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weSPOT: INQUIRY-BASED SCIENCE EDUCATION APPROACH AND TECHNOLOGIES IN ACTION

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Math, science and technology (MST) education in Europe is significantly based on experiments and problem solving. The innovative project weSPOT aims at enhancing MST education by emphasizing scientific inquiry, individualization of learning and the role of social interaction. To achieve this goal, students are supported by a set of software tools, helping them to plan, implement, comment and document their personal scientific experiments. The students are encouraged to share and discuss their experience and to learn how to conduct scientific research. They share their achievements in class as well as in their own social community (friends, family, scientists, etc.). This paper describes in details the scientific approach which is the base for the pilot experiments of the weSPOT methodology. It presents the first pilot of Inquiry-Based Science Education (IBSE) conducted in the First Privite Mathematical School and analyses applicability of the used software products.

Keywords: inquiry-based science education, technology-enhanced learning, weSPOT

2012 ACM Computing Classification: Education - collaborative learning, e-learning, mobile learning, collaborative and social computing - collaborative content creation, computer supported cooperative work, modeling and simulation - simulation tools, visualization toolkits, web services - mashups, ubiquitous and mobile computing systems and tools

1. INTRODUCTION

Modern conception of learning [1, 2] presents the aquiring of new knowledge and skills as a result of social interactions (conversations, discussions) and a practical solution of problems and tasks, the student interacts with the objects of reality, formulate their statements and assumptions seeks to justify and prove or refute. Unfortunately, the practice in most educational institutions do not comply with the requirements of the theory. Students at secondary schools and universities are mostly in a passive role in the classroom, and teachers are often in the role of mentors. Students are rarely motivated to take initiatives within their education and to expand it outside the school environment, provoked by curiosity.

One approach to solve the problem with the gap between theory and practice is the inquiry-based science education approach, in which students play the role of explorers and scientists as they try to address issues set by themselves, while finding answers to these questions is challenged by their own curiosity. This approach leverages a meaningful context for students to learn concepts by linking them with their personal experiences and insights. It leads to structured knowledge of the field of education and more skills to carry out effective research. In this way, students learn to explore, collaborate, be creative, use personal characteristics and identity, and have an impact in different environments and at different levels (e.g. individual, in the neighborhood, community, world).

Students can go through the process of inquiry-based learning at different levels of autonomy and complexity, respectively, with varying degrees of support [3]. At the lowest level, students are guided entirely by the teacher in defining the problem, choosing an appropriate method for studying it and finding a solution. At the highest level, called open inquiry, they drive the process of inquiry and analysis, make their own reasoning and explain the meaning of phenomena performing their activities individually or together, as well as sharing the knowledge representation they reached. The project weSPOT [4] aims at supporting the implementation of this approach through the design, development and testing of appropriate software tools that will enable students to:

- Customize their environment for inquiry-based education;
- Build, share and carry out research individually and/or in collaboration with their peers.

Thus, weSPOT aims to enable the connection of everyday life with training in subjects related to natural sciences in schools through the use of information and communication technologies (ICT).

From the perspective of European teachers, the weSPOT project will enable both teachers and students to apply an inquiry learning approach based on experiments, carried out in a real school environment. Such experiments can be supported by computer simulations and 3D images and video that will allow students to understand better the subject of natural sciences. This will make possible to develop new models of learning and teaching, which provoke students to research and create new bridges for the use of research results in business.

This article describes how some personal and social aspects of the research approach to learning can be accomplished through ICT support. It presents the currently deployed software tools, as well as a scenario for using them in conducting experiments along with its concrete implementation in a Bulgarian school and a brief analysis of the first results. In the Conclusion, further steps, which should be taken to support the technological support of the research-based training approach are drawn.

2. weSPOT INQUIRY–BASED SCIENCE EDUCATION

In the frame of the weSPOT project students are encouraged to go through the whole process of research, although the level of complexity of their research tasks can vary [5].

Visualization is the key to personal and social aspects of research training. Images are used for a description of the research process workflow in the training, which helps users to visualize better their research projects. Students can use images at different stages of their research to present their scientific reasoning, and/or integrate by images their questions, hypotheses, concepts, arguments, and data. As a strategy, the use of visualization aims to develop a knowledge map, through which students can link and articulate clearly their conceptual and procedural knowledge. Thus the visual language helps students to make a clear argument in order to generate comprehensible and clear plan of their documents.

In addition, weSPOT indicates when students have acquired a certain level of research expertise, so that their achievements are visible to others and can be used in their personal profiles in social networks.

weSPOT does not recommend a universal solution for all, but it starts from the pragmatic view that the optimal level of research actually is variable and it will likely vary for different students. It should reflect the key factors in the learning situation, including the content, context, the skills of the student, the teacher's knowledge and available materials. Students, compared to scientists, are beginners in research. When their knowledge on a given topic is limited, the open inquiry may not produce effective learning and may even hinder learning, adding internal cognitive tension. weSPOT model provides teachers and students with support and technological tools to grow step by step and reach competence, to progress and be able to find the optimum level of inquiry, which to meet their needs.

3. RELATED WORK

In the project weSPOT we plan and started to implement at the new level results from experience gained in other research projects. For example, the project Innovative Didactics for Web-Based Learning, IDWBL [6] considered five types of support for web-based learning: a web reference, web search, web research, e-mail project and collaboration. Students are guided by a teacher to experiment new methods and techniques. They share their inquires with teachers and each other, and thus achieve the learning objectives of the traditional classroom work. During the web-based learning projects teachers reported increased motivation for learning and development of mental processes in students.

The implementation of research-based education needs a practical methodology, approaches and tools that provide support for the daily practice. These needs are met by the methodology I*Teach [7] developed within the project Innovative Teacher. It is based on active, student-centered learning methods. The teacher is a partner in the process of realization of the didactic scenario, stimulating the development of creative talents of students [8]. The methodology was integrated into the projects TENCompetence [9] and ShareTEC [10] and in the training of teachers in vocational schools. Integration in ICT textbooks and methodological guides for teachers to use the research approach in training used in the project Fibonacci (http://www.fibonacci-project.eu/). In 2009 the I*Teach project was awarded as the most successful project of Leonardo da Vinci program.

Another relevant project is WebLabs - an European project aimed at developing a virtual learning environment (VLE) and a Weblabs learning model [11]. The learning environment allows students, teachers and researchers located in different geographical areas to be included in the overall process of research and education in mathematics and/or science. Understanding of the studied sciences is achieved through a partnership in the context of research. In addition, students accumulate social experience through collaboration and sharing of results [6].

Based on the experience gained in these projects, the conditions for a successful realization of the research-based approach in teaching students are formulated [12]: change the attitude of the teacher and provide strong support to students (micro level); support by the school management, providing necessary ICT infrastructure and building teacher teams to share experiences and good practices (meso level); the reformation of the curriculum, constantly offering training courses for teachers and a rich repository of resources based on national ICT infrastructure (macro level).

4. INFORMATION AND COMMUNICATION TECHNOLOGIES SUPPORTING PERSONAL AND SOCIAL ASPECTS OF INQUIRY

There is an abundance of software tools and services that can be used for the implementation of an ISBE approach. The main problem is to find out how they can be integrated and used together as much as possible in a meaningful and efficient way. weSPOT addresses this issue by providing a way to integrate data collected from a variety of research tools and services. It enables the integration of cognitive research tools and linking them to students' profiles as well as to their social and educational context. Individual and collaborative activities that engage students with various research tools will update the history and goals of student learning, and thus will enable them and their teachers to work in a unified learning environment in which they can monitor progress.

Testing the research tools offered by weSPOT with students and teachers in real-life scenarios in high school is essential for gathering requirements and feedback from end-users. The pilot project "Energy efficiency in buildings" was designed to implement the IBSE approach at guided level to help students identify the shortcomings of the building in which they are taught in terms of energy efficiency. Students are expected to predict (and provide evidence) what is the expected energy problems in the future. Working in teams, they will generate ideas to improve energy efficiency of future buildings. Teachers can help by asking questions such as:

- *What kind of new materials for new energy efficient building components, that conserve energy, to be used?*
- *What environmentally friendly technologies will provide high quality microclimate?*

In this way, students will come to better ideas and will develop skills in the field of education, but also will build new research skills and competences.

5. AIMS AND CONTENT OF THE PILOT EXPERIMENT

This pilot experiment is related to the Energy Efficiency in Buildings testbed. It is in the frame of an integrated training on the subject *Man and Nature* and *Information Technology* (IT) in 6th grade. It was led by three teachers (one teacher in *Man and Nature* and two IT teachers) and included 60 students aged 12-13 years from the First Private High School of Mathematics (PCHMG).

Domain competences, related to the subject *Human and nature*, which students should be able to develop during the pilot experiment were:

- Identifying processes, related to releasing and absorbing heat;
- Understanding that the current flow energy source gives consumers and describes the effects of thermal appliances;
- Calculating the cost of electricity used by household electrical appliances and finding ways to save it;
- Providing argumentation about the special role of man to protect and preserve energy;
- Observation and self-observation (of the objects in the nature and in the lab);
- Extracting information from graphs, tables and charts, and with IT;
- Forming attitude to the energy consumption.

The pilot experiment aimed to build also **inquiry skills** such as:

- Selecting among given questions and posing new scientific questions with guided support;
- Collecting certain data with guided support for what constitutes evidence;
- Formulating explanations from evidence with guided support;
- Linking areas and sources of scientific knowledge to clarify explanations;
- Communicating explanations based on scientific reasoning with guided support.

The scientific question of the experiment was: *What are the external factors influencing energy consumption and how the man can act to preserve it?*

Inquiry was organized as a completion between three 6 grade classes under the subtopic: **My classroom - the most energy efficient!**

Each class plays as a single team which search how much energy its classroom consumes and how it can save some energy without health risk. The main teams are divided into subteams according generated hypothesis and indicators chosen to measure. Each class collects and analyses data. At the end of the project each class presents its observations and conclusions in front of the other classes, parents and school managers. Each team shares ideas about increasing the energy efficiency of the building and provide argumentation based on its research.

The winner is the class providing most reasonable ideas.

Start and end date of inquiry are not accidental dates. They are especially selected: the start date, 17 November is the first day of the European Week for Waste Reduction (November 17-24); the end date, 5 June - the World Environment Day.

The environment for the inquiry is the classrooms of each of the three classes. They are located on a different floor of the building - basement, first and the second floor, and has different exposures. There are electric lights and air conditioners in each room. In some rooms joinery is old, while in the other - replaced with new one. Thermometers are placed on the wall of the rooms as well as on the outside wall.

6. PHASES OF THE EXPERIMENT

As a workflow of the pilot experiment students used the Mulholland et al model [13] with an inquiry cycle based on 8 phase octagonal (Fig 1). Realisation of each of these phases are presented shortly below.

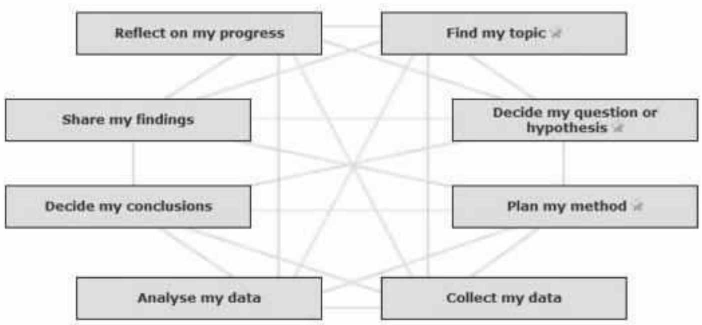


Figure 1: Inquiry Cycle [13]

6.1. FIND MY TOPIC

During the first stage - finding the topic, the teacher in Human and nature subject, introduced students to the problem of energy consumption (Fig. 2). She presented data about the energy consumption of the school during the last year and how much it costed. After introducing the main idea, she set common problems to each of the three classes:

- *What measures should the school board take to reduce the energy use?*
- *Is there a place for alternative energy sources in the classroom?*

Figure 2: Introducing the topic

6.2. DECIDE MY QUESTION OR HYPOTHESIS

The next stage was to form a question or hypothesis. In this stage the brainstorming process took place. The students discussed the questions (Fig. 3) and found more specific questions they should answer in advance. In the process they came up with the ideas for observations.

Some examples of their questions were:

- *What are the energy consumers in the classroom?*
- *How much energy do they consume?*
- *Are there any dependencies between external climate characteristics (the temperature, wind, is it sunny or not, exposure, etc.) and the energy consumption and what they are?*
- *How long during the day the air-conditioner is working? At what degrees of temperature?*
- *How the students keep the energy of the classroom - if they open the windows, do they leave the door open during the breaks, do they keep the lights unnecessary switched on, etc.*

Figure 3: Discussing the energy consumers and climate conditions

The students chose which are the most important questions and stated their hypothesis based on the expected answers. After formulating the hypothesis, they formed 5 teams in each class to explore each question/hypothesis in parallel.

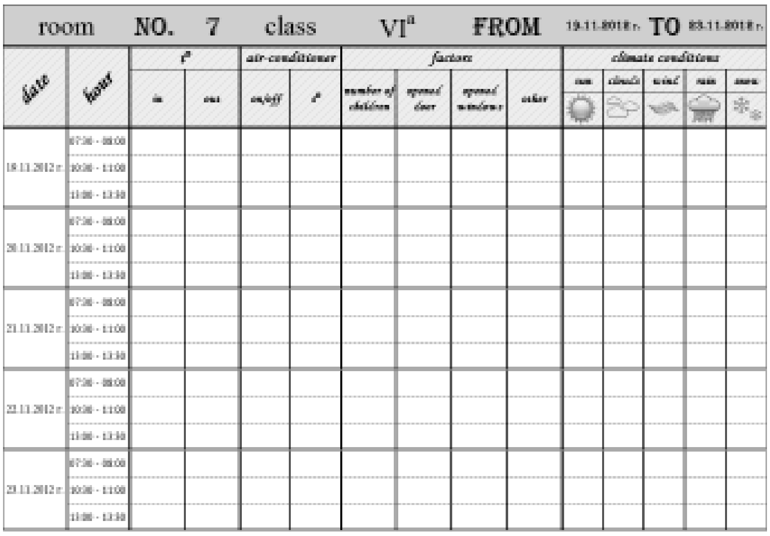
6.3. PLAN MY METHOD

During the third phase, according to the chosen questions the students in each team discussed what kind of information they need, how they can collect it, what they need to collect it and what they should and can measure in order to prove their hypotheses, formed in the previous phase.

Some examples:

- *To measure the temperature inside and outside the school building three times a day - early in the morning, in the middle of the school day and at lunch;*
- *To compare the temperature in the classroom and outside the building;*
- *To check at time of the measurement if the windows or doors are opened;*
- *To observe the external climate condition - is it sunny, windy, cloudy, etc.*
- *To check at what time the air conditioner is switched on and off;*
- *To calculate how much energy the air conditioner consumes per day;*
- *To do internet research about the particular model of the air conditioner and how it should be used in order to be the most efficient in working;*
- *To check at what time the lights are switched on and off; To calculate how much energy the lights consume per day;*
- *To check at what time during the day, the daylight in the classroom is enough for working properly;*
- *To provide informal interview with parents about the energy preservation at home.*

In this phase, the students composed a simple table (Fig. 4) for collecting the necessary data. They developed it on paper and put it on the wall of each classroom, so that in the next phase be able to fill in the data collected during the week. In order to not miss data from previous weeks, the students composed an electronic version of the table. It was made in the IT class. They used a spreadsheet to compose the desired table. They composed it, made validation rules, inserted a formula to calculate the dates automatically and put pictures for the weather conditions. They merged cells where it was necessary and put column and row headings. This was the first time where the IT and nature sciences were combined in the project.



room NO. 7 class VI^a FROM 19.11.2012 г. TO 23.11.2012 г.															
date	hour	t^o		air-conditioner		factors				climate conditions					
		in	out	on/off	t^o	number of children	opened door	opened windows	other	sun	clouds	wind	rain	snow
19.11.2012 г.	07:30 - 08:00													
	10:30 - 11:00													
	11:00 - 13:30													
20.11.2012 г.	07:30 - 08:00													
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Figure 4: The model of an electronic table for collecting data

The main goal was to encourage students to work in a team, not only in the class, but also to collaborate with other students from the other 6-th grades. Another goal was to put the students in an active position. In the second phase we reached this goal - they were very innovative, creative, defining many ideas and questions. During the process of composing the table they also worked together, shared opinions and knowledge. Some of our objectives were to develop their sense of civil position, to teach them to state an opinion and to defend it.

6.4. COLLECT MY DATA

During the fourth phase - collecting data, each team collected the data it has chosen to measure.

Before starting the collecting period, the students put thermometers in each classroom and outside the school. Fortunately the classrooms of the three classes are on different floors of the building - on the ground one, on the first and on the second. In each classroom they put a printed table on the wall for writing the measured data 3 times a day (Fig. 5).

Figure 5: Measuring the temperature in the classroom (left) and outside the school (right)

Right after measuring the observed factors students entered the collected data in the sheet. Once a week they entered the data from the wall sheets to the electronic spreadsheet during the classes of Information Technologies (Fig. 6).

Figure 6: Entering the data in a digital form

6.5. ANALYSE MY DATA

At this stage new teams were formed - every class should be presented at the final competition by one team. The new teams had to summarize the data from the whole class and to prepare diagrams and charts helping to find dependencies between observed external factors and energy consumption, human behavior and energy consumption, building condition and energy consumption, etc. Preparing diagrams and charts was in the classes of Information Technologies. During these lessons, the pupils learnt the basic chart types, what the main elements of a diagram are and how to create a diagram with the information, using spreadsheets.

6.6. DECIDE MY CONCLUSIONS

In the sixth stage, students made conclusions about their initial hypothesis. They discussed different scenarios. During the debate on the conclusions they made, each party provided its arguments and every student voted for one of the conclusions.

Based on these conclusions, the groups prepared a list of recommendations to the school management.

Some of the recommendations were in the following directions:

- *What time it is appropriate to switch on/off the lights according some found factors;*
- *What time it is appropriate to switch on/off the air conditioner according some found factors;*
- *Should the window frames or the doors be replaced;*
- *Is it possible to use some kind of alternative energy sources.*

6.7. SHARE MY FINDINGS

The seventh phase - sharing my finding, had two sub-phases.

The first sharing was after working on this pilot experiment for 2 months - at the end of January. Each of the teams in each class had to present the collected information on their topic in front of the other teams in the class. The presentation was about factors and conditions, which they had investigated. The students prepared the presentations. In order to be properly prepared for presenting their work, during the lessons of Information Technologies some of the presentational techniques were discussed.

The second sharing took place on the 5th of June - the World Environment Day. On this day the sharing was delivered in the form of competition between the three classes. In the competition not only students from the 6th grades took part, but also students from the 9th grade. The ninth graders organized the whole event. They were responsible for the preparation of the room, making the invitations for the jury, accompanying the guests, taking photos, etc. Every team from the 6th graders had a name and its own colour. Each team was suited in one of the Bulgarian flag's colours - white, green or red.

The competition was in 3 stages - an oral presentation, a practical workshop and solving PISA problems in natural sciences.

During the first stage every team shared in 10 minutes its conclusions and recommendations and provided evidence (data tables, diagrams, pictures, models)

Figure 7: A team shares the whole class findings

in order to prove it (Fig. 7). They also made concrete proposals for better energy consumption.

The second stage included a 12-minute practical workshop. Every team had a plastic box, which symbolized its classroom, a ruler, a pen, markers, a glue, a cardboard, an styrofoam, an aluminum foil and old newspapers. They had to isolate the box. The isolation was tasted by putting ice and a thermometer in every box (Fig. 8).

Figure 8: Experiments during the workshop

The last stage consisted of solving PISA problems. Every team had to solve problems and the first one had the right to answer, after pressing a button. When the team's answer was fully correct the team gained some points. Otherwise, the other two teams had the chance to answer in order to gain the points.

A jury formed by 3 university professors from Sofia University had to evaluate the presentation, conclusions and argumentation of each class. In front of the teachers, school managers and parents the jury decided which class was the winner. The decision was based upon the provided argumentations and answers of the questions from the audience.

There are a lot of criteria for evaluation. In addition to logical conclusions, based on the inquiry, there were also additional factors for rating the presentation,. Some of these factors are the organization of the presentation, its structure, the usage of graphics, the balance between text and graphics, spelling and grammatical errors, the appropriate design and the usage of presenting techniques. The main evaluation criteria for the practical task was the quality of the composed isolation and its aesthetics view. In the third stage, the first team with a correct answer to the problem gained the points. The winner was the team named Electra, that received the most points.

6.8. REFLECT ON MY PROGRESS

The last stage - the eighth one was the reflection on the progress. After the competition the classes participated in a group reflection with the three teachers. The reflection questions were:

- *Why the particular class is the winner?*
- *At what stages were they/we better? How did they/we achieve this?*

In each team reflection was concentrated on questions like:

- *How was the team work organized?*
- *Who had taken what responsibilities?*
- *How was the team communication performed?*
- *Were there "lazy" teammates and how did the team provoke them to work?*
- *How did the team members support each other?*

Each pupil was encouraged to think and share:

- *What were his own challenges during the project?*
- *What new did he learn?*

Finally, teachers summarised the conclusions and shared the recommendations for improvement in the next inquiry.

7. INFORMATION AND COMMUNICATION TECHNOLOGIES NEEDED TO SUPPORT IBSE IN THE EXPERIMENT

The use of the Mulholland et al model [13] in the experiment led us to the idea to use the integrated environment nQuiry [13], which allows a description and implementation of all phases of a chosen model. The web application nQuiry is based on Drupal and is especially developed to support IBSE.

The application supports tools for: selecting a model of research learning scenario (Fig. 9); describing of a scenario, associating user groups with it, data recording, sharing and dissemination of results.

Figure 9: Description of a research scenario for education in nQuiry

The experiment showed that although nQuiry provides a lot of utilities, it still needs additional options to be able to ensure an effective and efficient implementation of the research approach. For example, it is focused primarily on individual studies that can be monitored and controlled by the teacher. Although it has the tools to organize group work, it does not offers enough opportunities for visualizing and integration of the performance of the particular groups.

The pilot experiment showed that there is a need of additional tools in order to fully meet the needs of educational research, especially to support collaboration in a social environment.

Based on the observation during the pilot experiment, we think it will be perfect to have an integrated technological environment and tools to support activities in the different phases.

For the *first phase*, *finding topic*, it is good to have a shared place where preliminary notes by the teacher can be shared with all the students in the inquiry.

For the *phase of making hypothesis* - to have tools and a shared place for class brainstorming, tools for voting, place/option for subgroups (re)forming and working together. The technology environment should allow the subgroup work to be visible for other groups. In addition, tools should make possible for the subgroup to be able to share (if it likes) collected data outside of the main group. The teacher should be able to observe the brainstorming and to provide some directions if there is a need.

During the *phase of planing methods* the technological infrastructure should provide a common place for the whole class where each team can present its decision - what it will measure, observe, research and how. In addition, through technological tools the teacher should be able to provide separate feedback to each team as well as to the whole class. Moreover, the students should be able to have an open (shared) working space, supported by technology, to discuss what tools and resources are useful for the presented methods. They should have an opportunity (as well as the teacher) to recommend toolkits and resources for data collection and analysis.

In the *phase of collecting data* tools should be available to the teacher in order to be able to provide some pictograms, symbols, images or so, for the students to use to mark their observations in a common way. In the concrete experiment, it would be useful if the tool could provide them with graphical symbols for describing the weather (sunny, cloudy, rainy, etc.). A possibility to upload pictures directly from a mobile device and the system to mark the time of uploading is desirable. Using different tools students should be able to create and use a common dataset (for example an electronic spreadsheet) where each team to fill in its collected data. In the given case - a common electronic table is useful to measure at the same time on each date the internal and external temperature, the air conditioner settings, the whether characteristics etc. Tools should support students to organize different data sets according to the chosen method of research. The dataset should be visible to the other teams in the main group/class. It should be also shareable outside of the group.

During the *phase of analysing data* and *phase of making conclusions* the tools should support discussions within and between the teams, sharing of and voting on artefacts (photos, hypothesis, arguments), as well as feedback, including by the teacher. It will be useful to have an integration with mobile device applications, allowing to provide directly arguments or evidences for proposed conclusions, as well as immediate comments, notes and feedback.

In all of the phases tools should support rearrangement of the teams, as well as feedback or directions (if needed) from the teacher and other science experts.

These observations and recommendations were passed to the weSPOT developers in order to take them into account during the development of tools in the frame of the project. Some of them inspired the developers to create simulations, like the one shown in Fig. 10, which was developed by using the Elica software.

Figure 10: Classroom Energy Simulation (Summer) [14]

Looking on it the teacher of the Human and Nature subject reacted immediately "Great! Next pilot will take shorter time, because the children could experiment with a simulation and it will not be necessary to collect data for approximately six months. In addition, during the winter they could generate conclusions for the summer!"

8. THE IMPACT OF THE PILOT ON THE weSPOT INQUIRY-BASED LEARNING MODEL

Although the first weSPOT pilot was just finished, the process was closely monitored and used for the development of a new inqiury-based learning (IBL) model. The new model [15] (still not officially published) is simpler - it is based on 6 phases:

- Question/hypothesis
- Operationalisation (realisation of an idea with the aim to measure)
- Data collection
- Data analysis (processing)
- Interpretation/discussion
- Communication

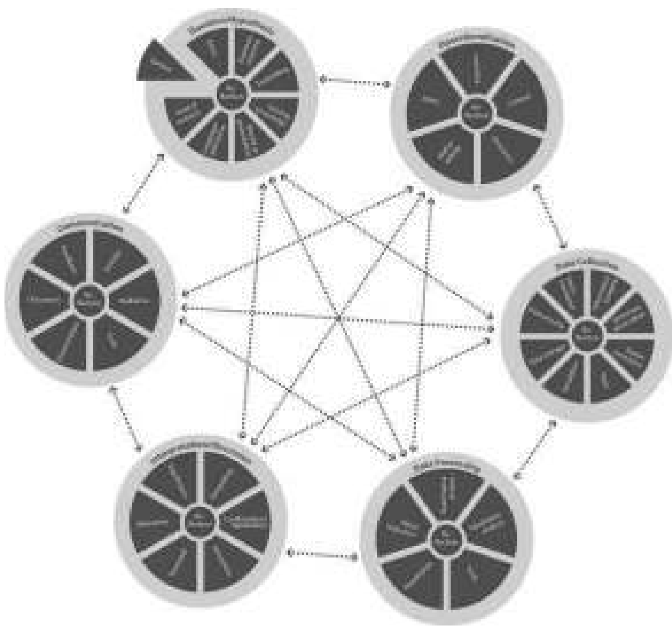

Figure 11: weSPOT IBL model [15]

The model shares many of the phases that Mulholland et al. [13] described (Fig. 11) [15], but it is more complex regarding the sub-phases providing a detailed description of things that teachers and students should consider when doing inquiry. It is mostly oriented to the inquiry competences that are developed during the process of education.

The weSPOT: *Information and communication technologies fit young researchers' learning needs* video [16] illustrates how the new model fits the pilot experiment phases. The pilot was very valuable for the weSPOT consortium also in identifying the needed technological tools which can provide the most effective way to teach according the IBL model. For example, a tool for real-time team forming and reforming, a tool for organization, implementation and summarization of brainstorming, shared data sheets, etc. and how these tools can improve the development of specific inquiry skills.

9. CONCLUSION

In this paper we presented the weSPOT methodology for science education. We showed how this methodology was applied in the First Private Mathematical School in Sofia, Bulgaria. This pilot experiment proves that Inquiry-Based Science Education (IBSE) is not only very interesting and innovative approach, but also that it is bringing higher motivation and is giving excellent results, especially when it is backed with the necessary software tools to support it.

This pilot also showed what improvements and further developments in these software tools are needed, which will be addressed in the next version of the weSPOT software framework. These new updated tools will be again applied and tested in a new set of pilot experiments not only in the secondary education, but also in the university courses as well.

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REFERENCES

1. Seely Brown, J., R. P. Adler: Minds on fire: open education, the long tail, and Learning 2.0. *EDUCAUSE Review*, **43**, 2008, 16–32.
2. Kolb, D. A.: Experiential learning: experience as the source of learning and development. Englewood Cliffs, NJ. Prentice Hall, 1984.
3. Tafoya, E., D. Sunal, P. Knecht: Assessing inquiry potential: A tool for curriculum decision makers. *School Science and Mathematics*, **80**, 1980, 43–48.
4. weSPOT, Working environment with social and personal open tools for inquiry based learning. EC, FP7- Project 318499, 2012-2015 http://portal.ou.nl/web/wespot/home
5. v. Merriönboer, J. J. G., P. Kirschner: Ten steps to complex learning: A systematic approach to four-component instructional design. London: Lawrence Erlbaum Associates, Publishers, 2007.

6. Sendova, E., I. Nikolova, G. Gachev, L. Moneva: Weblabs: A virtual laboratory for collaborative e-learning. In: *Proc. EduTech: Computer-aided design meets computer aided learning*. Dordrecht, Netherlands, 2004, 215–221.
7. Stefanova, E., E. Sendova, N. Nikolova, I. Nikolova: When I*Teach means I*learn - implementing a new methodology for building up ICT-enhanced skills. In: *Proc. Working Joint IFIP Conference: Informatics, Mathematics, and ICT: a 'golden triangle' (IFIP IMICT)*. Boston, USA, 2007.
8. Nikolova, N., E. Stefanova, E. Sendova: Op Art or the art of object-oriented Pprogramming. In: *5th International Conference on Informatics in Schools: Situation, Evolution and Perspectives (ISSEP 2011)*. Bratislava, Slovakia, 2011, 26–29.
9. Nikolova, N., K. Stefanov, K. Todorova, E. Stefanova, M. Ilieva, H. Sligte, D. Hernández-Leo: TENCompetence tools and I*Teach methodology in action: development of an active web-based teachers' community. In: *Rethinking Learning and Employment at a time of economic uncertainty*. Open Workshop, Manchester, UK, 2009.
10. Stefanova, E., N. Nikolova, E. Peltekova, K. Stefanov, T. Zafirova-Malcheva, E. Kovatcheva: Knowledge sharing with Share.TEC portal. In: *International Conference in E-learning and the Knowledge Society*. Bucharest, Romania, 2011, 273–278.
11. Mor, Y., C. Hoyles, K. Kahn, R. Noss, G. Simpson: Thinking in progress. *Micromath*, **20**, http://www.lkl.ac.uk/kscope/weblabs/papers/Thinking_in_process.p df, 2004, 17–23.
12. Nikolova, N., E. Stefanova: Inquiry-based science education in secondary school informatics - challenges and rewards. In: *First International Symposium on Innovation and Sustainability in Education (InSuEdu 2012)*. Thessaloniki, Greece, 2012 (in print).
13. Mulholland, P., S. Anastopoulou, T. Collins, M. Feisst, M. Gaved, L. Kerawalla, M. Paxton, E. Scanlon, M. Sharples, M. Wright: nQuire: technological support for personal inquiry learning. *IEEE Transactions on Learning Technologies*, **5**, no. 2, 2012, 157–169.
14. Boytchev, P.: Classroom energy simulation (Summer) - weSPOT channel. https://www.youtube.com/watch?v=LbY_Wi9l5NM (retrieved on 12/06/2013))
15. Aristidis Protopsaltis, et all: DELIVERABLE D2.3.1: Pedagogical and Diagnostic Framework, draft version. https://asset1.basecamp.com/1774169/projects/877175-project-weSPOT/attachments/34335957/weSPOTD12.docx. (Retrieved on 14 June 2013).

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