematics (FPHSM), 4 - the National High School of Mathematics and Sciences (NHSNS). Three teachers – a Human and Nature & Chemistry teacher at FPHSM (TD), a teacher of Physics at NHSNS (JA), and a teacher of Chemistry at NHSNS (NV), all in their fifties, have more than 25 years teaching experience. Two teachers in Information technologies (DP from FPMHS and MI from NHSNS), both in their thirties, are very actively implementing new pedagogical approaches in their practice, both are most motivated teachers using Moodle at their schools. Two teachers (DG and AY), 25 years old, are recent graduates and a first year teachers, respectively at NHSNS and FPMHS, both are experienced users of ICT in teaching practice. TD has rich experience in using the project-based approach. During the school year 2012/2013 TD experimented with the weSPOT model in her classes and demonstrated that it is applicable in school practice [9]. DG was accompanied by ten 9th grade students with Biology profile, whom she supervises (NHSNS).

3.2 Procedure and Material

A couple of days before the workshops, the participants received preparatory material they were requested to study in advance. The documentation set included written documents on the concept of inquiry-based learning (IBL), short descriptions of the weSPOT tools and their functionalities, links to screencasts and videos on the tools and their functionalities and finally, a paper mock-up which will be described in more detail below. In the following we focus on the procedure and the methods at the workshops.

Cognitive Walkthrough. At the workshop we started with a cognitive walkthrough. In general, a cognitive walkthrough is considered as standard technique wherein experts examine perceived usefulness and usability in an early phase of an evaluation [10]. In the case of weSPOT, a cognitive walkthrough has been applied to unveil requirements, needs and expectations of teachers and students rather than to examine usability. Usability and perceived usefulness were in focus during the hands-on sessions (see below). According to [11], participants of the cognitive walkthrough should imagine a particular task and a setting in which the software should be applied. The aim of the cognitive walkthrough´s task structure is to provide participants with a "real-life like" setting (without relying on the availability or accessibility of the software).

In accordance with an empirical study of [12] who also evaluated a software supporting IBL, the six-phases have been compiled into three IBL periods. These three periods are:

1. *Claim* (encompassing the inquiry phases *Question/Hypothesis* and *Operationalization*) followed by
2. *Evidence* (encompassing the inquiry phases *Data Collection* and *Data Analysis*) and
3. *Reasoning* (encompassing the inquiry phases *Interpretation/Discussion* and *Communication*).

According to [13] a paper-mock-up provides participants with an idea of the system and its functionalities. The weSPOT paper mock-up is a poster which shows the weSPOT IBL model in the middle and the software's functionalities by means of screenshots and key words. In addition to that, it explicates the relations between the 'pedagogical' part (i.e. the IBL model) and the "technical" part (i.e. the tools and their functionalities). Figure 1 gives an impression of what the paper mock-up looked like.

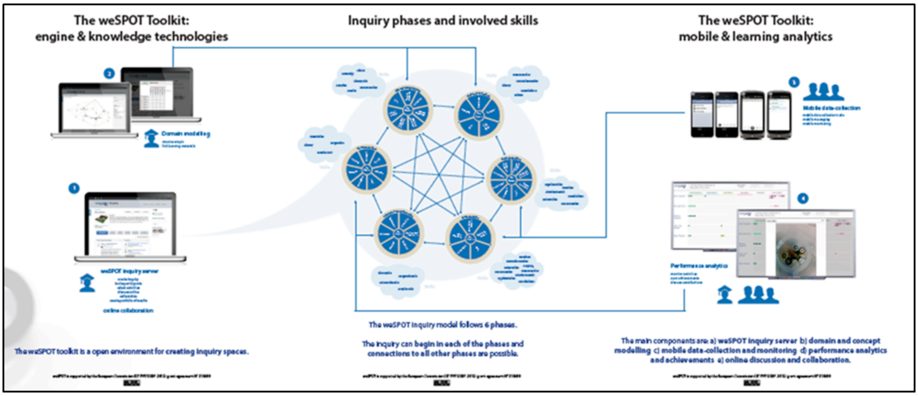

Fig. 1. The paper mock-up summarizes the pedagogical IBL model (center) and the four components of the weSPOT toolkit presented to the participants (FCA, upper-left corner, WIE, lower-left corner, PIM, upper-right corner and LARAe, lower-right corner). Lines indicate in which phases of the inquiry process particular weSPOT components can be used.

The same set of open questions has been asked at the end of every period:

- Which inquiry activities they would perform to fulfil the task,
- In which sequence they would perform these activities,
- Which necessary activities they considered were not included in the weSPOT IBL-model, and
- Which components of the weSPOT software they would apply to support the activities.

Focus Group. The second part of the workshop aimed at a collaborative discussion of the paper mock-up. Such a focus group should give all participants the opportunity to express their thoughts and ideas which came up during the individual cognitive walkthroughs and to share them (if possible in the set-up) with others. The discussion was guided by the interviewer who asked the same set of questions as for the three periods of the cognitive walkthrough.

Hands-on session. At the end of the workshop the participants took part in a "hands-on" session. To ensure that every participant tried out all the tools and functionalities, a set of pre-defined tasks (listed on a sheet of paper) were to be performed. The interviewer was instructed to 'stay in the background' and to only intervene when the participants required some help. Ideally, the participants started to engage with the Inquiry Space (WIE), followed by the Formal Concept Analysis tool (FCA), the Personal Inquiry Manager (PIM), and finally, the Learning Analytics Reflection and Awareness environment (LARAe).

3.3 Evaluation procedure in practice

While all weSPOT project members followed the procedure as described above, workshop organization depended on the number of participants. Therefore, each case will be described separately.

Dutch case. The workshop consisted of a cognitive walkthrough (2 hours) and a hands-on session (2 hours). The teacher (JH) had studied the materials sent to him in advance and had explored the weSPOT engine to some extent (opened a weSPOT account and logged in into the system).

The workshop started with a cognitive walkthrough which consisted of three separate parts. Each part (claim, evidence, and reasoning) was presented through representations of constituent inquiry phases and respective tasks and activities. As requested at the start of the workshop, JH came up with a realistic scenario of inquiry related activities and elaborated on this scenario in relation to each phase of the inquiry process and constituent tasks and activities.

In the hands-on session JH explored the Inquiry Space (logged in, started a new inquiry, activated and tried out several widgets), the FCA tool (explored the provided exemplary domain visualization and constructed a domain representation with this tool). Furthermore, JH explored the LARAe tool and a mock-up of PIM since the tool was not available for testing. Throughout the session JH elaborated on the possibilities of the toolkit and each of the explored tools and indicated what tools present an opportunity or a challenge for him as a designer and the students and in what way.

The session was recorded with Audacity, a summary of the transcript was made and used to fill in the evaluation forms (as shown in Table 3).

Greek case. The workshop in the Greek case consisted of a cognitive walkthrough and a hands-on session and lasted almost 5 hours. Before the workshops, the participant was sent the preparatory materials, was requested to study them in advance and to formulate possible questions on the content of the materials and the process of the workshop.

At the beginning of the workshop, the researcher provided the participant with a short overview of the pedagogical orientation of the weSPOT project and its toolkit as well as the domain that was the focus of the inquiry activities (earthquakes). The participant posed the questions that he had formulated while studying the preparatory materials with a short discussion following.

Then, the cognitive walkthrough took place, with the participant coming up with a scenario of inquiry activities in the earthquake domain and elaborating on it for each phase of the inquiry process. The participant used the paper mock-up and answered a set of open questions at the end of each period (claim, evidence, and reasoning) in a reflective and comprehensive manner.

In the hands-on session that followed, the participant explored the Inquiry Space (logged in, started a new inquiry, activated and tried out several widgets). The paper with the predefined tasks was used in order to ensure that the participant tried out all the functionalities of the tool. During this process the researcher intervened only when the participant required help – which did not occurred often.

The activities were observed by the researcher who kept detailed notes both on the participants' feedback and on his non-verbal reactions, which were used to fill in the evaluation forms.

Bulgarian case. By the start of the workshop, both the teachers and the students had studied materials sent in advance and formulated particular ideas for tasks and scenario's in which weSPOT tools could be applied.

During the cognitive walkthrough, participants were requested to think about all possible scenarios for inquiries; no constraints to their imagination were imposed. Each teacher came with a rich scenario for inquiry-based activities. Students who accompanied one of the teachers presented a scenario of their own. During the focus group, participants elaborated on their imaginary scenarios and activity scripts.

At the hands-on session the participating teachers and students tested the weSPOT toolkit components and gave feedback, based on their school practice and experience. The teachers logged in to the weSPOT inquiry space, created new inquiries, tried to add different widgets to existing inquiries, tried out the FCA tool and LARAe. Furthermore they tried out the mobile application ARLearn (as PIM was not available for testing yet). They gave improvement suggestions and provided underpinning for the suggestions.

All actions were observed by the researchers and detailed activity reports were compiled.

4 Evaluation results and discussion

To illustrate the qualitative results and provide deeper understanding of the contribution of the evaluation to further development, we shall discuss the inquiry-based scenarios generated by the participants in detail and will elaborate on the comments provided by the participants on each evaluated tool.

4.1 Scenarios for inquiry-based learning

Cognitive walkthrough sessions conducted as an individual sessions allowed to gather a set of rich scenarios of inquiry-based learning. An overview of these scenarios is included in Table 2.

Table 2. Scenarios for inquiry-based learning with weSPOT

Teacher/Case	Scenario: how weSPOT IBL could be used in the class
JH, teacher of Chemistry and Nutrition / Dutch case	"*A healthy school restaurant*", an inquiry project on the nutrition values of different products that could be used for cooking and consumption in a school restaurant. One of the tasks JH had in mind was a group task for students on investigating particular nutrition values of fish products that can be purchased in specialized fish shops or at the market place. To fulfil this task, students were expected to formulate questions, prepare and hold interviews with

	several experts using mobile devices, process collected information and report to the group.
IK, teacher of physics / Greek case	*"Earthquakes scenario"*, in which student make use of a pre-given set of seismographic data; they should come up with research questions data driven, decide on the method of analysis and conduct the analysis. The aim of the task is to facilitate students realize that sometimes researchers have a given set of data and have to exploit them as fully as possible rather than start from a pre-determined research question. From a science content perspective, students were expected to familiarize with concepts of seismic waves, calculating difference of arrival time between different types of ways and methods of locating the epicentre of an earthquake.
TD, teacher of Human Nature, Chemistry and Ecology / Bulgarian case	A project on the importance of water and a variety of water sources: *Hidden treasure – her Majesty the Water*. The project´s set-up includes separating students in teams, conducting activities in the school, but also collecting pictures, audio and video interviews out of the classrooms, during excursions to the water sources and collecting data there.
NV, teacher of Chemistry / Bulgarian case	A project on the effects of food on health, to find answers to the question how various substances used in food, household chemicals, cosmetics, drugs affect a healthy lifestyle: *Secrets under the label*.
JA, teacher of Physics / Bulgarian case	*The lost energy*. This idea came from the natural observation in the school-building, where there are some points with big concentration of crossing people (students and teachers) at fixed moments during the day. Such a place is for example the entrance of the school in the morning. The questions for students would be: Could be possible to 'catch' the energy of all the people walking there and to use it? Starting from that question, the teacher designs the settings for inquiry for the lost energy.
9 students with Biology profile and their supervisor / Bulgarian case	The inquiry, which the students are interested to do, is related to *The cell mutations*.

As illustrated in Table 2, teachers came up with different ideas for students' inquiries, varying in terms of scientific content focus, proposed inquiry activities and the sequence of the activities. With this variety of scenarios teachers' needs that arise from various teaching and learning processes could be made explicit. This enabled the development of an inquiry toolkit, the functionalities and applications of which are not restricted in a specific scientific domain and/or inquiry process, but rather provide an inquiry platform for all kinds of inquiries.

4.2 Inquiry design ideas

During the cognitive walkthrough and consequent focus groups and hands-on sessions, participants elaborated on how such scenarios could be implemented. They also presented and discussed ideas about conducting inquiries, shared plans and proposed design solutions.

The Dutch teacher (JH) had a highly structured inquiry scenario in mind for his students. He was planning to design and organize each inquiry phase, define every particular widget in a phase and provide specific instructions per widget. Discussing the initial inquiry phase, JH stressed the necessity of Ethics at the start of an inquiry and ensuring that students understand the consequences of collecting information with mobile devices, sharing images and interview data with others, uploading the information in the inquiry space. JH considered it vital to control student activities throughout the process, monitoring whether they are on track, what their actions are and providing just-in-time feedback and encouragement. Furthermore, JH expected students to be communicating extensively during data collection tasks and wanted to make such discussions a part of students assignment.

Bulgarian teachers had different inquiry scenarios in mind for their students; however, the proposed design solutions were similar. They included the following steps:

The teacher starts an inquiry and organises the inquiry space in WIE so that students can pose questions by activating the corresponding component (the Question widget). The instruction and learning activities are designed by teachers, who make generating hypotheses possible by activating the Mind map component (Mind map widget) the FCA component or with the help of other widgets (i.e. pages and files). Then the students are invited by the teachers, who give the young researchers the stage: first to generate questions and hypotheses, to make teams, working on different hypotheses, as a group in one weSPOT inquiry or in sub-inquiries within one inquiry (e.g. teams working on different topics within the same theme).

In the Greek case the participant developed a scenario on the earthquakes domain, which exploited the attributes of the weSPOT inquiry model as much as possible, mainly its flexibility and the focus on reflection. In contrast with the linearity of inquiry process that some students might have in mind (first formulate questions, then decide the method of analysis, collect and analyze data etc.), in this scenario the data are beforehand given to the students; they should come up with research questions that might be answered with this set of data, and then decide on the method analysis.

The teacher starts an inquiry and designs the inquiry space in WIE as follows: the teacher allocates students to each group (if subgroups); the teacher structures the domain – decide on objects and attributes, link resources (using FCA tool); the teacher adds datasheets with earthquake data; the students log in to the system, join the inquiry, view the datasheet and the FCA lattice view, discuss and keep notes in the system; the students use mind mapping for linking concepts; the students formulate their question and insert it to the system; the teacher creates a page on methodology for analysing the data; the students views the page on methodology; the students analyse the data, conclude and communicate results; the students reflect on results using LARAe.

4.3 First impressions of the weSPOT components

An elaboration on inquiry design and introductory hands-on sessions of exploring the tools (the Dutch and the Greek cases), a group discussion of available tools and mock-ups in an inquiry-based learning toolkit between several teachers (the Bulgarian case) gives an interesting overview of the first user expectations of these tools (WIE, FCA, LARAe and PIM).

WIE. In general, the Dutch participant (JH) was positive and enthusiastic about the possibilities of weSPOT toolkit for designing inquiry-based learning and committed himself to the project. JH intended to use WIE for organizing and structuring the inquiry.

The main conclusion of the Bulgarian participants was that the weSPOT inquiry toolkit and the WIE in particular, contained the potential to become a real support tool for applying the inquiry-based learning model in their practice in a well-organized way. They considered integration of appropriate tools, supporting IBL as a main advantage.

Bulgarian teachers had a series of specific requests concerning WIE, in particular group work in WIE. During the focus group, Bulgarian participants discussed how working with groups in WIE could be managed. The discussion focused on the following topics and open questions:

- Whether students should be added to groups at a sub-inquiry level or whether they should be let join such groups.
- Whether members of such sub-groups should plan the inquiry activities or whether these should be prescribed by the teacher.
- Whether the teacher or students would design data collection tasks, collect data, analyse them and then get back to the starting inquiry in order to share findings with other teams.

Furthermore, the teachers expected the students to be able to combine the results in the started inquiry and then to formulate conclusions.

In the Greek case, the participant gave feedback on which inquiry activities he would perform in each phase (claim, evidence and reasoning) as well as his proposed sequence of activities for the specific scenario. For some activities he acknowledged that they might be important for other scenarios but irrelevant to the one he has in mind. Apart from this, IK stressed the necessity to add as an activity in the "claim" phase to link the tasks both with students pre-existing knowledge and to their everyday life in order to motivate them and engage them in the inquiry process. For the "evidence" phase he proposed to add as an activity students to discuss and decide on the method of analysis – which is actually an activity of the weSPOT inquiry model but not mentioned during the cognitive walkthrough. Finally, for the reasoning process, the participant considered vital to allocate time for the students to reflect on and discuss about the significance of their results – a process which is at the heart of research.

As for the use of WIE, in general IK was positive of the functionalities of the system, in a sense that it offers a variety of components in one platform that facilitate students conducting inquiries. He did not come up with tools that he misses for conducting the inquiry scenario that he had in mind; in contrast, he mentioned that maybe the system offers too many functionalities for teachers or students who are novice in ICT use. He strongly recommended that other teachers who would like to use WIE in their classes should devote enough time to training, in order to avoid unsuccessful learning outcomes due to unfamiliarity with the weSPOT toolkit.

FCA. The Dutch participant was interested in the possibilities of structuring domain knowledge and available sources through FCA, however, he considered this tool as too complex for his students and did not intend to try it out with them. According to JH, FCA could be used for communication purposes between teachers designing inquiries.

Bulgarian teachers found the FCA tool useful for structuring learning materials during an inquiry.

As for the Greek teacher although he did not interacted with other that tools than WIE to time limits, he was highly interested in the functionalities of FCA (for teachers structuring their inquiries) and committed himself to further exploring its possibilities.

LARAe. JH was most positive about the use of LARAe for the purpose of actively monitoring student activities. He stressed his intention to use the tool on a continuous basis. JH considered this tool as a teacher-oriented tool. JH was sceptical about students' use of LARAe as he did not expect that the students would be prepared to invest time and effort in learning to understand and interpret visual information to give each other feedback and for self-assessment purposes.

Bulgarian participants appreciated the idea of monitoring students with a Learning Analytics tool (LARAe), however, the version of the tool they experimented with lacked the expected desired functionalities: for example, in a visualization of the student progress, they were interested in getting an overview of what still had to be done by individual students.

PIM. The Dutch participant was enthusiastic about using PIM for collecting and sharing data by students. In his perspective, students appreciated and made extensive use of instant communication functionalities on their personal mobile devices. Having a chat functionality within WIE and the mobile PIM component would, according to JH steer active discussions during the inquiry process.

Bulgarian participants also appreciated the possibility of using a mobile data collection tool.

4.4 Discussion

In total, the three case studies described above delivered complementary insights on user´s requirements and perspectives on how to improve the usability of the components in general and their features in particular.

Most of the requirements were related to the WIE component, which is probably due to the fact that it is the entry point when starting a new inquiry or when continuing with already existing ones. Besides that, the WIE is the portal to the remaining components (PIM, FCA, LARAe) and a bunch of widgets (Question widget, a Mind map widget, a File upload widget, a Page widget, and a Discussion Forum widget). The main clusters of suggestions on the WIE component were on: i) *a focus on ethics*, i.e. the necessity to create space (or a separate widget) enabling students and teachers to discuss and reflect upon ethical issues (in particular before starting with the data collection), ii) *privacy issues*, e.g. students should be aware of the consequences when uploading files or sharing them with their peers and their privacy should be protected and finally, iii) *user management* requirements. This third cluster of requirements relates to the teachers wish to facilitate collaboration among students by working together in groups. One of the consecutive releases of weSPOT already provided the opportunity to duplicate an inquiry (e.g. in case the teacher wants to share an existing inquiry space with another class or even with other teachers) and the opportunity to set up sub-inquiries (this is aiming to support group activities among the students).

The most concrete suggestions for improvement were related to the LARAe component; the comments and suggestions on the two remaining components, the FCA and the PIM, were more general. The main idea behind LARAe, i.e. providing an overview of all student´s activities, has been very appreciated by participants of all case studies. This functionality facilitates the teacher in monitoring whether the students are on track and in providing feedback. However, visualizing a broader range of different kinds of activities and related metrics (e.g. amount of uploaded files or contributions to the discussion widget, etc.) bears the risk of getting confusing. In particular the participants from the Bulgarian case study made several valuable suggestions on how to improve the visualization, for example by re-arranging the data.

5 How observed results fed back

The open comments and suggestions for improvement from end-users which were gathered during the workshops have been further processed by the evaluators in a way which resulted in a form as shown in Table 3.

First, all end-user´s remarks which have been noted by the interviewers among all case studies have been collected and numbered (see upper-left cell in Table 3). In addition to that, the case study where the remark originated from has been noted (see ‘Source’). It has been considered as important to collect original quotes of the users. Context information was added to the original quotes by the evaluators (see ‘Quote from Workshop’). This context information was to help the developers to fully grasp the meaning of the comments. Based on the original remark and its context, project members who organized the evaluations, deduced concrete suggestions (in form of a user story or an additional requirement) for improvement for the developers (see ‘Proposed solution’). In this sense, the evaluators took the role of mediators between the end-users, i.e. the teachers and students, on the one side, and the developers from the weSPOT consortium on the other side.

The proposed solution led to a trac-ticket[3] (with a number, see ‘Trac-ticket #’) which was discussed, prioritized and assigned to individual developers at the ‘sprint-meetings’. Overall, 68 of such tickets have been created. The following table shows a representative example.

[3] http://trac.edgewall.org/

Table 3. End-user´s comment have been collected and further processed as forms.

#37	Quote from Workshop	[To] divide learners in smaller or larger groups [or even] double groups in some cases for discussing input.	Trac-ticket #	615
Context of the "Quote"		Response of the participant to the question "which additional activities would you carry out during the phases "Data collection and data analysis"?	Status	CLOSED (fixed)
Proposed solution		Provide the possibility to “copy” an inquiry so that different groups can work together. This should be adaptable, i.e. it should be possible to add / exclude students from such group inquiries.	Source	OUNL1
Implementation		Group / user management has been improved: The inquiry owner (usually the teacher) can either clone an inquiry (i.e. duplicate it) or create several sub-inquiries. Individuals or groups of students can be invited to these sub-inquiries. This enables them to work together on a particular inquiry (including collaborative discussions on input from peers or the teacher).		

At such sprint-meetings, it became clear whether the proposed solution was valid and implementable or whether modifications had to be elaborated. In the latter case, the bottom field of the form was foreseen for describing how the remark has been actually taken into account (see ‘Implementation’). From time to time, the status information of the requirement was been updated (see ‘Status’).

Another example of such a comment from the participants was the request to integrate weSPOT with social networks for sharing results and collected data. This comment was rather unexpected for the developers since such features already existed. However, the fact that the participants asked for this indicated that the according features should have a more prominent, and thus, more visible place at the WIE interface.

6 Implications and future work

In this paper we focused on a representative subset of three case studies of the qualitative formative evaluations that were conducted for the weSPOT inquiry toolkit development. Overall, the project members of weSPOT conducted 12 case studies built upon the blueprint described in section 2. These case studies took place in 8 countries (Netherlands, Bulgaria, Greece, United Kingdom, Brazil, Slovenia, Bosnia and Herzegovina, and Germany) with different constellations of participants (e.g. one or more teachers with or without students) at different points in time over a period of several months. This was primarily due to time constrains of the teachers and students. However, such constrains turned out to be a great advantage since the evolved practice suited well with the 'agile' software development approach. Some of the end-users` remarks and suggestions for improvement from early case studies have been implemented rather soon after they had been discussed at a sprint meeting. Thus, it could happen that the participants from later case studies had the opportunity to engage with a newer, improved release of the weSPOT platform which encompassed the already implemented requirements from previous case studies.

In addition to that, some of the early users´ remarks led to methodological improvements, e.g. a refinement of the instruction, and thus, they helped the project team to better support end-users of later case studies.

Besides the obvious advantage of carrying out evaluation activities at a rather early phase of software development, i.e. taking care that the product 'goes in the right direction' from the very beginning, it had another positive side-effect: The potential end-users, in particular teachers, had the opportunity to get familiar with the software components as well as with the underlying pedagogical principles of inquiry-based learning. This kind of incidental 'training' is a great foundation for their own usage of weSPOT in the classroom as well as future evaluation activities with students (see below). In addition to that, applying a rather formal approach of collecting and processing the end-users remarks (see Table 3), enables the evaluators to give feedback to the end-users themselves on whether and how their comments have been taken into account. Such feedback is encouraging to the participants as active co-developers of an educational innovation.

The trac-tickets which resulted from the evaluation activities have been discussed during sprint-meetings which brought project members with different professional backgrounds, such as developers, psychologists, pedagogues and instructional designers, together and helped to create a common understanding.

The described evaluation activities not only had an impact on the software development, but also on the refinement of the weSPOT pedagogical model [4]. The cognitive walkthroughs and the end-users interactions with the paper mock-up provided the evaluator with new insights on *how the teachers would conduct* scientific inquiries with their students, what educational scenarios they planned to pursue. Complexity of proposed scenarios seems to be in line with the school context and expected depth of knowledge teachers define as learning objectives. However, we see that the diversity in the curricula, instructional foci and designs does not create barriers to opting for innovative approaches to learning or using innovative software. Finally this method uncovered *how the teachers see* the mapping between the pedagogical model on the one side and the software components and their functionalities on the other side.

Current (December 2014) evaluation activities in weSPOT differ in two main aspects from the qualitative evaluation activities described in the present paper: i) They have a stronger focus on quantitative outcomes (e.g. numeric results from standardized questionnaires) and ii) participants will be students only. The students will do an inquiry set up by their teacher. A wide range of different constructs and variables will be measured by means of questionnaires, in some cases, as a pre- and post-test: domain-specific (declarative) knowledge, (procedural) inquiry skills and scientific literacy, intrinsic motivation and cognitive load, and finally, perceived usability of the different components. It is foreseen to enrich these quantitative results by qualitative insights to be gathered during semi-structured interviews or focus groups with the students at the very end of evaluations.

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