INSTEM Shaping the future of STEM education

Innovation Networks in Science, Technology, Engineering & Mathematics

Romanian National case study: Analysis on the Fibonacci project August 2014

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1. Contextual description

The activities related to the support of science education at pre-university level began at the National Institute for Laser, Plasma and Radiation Physics (Magurele, Romania) in 2003 with its involvement in the EU's Comenius network "Hands-on Science" (http://www.hsci.info/). Based on the experience acquired through this first project, the national educational network "Hands-on Science, Romania" was established. This network imposed itself as a major national player in the years to come. Between 2006 and 2007 the consolidation of the educational activities at the Institute took place, as in the frame of the national project "Scientific education for a knowledge-based society – SET 2010" the Center for Science Education and Training – CSET (http://education.inflpr.ro/ro/home.htm) was established, aiming to support science education from kindergarten to high school. Over the next ten years CSET run several national and international projects, involving hundreds of school teachers and thousands of school students, all over Romania. The number of participants in various projects activities is quite impressive as proved by the number of visitors of each project web site (when these numbers are available they are given below in parenthesis):

- the "PHOTON" project, Problem Based Learning - http://education.inflpr.ro/ro/ home.htm: three Romanian high school teachers attended on-line professional development courses organized by the New England Board for Higher Education in the United States (2007-2008);
- the "Pollen" project (www.pollen-europa.net) to which CSET was an associate partner (2006-2009);
- the "Light in our life" project, with participants from Canada, Greece, Italy, Romania and United States, having as main theme the role of light in human civilisation (2009);
- the national project "Discover!" (http://education.inflpr.ro/ro/Descopera.htm) focused on teachers professional development (2009-2011);
- the FP7 EU project "Fibonacci" (http://education.inflpr.ro/ro/Fibonacci1.htm) , aiming to disseminate inquiry-based methods in science and mathematics, at European level, (2010-2013, 4225 visitors of the site);

- the FP7 EU project “Creative Little Scientists” (http://education.inflpr.ro/ro/MiciiCercetatoriCreativi.htm), a research project investigating the development of creativity at early age, in the context of science and mathematics education through inquiry (2011-2014, 4660 visitors of the site);
- the national project "Inquiry-Based Education in Science and Technology - i-BEST" (http://education.inflpr.ro/ro/IBEST.htm), devoted to the promotion of inquiry-based science learning (2012-2016, 5941 visitors of the site);
- the project « Chercheur en herbe” (http://education.inflpr.ro/ro/CercetatorIn Devenire1.htm), a collaboration between CSET and the French School in Bucharest, focused on the promotion of collaboration in science teaching between the two educational systems (2010-2012);
- the LLL EU’s Comenius network “INSTEM - Inquiry Network for Science, Technology, Engineering, Mathematics Education", a network of European networks interested into IBSE (2012-2015);
- the LLL EU’s Comenius network "SUSTAIN - Supporting Science Teaching Advancement through Inquiry", project promoting the education for sustainable development in relation to IBSE.

Almost each project has its dedicated Internet site where the goal, objectives and main achievements are presented. Activities associated to the project are listed and examples of partner teachers’ results are introduced to the public at large.

In order to setup a national community of practice in relation to IBSE methods we developed:

- a collaborative platform (http://81.181.130.13/ibest/) through which teachers can participate to common, nation wide school projects such as: “Spring is coming”, “Weather and its parameters”, “Sound pollution”, Water quality” and “UV radiation hazard”;
- an e-learning platform (http://81.181.130.13/teachscience/), where learning units for science teaching are available;
- a virtual library, where teachers can access learning units we developed in cooperation with Romanian science teachers, or translations of learning modules from European and American projects.

For some learning units we developed educational aids, available to school teaches. In order to support technology teaching, we set a “robotics club” at one high school in the city of Galati (http://cuza.licee.edu.ro/pages/despre/extracurriculare/robotica/prezentare%20activ%20cerc%20robotica.pdf).

CSET is founding member of the “Hands-on Science” International Association and of the “Network of Youth of Excellence – NYEX” (http://www.nyex.de/). We have cooperation with National Optical Astronomy Observatory – NOAO in the United States, Weisman Institute in Israel, and some of our projects were supported by professional international organizations like SPIE and OSA.

At national level we are working with school inspectorates, teachers training centers, parents associations, and a lot of educational establishments. Yearly we are organizing in cooperation with them the international conference “Science Education in School” and satellite events such contests, science fairs, symposia, demo sessions, courses, and exchanges of best practice. Periodically, we are organizing teachers’ surveys on educational issues, with the participation of a large pool of teachers (between 250 and 350 participants per action).

Considering the great variety of national and international projects we participated and the diversity of educational approaches we interacted with, we can claim quite a good knowledge of the issue and we can express a qualified point of view on these matters. We have also the big advantage of interacting with a great number of teacher educators, mentors, researchers and end-users (school teachers and students). The age span of the children we interacted ranges from three years old to 18 years old.

From all the projects we had, we decided to select the “Fibonacci” project as a national case study , considering that it can be a very good model for the integration of educational practice in science and mathematics education at European level.

At its beginning, the “Fibonacci” project gathered 25 entities (universities, research institutes, academies, foundations) from 21 European countries (Austria, Belgium, Bulgaria, Czech Republic, Denmark, Estonia, France, Finland, Germany, Greece, Ireland, Italy, Luxemburg, The Netherlands, Poland, Portugal, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey, UK/ England/ Northern Ireland/ Scotland) in an effort to design a guide for partners work on inquiry-based education in science and mathematics, and to organize at continent level the dissemination and exchange of good practice (Annex 1 lists the partners and their affiliation). Experts in pedagogical sciences, as well as in science and mathematics teaching and learning were coordinated by a Scientific Committee, while the entire run of the project was monitored by an external consulting company.

As indicated in the cited “Fibonacci” booklet, the project was based on a set of three pillars defined by the coordinating team to assist project partners in implementing the project philosophy at national stage [1]:

- By learning through inquiry, students have to understand and adopt concepts, gather evidence on their research and develop critical thinking. Principles setup previously by the German “SINUS-Transfer” and the French “La main à la pâte” programmes are supported:
    - “developing a problem-based culture;
    - working in a scientific manner;
    - learning from mistakes;
    - securing basic knowledge;
    - promoting cumulative learning;
    - experiencing subject boundaries and interdisciplinary approaches;
    - promoting the participation of girls and boys;
    - promoting student cooperation;
    - promoting autonomous learning.”

- The project as a whole encourages local initiative to support education for innovation and sustainability. The communities to which students and schools belong have to play a major role in developing sustainable models for science and mathematics education.
- An innovative aspect of the “Fibonacci” project resides in the adaptation of a novel, very efficient interaction and dissemination scheme involving actors engaged in running the project – the twinning strategy. Around a network of Reference Centers (RC), with recognized expertise in inquiry-based education are grouped successively less experienced centers (Twining Centers – TC), which are trained to become centers of excellence through exchange visits, training sessions, and seminars. This cross fertilization approach, we can say was the most powerful tool of the project, as it allowed exchanges

of practices, a better understanding of local conditions and limits, formulation of common solutions. In the mean time, this approach helped participants to learn one form another, by exposing them to different educational practices, cultural background and teaching methods.

Another contribution of the cited project booklet is represented by the conceptualization done for the process of inquiry teaching and learning, placed both in the historical context and in the frame of EU present requirements.

An interesting outcome is the comparative evaluation, highlighting the communalities and differentiations of inquiry education in science and mathematics, considerations which can be of interest for those trying to go both ways. The project analysis underlined also the consequences of these differentiations between the two for classroom practice.

By the end of the project 62 Centers on Science and Mathematics Education were active, involving over 5,900 school teachers and engaging more that 306,600 school students across Europe. During the project lifetime local and country wide learning communities were established in the partner countries, which contributed to the sustainability of the project beyond its financed period.

Over the four years of the project were organized:

- two international conferences;
- a series of seminars;
- 84 field visits and exchange of experts;
- five European training sessions on common topics.

Participating parties developed learning modules for science and mathematics teaching through inquiry (http://www.fibonacci-project.eu/, see Resources > Examples of activities > “In mathematics” and “In science”).

In order to reinforce science and mathematics teaching through inquiry, in formal and non-formal environments by multidisciplinary approaches, the project partners formed five working groups which prepared five booklets on the following topics for interest to teachers:

- Deepening the specificities of scientific inquiry in mathematics;
- Deepening the specificities of scientific inquiry in natural sciences;

- Implementing and expanding a Reference Centre;
- Cross disciplinary approaches;
- Using the external environment of the school.

The booklets are available on the project web site (http://www.fibonacci-project.eu/, > Project > Common topics).

Another significant result of the project is the “Self-Reflection Tool for Teachers” and the “Diagnostic Tool for CPD Providers” designed to assist school teachers in evaluating their inquiry-based understanding and practice, and to help teacher trainers to assess, during the preliminary stage and in the post professional development course, teachers skills, attitudes and advance in relation to IB teaching and learning. The tools consist of sets of evaluation and self-evaluation questions designed to support CDP course providers and end-users in their estimations and planning. The set of tools targets either pre-school or primary/ middle school practitioners.

During the project more than 450 Romanian school teachers and over 2850 school students were engaged in “Fibonacci” related activities.

2. Analysis

The impact of the Fibonacci project on CSET educational programs will be analyzed in relation to Figure 1 in Annex 2, where the complex interaction between the Fibonacci partners and the CSET team is illustrated synthetically.

Considering the complexity of the project structure and the number of partners involved there are numerous aspects which impinged on the way activities were run by CSET after the completion of the project. To simplify the review we are performing, the analysis will be carried out over five main directions, with an emphasis on major implications:

- management;
- tools;
- resources;
- professional development;
- the “Greenwave” subproject.

2.1 Management issues

On the management site three directions brought a significant contribution to our future activities: (i) the accommodation with the way the financial management and reporting was imposed through the project; (ii) the conceptual design of educational activities we are planning based on a better understanding of inquiry-based science and mathematics education (IBSME) concepts; (iii) the exercise of team work in preparing the transversal topics booklets.

The project offered to us the possibility to learn about the management and reporting in the case of an ample European project, to reinforce the way we use FP7 forms and to adapt ourselves to other countries practice. On the other side, various forms of evaluation of projects outcomes done by the consulting company (surveys concerning teachers feedback, questionnaires addressed to participants, on site visits to observe the modality we implement the project in Romania) proved to be of real help in focusing our efforts on projects goals and timeline.

The participation to the "Fibonacci" project clarified to us some of the updated concepts on IBSME and accommodated us with various interpretations and practice across Europe [2]. We acquired new knowledge in relation to classroom practice in more advanced countries such as France, UK, Austria, Denmark, Sweden in the field of inquiry applied to science teaching and we had the opportunity to study practical aspects on IBE in mathematics, subject which was not so closed to our work. The materials and demonstrations on this issue offered by the German team proved to be extremely valuable.

In relation to the development of the booklet addressing transversal IBSME subjects we participated to the preparation of the "Cross disciplinary approaches" brochure, along with teams from Netherlands, UK, Ireland, France and Estonia [3]. It was a big challenge and a great opportunity for the Romanian team from several points of view: (i) the subject required a multidisciplinary approach; (ii) the partners involved were redoubtable experts in this filed; (iii) we have to adhere to curriculum development practices of other cultures and educational contexts. The production of this material offered countless opportunities for debates and exchange of opinions, in order to devise teaching materials which can be used in different countries, under different circumstances. In the mean time, the various backgrounds of the co-authors and their different perspective on the treated subjects gave way to very original results. I our opinion, the booklet can be considered as a model for employing inquiry across curriculum, by the way it integrates different subjects (measuring science, mathematics, geography, history, literacy, paleontology, the use of ICT) to offer a holistic approach in science teaching and learning.

2.2 Fibonacci tools

In order to assist the participants in handling the project and to have an almost "real-time" picture of its development, an extensive teachers' survey was conducted by the consulting company. Data collected through this survey was used by the evaluators to assemble a vision on the project participants, their background and their vision on inquiry and, in the mean time, facilitated national project coordinators to assess project impact on participants. Based on these surveys results we were able to better estimate our partner schools needs and involvement in the project.

Four additional diagnostic tools were setup by the project experts, two dedicated to pre-school and primary/ middle school teachers and two planned to be used by providers of professional development courses [4]. These tools are collections of questions aiming to facilitate teachers' trainers or teachers to evaluate the end-users understanding and practice of inquiry, according to the Fibonacci declared and accepted principles mentioned above.

The booklet includes instructions for professional development providers on the use of the tools:

- how to organize an interview with the evaluated teacher;
- how to plan and run a classroom visit;
- how to observe teacher-pupils interactions;
- how to monitor pupils activities and results during the lesson;
- how to collect and interpret acquired data.

The complementary material for teachers' self assessment addresses issues such as:

- criteria for inquiry practice evaluation;
- how evidences have to be gathered on: teacher's role; pupils activities; pupils records;
- suggestions on reflection, analysis and post assessment action.

As the tools have different beneficiaries (kindergarten educators or primary/ middle school teachers) full instructions are given on the way they have to be employed in various school contexts. The questions are grouped in several categories targeting specific inquiry related concepts:

- “building on pupils' ideas;
- supporting pupils' own investigations;
- guiding analysis and conclusions;
- carrying out investigations;
- working with others;
- records pupils make of their work;
- puplis' written records;
- guiding children to share ideas.”

The document provides also some examples on the way these tools were applied in partner countries, as examples of best practice.

At this point we have to underline the originality of this approach and its very practical focus. In our opinion these tools are extremely useful instruments very well structured. Probably they might become at some point a standard for inquiry practice investigation.

We used these tools in the frame of the national project we are running “Inquiry-Based Education in Science and Technology - i-BEST" to organize two teachers’ survey, one for kindergarten educators and one for primary school teachers. For these activities we translated the Fibonacci tools questionnaires and distributed them to partner school teaches. Based on the answers gathered from kindergarten teacher we already prepared a journal paper, due for publication in the journal of the Romanian Physical Society [5]. Another paper is planned for the near future, supported by the survey outcomes we have. According to our knowledge, it is the first time the Fibonacci tools are used on a large scale investigation in a European country.

2.3 Fibonacci resources

As mentioned above, the project partners developed a lot of exemplary teaching resources available from the project web site. Our interaction with "Fibonacci" project participants implied the translation of some learning units prepared by colleagues from Slovakia, Slovenia, Austria, and France. These translations were either distributed to some schools collaborating with CSET, for being tested, or were posted in the virtual library (http://81.181.130.13/teachscience/) of our Center. Periodically we advertise the new documents which can be accessed on the web site for downloading.

Another aspect concerning our cooperation regarding the available resources refers to the advice we received from some partners in developing our own training kits. In some situations, we bought sets of training aids developed in other countries to act as models for Romanian school teachers.

Of great help proved to be the books on the practice related to inquiry in mathematics education we received from Bulgarian experts.

In some instances we run demo sessions on IBSE by using videos distributed by the French Foundation "La main à la pâte".

2.4 Teachers' professional development

One main line of action of the "Fibonacci" project was the setup of strategies for teachers' professional development. Within this context the major direction of work we benefited are related to field visits, demo sessions and courses, debated on modern means to encourage the use of IBSME in European school. The Romanian participants attended several field visits which made possible exchange of ideas, discussions with teachers' trainers and participation to practical lessons. Besides that these field visits offered the opportunity to visit training facilities, school units and resource centres. All these complex activities provided valuable first hand information on the educational systems in different countries, their science and mathematics curricula, their assessment systems. We learn a lot from these events as far as we had the opportunity to understand various educational approaches, to see the organizational schemes and to catch the educational message of different cultures. On the students achievement assessment we learned about the way formative assessment is done in countries such as Germany, France, Sweden, or UK. It was an important contribution of the project to our own professional development as teacher's trainers, as far as formative assessment is not so wide spread in Romania.

Whenever it was possible, these field visits were used as a mean for young researchers training or Romanian teachers' professional development. In the last years, when we organized the International Conference "Science Education in Schools", we invited colleagues from "Fibonacci" project to deliver workshops to Romanian teachers. For example in 2012-2013 more than 250 Romanian teachers attended such short course.

On the other side, when partners from "Fibonacci" project visited Romania we delivered demo courses from them in different towns. In this way they had the possibility to understand what is happening in Romania on inquiry-based learning and the opportunities we have to push further what we have learned from the project. Based on the exchanges we had, we prepared together a short book dedicated to examples of good practice in IBSE, book published in the Netherlands. At the same time, our colleagues participated to some classes delivered by Romanian school teachers at pre-school and primary school level.

2.5 The Greenwave subproject

One of the greatest successes of the "Fibonacci" project in Romania was the "Greenwave" subproject. "Greenwave" invited school students over Europe to carry out observation on plants and small animals during the spring time and to report their findings on a central platform. In this way, the information gathered each year between February and May provides an inside view on spring advancement on the continent from South to North and from East to West. Romanian school children of all ages were very captivated by this program and their number was among the greatest at European level. The projects run over three school years and by the end of the "Fibonacci" project most of the participants (students and teachers) were very disappointed as their participation was interrupted.

Considering the enthusiasm of our participants we decided to continue this type of collective project and developed in the frame of the national project "Inquiry-Based Education in Science and Technology - i-BEST" the collaborative platform we mentioned before. The national platform was extended by including a multitude of activities: "Spring is coming" - the observation of the growth of plants during spring time; (ii) "Weather and its parameters" – measurements of rainfall, air temperature and wind speed for the characterization of weather during a period of two months; (iii) “Water quality” - the evaluation of the quality of rivers, lakes and household water; (iv) “Sounds” - the estimation of noise pollution and acoustic insulation; (v) “UV radiation hazard” - the investigation of the UV radiation to which the population is exposed.. Each school year more than 150 schools spread across Romania enrolled in these investigations. The platform offers a synthetic view on the participants’ territorial distribution (Figure 2), and enable the access of all interested parties to results of school projects, as these results are expressed either as posters (Figure 3) or worksheets (Figure 4) or in graphical form (Figure 5), embedding the outcomes of the measurements performed by each participating school.

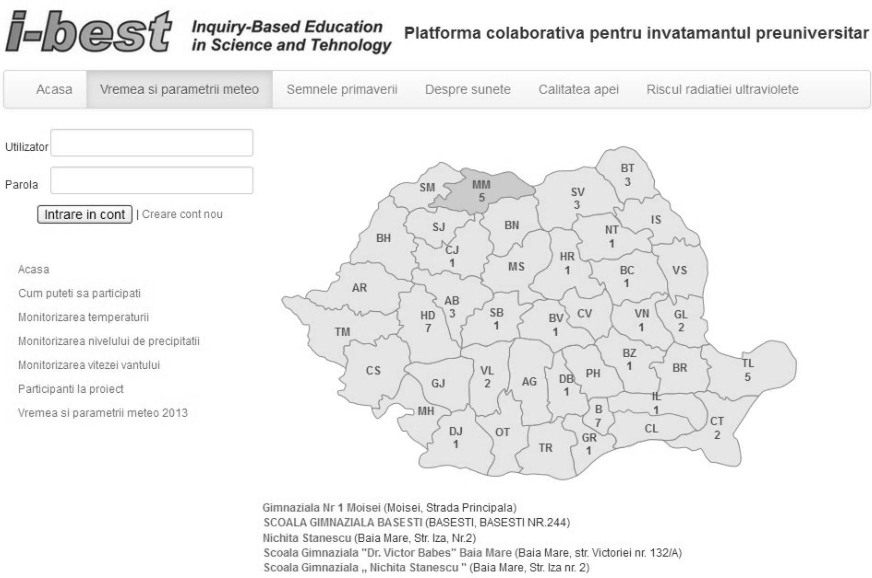
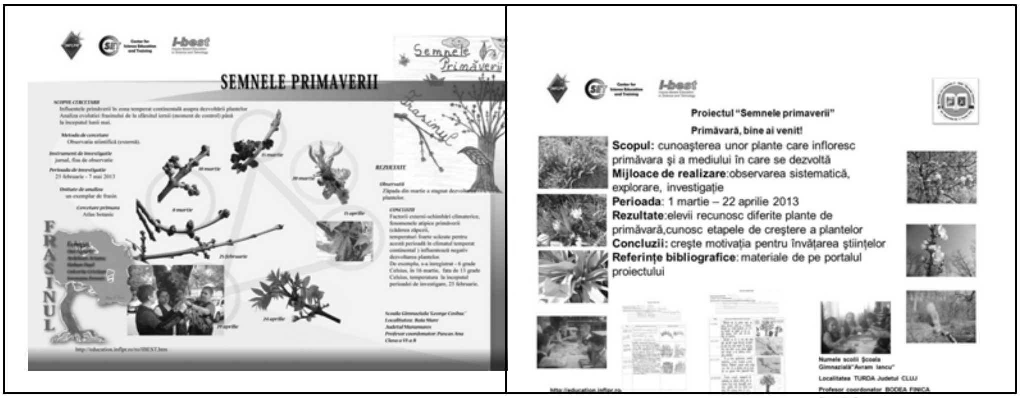


Figure 2. The territorial distribution of schools participating to the project “Signs of Spring” in 2014.

Another major advantage of the collaborative platform we designed consists in the technical information we obtain in relation to the operating systems employed or to the browsers used, information which make possible the optimisation to the platform design for multiple users working simultaneously on the same topic.



a b

Figure 3. Posters made by the 6th grade students at the “George Cosbuc” School, Baia Mare (a) and by the 2nd grade students at “Avram Iancu” School, Turda (b).

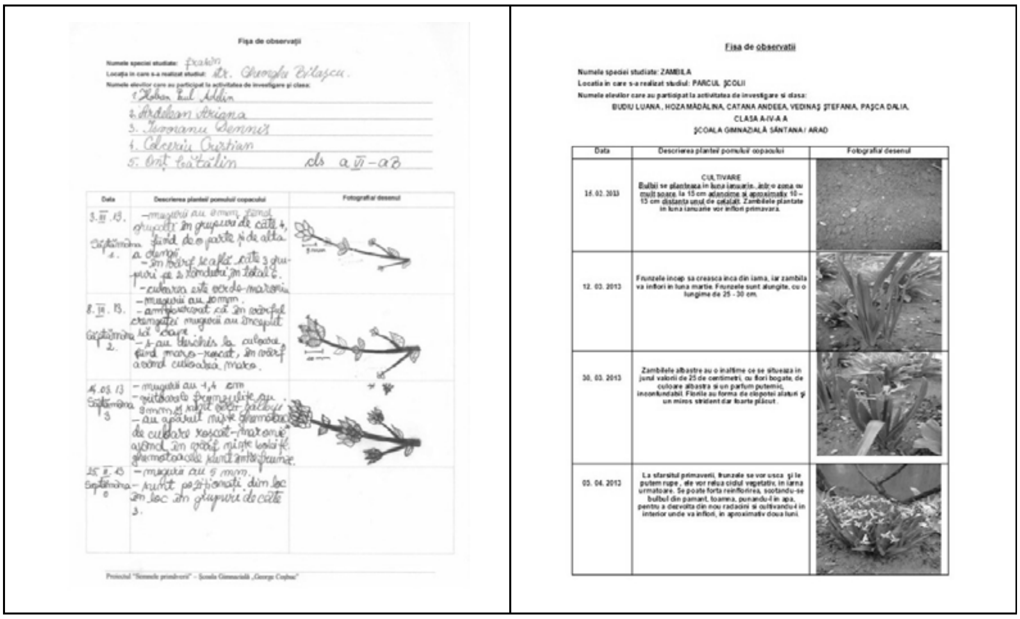
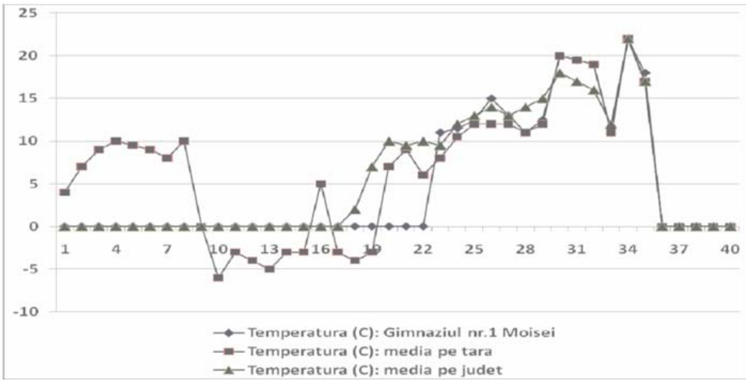
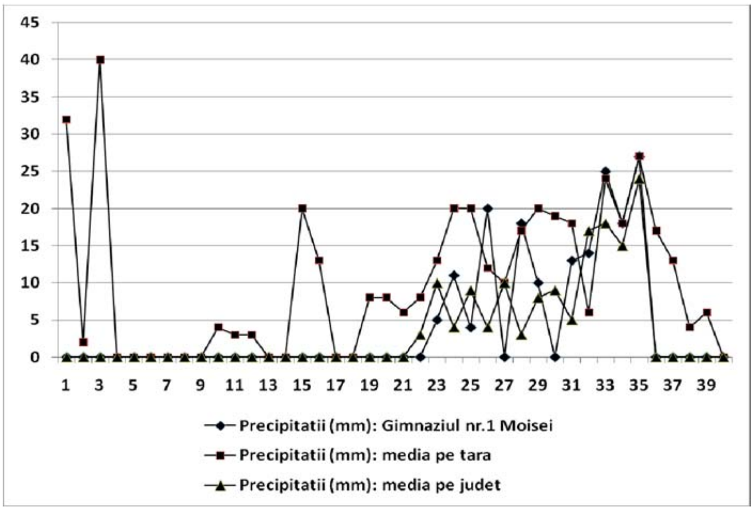


Figure 4. Worksheets completed by students showing the activities advancement.



a)



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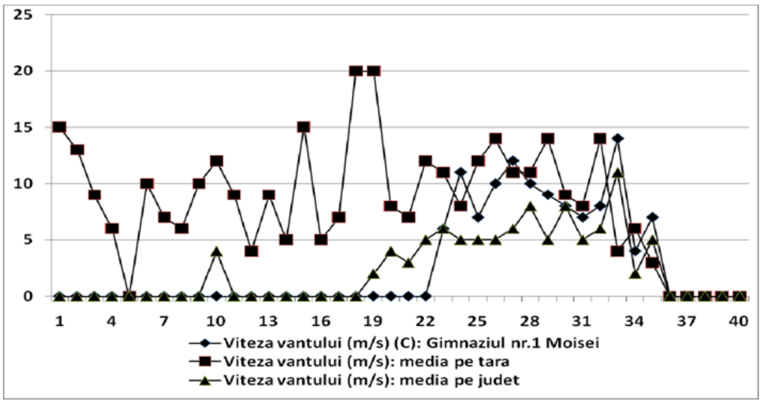

c)

Figure 4. Examples of the mean temperature (a), rain fall (b), and wind speed (c), accessed from the project data base.

2.6 Limiting issues

Our participation to the "Fibonacci" project showed several limitations we have to consider in relation to the use of IBSE in Romanian schools as promoted by the EU project:

- Most of the Romanian science and mathematics teachers have difficulties in communicating in foreign languages. For these reasons, it is quite difficult for them to pay visits abroad or attend courses in a foreign language. Partially, we solve the issue by organizing demo sessions and courses in Romania and providing appropriate translation.
- On the same line, we had to translate learning units or modules from French or English, in order to increase the accessibility to these resources.
- The Romanian educational system is much centralised and an burocratic one so, teachers have little choice to tests and implement new pedagogical methods.
- The IBSE approach is little known in Romania, and it is not officially supported / recognized by authorities, and for this reason school teachers are little experienced on it.
- There is no expertise in training Romanian teachers on IBSE. We promoted for the first time this methods through two courses we had in the frame of the national "Discover!" project, courses accredited by the Romanian ministry of Education.
- Romanian teachers are missing the resources and technical means to run IBSE like activities.
- The Romanian educational system is based mostly on reproduction of memorized facts instead of asking students to use their knowledge to run their own investigations.
- The Romanian curriculum does not address IBSE, and, according to some studies we done, official documents barely address issues as innovation, investigation, creativity.
- The school curriculum asks too many information to be passed on, so that time constrains limits teachers options in the classroom.

- There are too many school children in a class, while no school assistant is available to support the teacher during science classes.
- One of the major drawbacks of the Romanian educational system resides in the widespread of summative assessment in detriment of the formative assessment. There is no formal assessment practice as a common ground for students' evaluation.
- The Romanian educational system lacks the ability to teach students to learn by themselves (no learning to learn approach exists).
- In spite of the fact that computing facilities exist in Romanian schools, ICT technology is used almost exclusively for virtual classes, data loggers and sensors are exceptions in Romanian school. For this reason, school students are more accustomed with the virtual world of experiments; they miss the contact with concrete reality surrounding them, and have poorly developed technical skills.
- The Romanian educational system does not train students to formulate questions by their own, and does not allow a dialog initiated by the learner.
- Only quite recently team work is encouraged in running experiments/ investigations.
- The Romanian school student is not accustomed with the idea of failure, seen as a reasonable research phase in understanding his environment.
- School students are not trained to present results based on evidences, to argue with peers and to debate the outcomes. Critical thinking is not encouraged.

2.7 Impact of previous experience on the INSTEM project

By analyzing our involvement in the "Fibonacci" project and the results we obtained, we can say that our participation to the INSTEM project can be regarded as another opportunity to interact with experts in the field at European level, to clarify some issues related to IBSE practice as perceived nowadays at European level, to discuss with our colleagues the challenges we faced and to look for more appropriate answers to our problems listed above.

We are confident that the lessons we learned from the "Fibonacci" project will be useful to formulate a new dimension to inquiry-based pedagogy, as far as our limitations, failure and difficulties are part of the unified Europe we intend to build.

Besides that, constrains of the Romanian educational system have to be transcended as part of a common legacy we are facing.

Nevertheless, the above analysis proves that close interactions between people having the same goals and ideals, exchange of best practice at first-hand, sharing of ideas and resources, common efforts in designing new learning units or training aids are the most effective means to shape a common market of knowledge, supported by creativity and innovation. As it happens nowadays with jobs such medical doctors, financing people, researchers, has to happen with teachers, they have to be trained to be able to access the single workforce market, which is not the case today.

From our experience we can recommend as models for further pursuit at European level:

- the use of “Fibonacci” tools for self-assessment of teachers and for CPD providers;
- exchange of field visits;
- organization of courses and workshops for school teachers delivered by foreign lecturers;
- translation of resources;
- the use of collaborative platforms by teachers from different countries to run common projects;
- design by international teams of experts of model IBSE learning units with a cross-disciplinary character;
- establish of virtual teams of children from different countries to investigate the some subject of interest for their communities.

3. Conclusions

To conclude we can say now that the participation to the “Fibonacci” project:

- enlarged our horizon on IBSME;
- diversified our access to resources;
- provided new opportunities to improve our courses for teachers

- assisted us implementing a national community of practice on IBSE;
- provided a better visibility for our efforts and results at national level;
- brought some innovative methods of science teaching in Romania;
- offered us a high status at national level in the field of science education at pre- university level;
- multiplied our external contacts and partners;
- assisted us in rising the interest of science teachers community on our work.

Acknowledgements

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