Sustainable inquiry based learning with ICT. Projectrapportage. SURFInnovatieregeling Duurzaamheid & ICT

Citation for published version (APA):

Firssova, O., Börner, D., Rusman, E., Kalz, M., Ternier, S., Pannekeet, K., Specht, M., & Van der Klink, M. (2014). *Sustainable inquiry based learning with ICT. Projectrapportage. SURFInnovatieregeling Duurzaamheid & ICT*.

Document status and date:
Published: 01/01/2014

Document Version:
Peer reviewed version

Document license:
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Project Report

SURFInnovatieregeling Duurzaamheid & ICT

Sustainable inquiry based learning with ICT

Duurzaam onderzoekend leren met ICT

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January 2014

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Project Report

This report summarizes the results of the project "Sustainable inquiry based learning with ICT / Duurzaam onderzoekend leren met ICT" funded by the SURFnet Innovation grant for sustainable ICT solutions. This project was conducted from May 2013 to November 2013 by researchers of CELSTEC, OU. This project was aimed at developing, implementing and evaluating a learning and teaching scenario and a set of reusable tools for contextualized inquiry based science learning with mobile and open source technologies.

Situating the project among other initiatives

The project *"Sustainable inquiry based learning with ICT"* builds on a number of recently completed and on-going research and development initiatives, thus being a manifestation of the sustainability concept in every sense of the word.

It is a direct follow-up of two earlier projects co-funded by SURFnet Innovation grants for sustainable ICT solutions and CELSTEC, OU, namely the projects *"Energy Awareness Displays – Making the Invisible Visible*" and "*Energy Conservation Behaviour Toolkit – Incentive Mechanisms for Effective Decrease of Energy Consumption at the Workplace*" (Börner, Storm, Kalz & Specht, 2012; Kalz, Börner, Ternier & Specht, 2013). These projects contributed to conceptualizing and designing an intervention on energy consumption behaviour and awareness growth in the context of formal secondary education.

In its turn, the project *Sustainable inquiry based learning with ICT* contributes to the weSPOT project, an international initiative funded by the European Commission (weSPOT, n.d.). weSPOT is aimed at propagating scientific inquiry as the approach to science learning and teaching with the help of ubiquitous mobile and open source digital tools and technologies.

The project is also linked to the Opeduca initiative coordinated by the Rhine-Meuse Regional Center of Expertise on Education for Sustainable Development (Opeduca, n.d). Opeduca stands for open education and knowledge development based on the principles of life-long learning in both formal and informal contexts. The Opeduca Rhine-Meuse RCE provides initial schooling for school teachers on inquiry-based and discovery learning, coordinates and supports extra-curricular activities for students as field trips, contacts with domain experts live or via online channels.

The background of the problems addressed

Energy consumption in daily life and formal curricula: environmental awareness development

Energy as a science topic is included in formal science curricula both in primary and secondary education. Environmental issues, including energy consumption and conservation issues are continuously in the media. Yet, not much is known about the knowledge and views of the young people on energy consumption while the young people are ubiquitous technology and energy consumers. Kwan & Miles (1999) recommended identifying childrens' opinions and building on them in order to achieve success in environmental education. Learning about their own ecological footprints, gaining understanding of at least some of the current patterns of energy consumption and their consequences, can support schoolchildren in forming opinions, generating and articulating ideas, help make abstract school knowledge tangible. As a first step, insights in the knowledge level and the interest in the topic, both linked to school curricula and everyday life need to be obtained.

Inquiry-based learning and conducting scientific inquiries

Inquiry-based approach to learning and teaching science has been widely recognized as a promising approach that can support young learners in becoming scientifically literate citizens. The scientific inquiry approach focuses on relations between phenomena, on understanding cause-consequence relations, on discovering them in the surrounding environment, testing them in experiments, finding plausible explanations and digging further to find explanations to phenomena that are less evident (weSPOT, n.d., Protopsaltis, e.a., 2013). Scientific inquiry has the potential of connecting formal school learning and everyday life experiences, challenges and solutions. Thus, it helps prepare learners to functioning in an increasingly more complex technologically enhanced world. Inquiry-based learning has already found its way into school formal curricula, yet its place remains modest and there are still huge gaps between formal school curricula in science, requirements of universities and professions as far as systematic scientific inquiry is concerned (Van Rens, Pilot & van der Schee, 2010). Strengthening inquiry-based science learning in school curricula can help bridge these gaps. Feasibility of inquiry-based projects as introductions to science learning needs to be tested.

Ubiquitous tools and technologies for inquiry-based learning

In the last ten years social and mobile media have gained popularity and have become important media channels for the learners of between 12 and 25 years old. This trend has not yet led to major innovations in the teaching approaches as schools keep refraining from

enriching pedagogies with mobile and social media tools, which young learners find attractive and which are already broadly represented in their daily life. Based on the insights on innovative good practice and new research findings and ideas, we can state that informal learning can be boosted by the use of ubiquitous tools and that formal curricula can benefit from innovative approaches as well as experiments of the early adopters of new technologies demonstrate (c.f., Littleton, Scanlon, & Sharples, 2012). These findings need to be further tested in ecologically valid situations of average technology users.

The project *Sustainable inquiry based learning with ICT* contributed to tackling the challenges sketched above by designing, developing and implementing an instructional intervention in the form of a pilot.

Its aims were

- to investigate the feasibility of implementing an inquiry learning scenario on energy consumption in the direct environment of the learner and integrating such a scenario in the school curriculum;
- to test prototypes of tools for inquiry-based learning designed and developed in the weSPOT project, in particular tools for data collection;
- to study the impact of an inquiry-based learning activity on knowledge domain development and on awareness of energy consumption related issues;
- to validate evaluation instruments for their further application in weSPOT context and other relevant contexts.

In order to reach these aims:

- An inquiry-based project was conducted in the science curriculum on the topic of Energy consumption using serious game and mobile learning principles.
- A series of instructional scripts (games) were designed to guide students in individual and collaborative inquiry activities on the topic of energy consumption.
- These scripts were delivered on personal mobile devices designed with the help of ARLearn toolkit as a series of games, i.e. including game elements (challenges, fun elements and incentives).
- A system of data collection on energy consumption of appliances the school building was implemented at a school location.
- Data on use of mobile devices throughout the pilot were logged.

- Both prior to the pilot and after it, data were collected on learners basic knowledge of energy consumption and on students' motivation. Furthermore, an inventory on students' beliefs about knowledge and knowledge development was held.

The report gives a general overview of the pilot and the extent to which these aims were reached. The appendix includes a detailed account of the pilot and some illustrations.

Pilot overview

To achieve the pilot goals an inquiry-based learning activity in the form of a serious game on the topic of Energy and Sustainable Development was designed and integrated in the science curriculum of a secondary school (beginners' level, HAVO2/K8). In this framework students (n=85) worked between 2 and 4 hours a week during a 5 week period on a project on energy consumption. The pilot ran from October 22 till November 21 2013.

The project was organized as a 6-phase inquiry cycle. Students started the project with a general introduction on the topic of energy consumption and an introduction of tools (an app for their smartphones). They posed research questions in small teams, decided together how they would tackle the task, collected and analysed data to answer the questions that they posed and presented the results orally and with short reports in the form of posters.

To enable easy access to energy consumption data of different appliances and devices students used an electric power measuring sensor network Plugwise which was temporarily installed in the school building to measure power consumption of separate appliances and devices.

During the project students acquired and applied knowledge of concepts such as electricity, energy consumption and energy efficiency, and trained research skills by conducting observations and measurements, doing calculations, analysing and interpreting information. Thus, the project served to introduce its participants, HAVO2 students to a relevant domain specific topic and to the scientific inquiry methodology and doing research in a systematic way.

Throughout the pilot instructional support was provided by the teachers and by the researcher at regular class instructional moments and delivered through personal mobile devices (smartphones and tablets). Scripted instruction sent to their mobile devices included guidance of data collection in the orientation phase (at home and at school) and in the data collection phase (at school) by audio, video, photo and text. Scripts were developed in ARLearn, a toolkit for developing mobile games scripts (ou.nl/arlearn, n.d.).

Prior to the pilot a try-out was organized to let the students install an app on the personal mobile devices and get acquainted with some of the functionalities of this app. Informed consent request letters were distributed among the students for them and their parents.

Pilot results

Both design and implementation of the learning activity and the tools used by students formed the focus of the pilot. As tools and scenarios were to be used in an on-going curriculum, they were developed in collaboration with secondary school teachers responsible for the science curriculum. This first collaborative effort on designing inquiry-based learning together with the teachers constituted an object of formative evaluation as well. Furthermore, the pilot was used to develop and validate several evaluation instruments (questionnaires) for studying the effects of inquiry based science learning with technology. These questionnaires will be used in follow-up studies both nationally and internationally in the weSPOT project frame.

The collected data set includes two questionnaires filled in by the participants before and after the pilot, ARLearn data logs, school grades assigned by the teachers for participation in the project and the script of the teachers' debriefing interview. Both questionnaires included a basic knowledge test of energy consumption related concepts, two energy consumption awareness scales, a motivation scale and the perceived mental effort scale. The post-test questionnaire also included an knowledge and knowledge development beliefs scale.

According to the collected data, students have a better understanding of basic concepts of energy consumption and saving after the pilot as they score significantly better on the test items and provide explanations of the answers. The general knowledge level on the issues included in the basic knowledge set remains relatively low.

As for motivation, the idea of using mobile phones for learning was met with enthusiastic reactions. According to self-reports practically all students actually used some of the ARLearn game scripts. In their evaluation (measured holistically with a single yes/no item) they expressed appreciation of activities that included actions (taking pictures, recording) and were negative on games that focussed on supportive information. Understandably, they are most critical of inadequate functioning of internet and the lack of structure because of last-minute changes in the activity to compensate for malfunctioning facilities. Evaluation data help explain the fact that the level of motivation, measured with a 17-item inventory (Deci & Ryan, 1985) was significantly lower after the activity than before and that limited, yet significant difference in motivation levels between girls and boys faded away after the experience.

In this pilot materials that can be used in follow-up studies of inquiry-based learning were designed, developed and tested by real users. Evaluations of the end-users and observations of the process provide input for improvements and allow researchers and school teachers to proceed on implementing inquiry based learning in school practice.

The pilot and in particular testing the scripts and scenarios of inquiry based learning with students and teachers helped to formulate requirements and use cases for developers of mobile and social media technologies based on end-users experiences. Thus, the pilot served as a baseline iteration in research of inquiry based learning with mobile technologies following the design-based research methodology. Several follow up activities are scheduled, including a new pilot run with the class of 2014-2015 on the same topic with revised and improved tools and materials.

The pilot pointed to both opportunities and challenges of using personal mobile devices in the school context. Data collected in the pilot from the questionnaires and the data-logs will be further analysed to understand these challenges and develop school-proof approaches. The pilot also pointed to specific challenges of integrating external tools (like Plugwise) into a school network.

The pilot generated data on energy awareness of the young people. This enables insights into mechanisms that potentially impact their behaviour with regards to energy consumption and preservation.

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Acknowledgements

The project was fully funded by SURFnet innovation grant for sustainable ICT solutions. It made use of the technical solutions designed and developed in previous project co-financed by SURFnet Innovation grants and CELSTEC, research institute ath the Open University Netherlands. It made use of an inquiry learning model and technological solutions developed in weSPOT project (wespot.net, n.d.).

Appendix

1. Impressions from the pilot set

Appendix 1 Impressions from the pilot set

Figure 1. Photo taken during exploration of the energy consumers in the school building with ARLearn

Figure 2. A poster on the energy consumption of the soft drink vs snack machine

Figure 3 Students presenting their inquiry