American Journal of Educational Research, 2015, Vol. 3, No. 8, 968-976
Available online at http://pubs.sciepub.com/education/3/8/4

DOI:10.12691/education-3-8-4

Student and Teacher Perceptions of Inquiry Based Science Education in Secondary Education in Greece

Kallia Katsampoxaki-Hodgetts*, Maria Fouskaki, Katy Siakavara, Roumpini Moschochoritou, Nikos Chaniotakis

Department of Chemistry, University of Crete, Vasilika Voutes, Iraklion, Greece
*Corresponding author: kalliahodgetts@gmail.com

Received May 18, 2015; Revised July 03, 2015; Accepted July 06, 2015

Abstract National Science education reform initiatives stress the need for steering away from the traditional teacher-centered mode of instruction. This study is part of a three-year project 'Chain Reaction', funded by the European Commission, investigating the approaches of a sustainable Inquiry Based Science Education (IBSE) framework across twelve partner countries. The purpose of this paper is to provide information on how this innovative project was integrated in five Greek Secondary Schools, and to explore the perceptions of all stakeholders: management, teacher educators, teachers and students. Five schools, ten teachers, and one hundred and fifty students aged 14-16 took part in this study. Quantitative and qualitative methods were employed to identify all stakeholders' views. Based on this analysis, it is suggested that as long as this project is tailored to each partner's individual cultural and curricular needs, all stakeholders had a positive experience, which constitutes IBSE as an optimal learning mode with positive contribution to the educational process.

Keywords: *educational reform, evaluation, inquiry based science education, IBSE, science education*

Cite This Article: Kallia Katsampoxaki-Hodgetts, Maria Fouskaki, Katy Siakavara, Roumpini Moschochoritou, and Nikos Chaniotakis, "Student and Teacher Perceptions of Inquiry Based Science Education in Secondary Education in Greece." *American Journal of Educational Research*, vol. 3, no. 8 (2015): 968-976. doi: 10.12691/education-3-8-4.

1. Introduction

National Science Education reform initiatives [1,2] have stressed the need of a sustainable framework of Inquiry Based Science Education (IBSE) in both primary and secondary education. There is extensive literature on teachers and students' perceptions based on surveys providing positive feedback regarding IBSE [3,4] which justifies an emerging trend urging teachers and teacher educators to incorporate IBSE approaches and curricula in order to converge from the traditional teacher-centered and highly structured mode to a more meaningful, informal, flexible, peer-reviewed, collaborative, student-driven inquiry. IBSE approaches are often coupled with curricula that allow students to explore authentic scientific phenomena, generate research questions, conduct investigations, generate their own conclusions, and communicate their findings with peers, in compliance with reform initiatives [1,2]. However, despite all the reform initiatives and the limited empirical data documenting the reality of teachers enacting IBSE [4] in the classroom, so far, the majority of teachers have been found to hold uninformed or naïve conceptions of the nature of science (NoS) and what constitutes scientific inquiry and its process [4,5].

In this work, we collect and analyse quantitative and qualitative data with the aim of providing information on how "tested and tried" IBSE curricula were integrated in five Greek Secondary Schools, and to explore the perceptions (and conceptions) of all stakeholders: management, teacher educators, teachers and students regarding the nature of science, scientific inquiry and pedagogical approaches.

2. Theoretical Framework

Over the last few decades, teacher educators and education authorities have called for the systematic development of science curricula that encourage active student involvement in student centered approaches and real life involvement in science [4,6,7,8,9,10]. Existing curricula seem to be in need of further revision as known challenges still remain unresolved [11]; students' preference to science is decreasing, boys outnumber girls in science projects and rural students experience discouraging low achievement and attitude setbacks [12].

By definition, scientific inquiry is the intentional process of posing questions for science, diagnosing problems, critiquing experiments, developing and using models and distinguishing alternatives, planning and carrying out investigations, searching for information, analyzing and interpreting data, debating with peers, engaging in argument from evidence, evaluating and communicating information. [2,13,14]. Yet, inquiry based science education (IBSE) is not just focusing on content or process only [4,15]. It has now shifted its attention towards inductive or bottom-up pedagogies that comply with socio-constructivism educational approaches [11] collective scaffolding and co-construction of knowledge [16] in order to facilitate student content knowledge and increase student motivation. With inquiry-based curricula students can acquire experiences and construct knowledge in a range of intellectual and social interactions that foster critical thinking, reflection, self-criticism, team-work, autonomous thinking and information literacy [8,17].

Teachers' content knowledge (CK) and pedagogical content knowledge (PCK) often serve as vehicles that drive guided or open approaches to IBSE forward [10] but they are not sufficient. A strong indicator of teacher enactment is teacher beliefs of science research and his or her understanding of the nature of science (NoS) and scientific inquiry. Yet, despite teacher robust understanding of NoS, when faced with the challenge of having to take up multiple roles during IBSE enactment [18] time pressures and demanding curricula, teachers often resort to more guided inquiry practices [19] or ask for more guidelines or scaffolding themselves. Capps and Crawford (2012) posit that if we expect teachers to use new instructional approaches, we need to provide them with well-designed curricula and training as well as ongoing opportunities to learn and teach in this way.

The use of Information technology is a key component of IBSE. Maor and Fraser [20] study how the use of technology enabled students to develop higher-level thinking skills such as analyzing relationships and discovering commonalities or differences. The implementation of inquiry approaches in schools is expected to support the development of students' skills, experiences and ideas simulating what scientists do during research work. When students engage in inquiry, they become more capable in formulating hypotheses and ask broader and more complex investigative questions [20] which are communicated among them in a non-threatening collaborative environment.

The purpose of this paper is to report, compare and contrast the views of different stakeholders involved in the project with regards to aims, interest, usability, the nature and stages of science and scientific inquiry, the profile of a scientist. All stakeholders were asked to indicate their degree of agreement with a variety of statements regarding a wide range of scientific inquiry stages and processes conducted in the classroom or in the laboratory.

3. Context of the Study

Participants in this study included secondary education students (n=150), aged 14-16, in five schools and their respective science teachers, teacher educators and the management of the European Project "Chain Reaction: *A Sustainable Approach to Inquiry Based Science Education*" at the University of Crete. The study was supervised by the Department of Chemistry, University of Crete, in Greece and commenced its implementation in June 2013. Main objectives included:

-provision of interactive and engaging IBSE professional development to teacher education professionals using tried and tested inquiry based science resources (EUPRBs) by SHU since 1997.

-adaptation and dissemination of a set of themed inquiry based science resources (EUPRBs) which have been adapted to meet each partner's cultural and curricular needs, to be used for briefing teachers and in the classroom

-promotion of the use of IBSE in secondary schools across the 12 partners via a programme of teacher development in order to engage young people in science through student-led inquiry based research

-bridging the existing gap between science teachers and the science education community.

After obtaining University of Crete and local secondary education board permission, participants signed consent forms agreeing to participate in this and other IBSE-related research. The actual EUPRB projects in schools were enacted in October 2013 and were completed in March 2013.

The sample comprised of 150 students, 66 boys and 84 girls, ten teachers, two teacher educators, and two project managers and it represented 99% of the participants involved in this project. Teachers were given a one-day formative training which included lectures on the project's objectives, the nature of IBSE, approaches and challenges, the nature of science, and the available curricula. They were also involved in a hands-on workshop in which they had to devise a plan of action regarding an IBSE topic. The schools involved in the study were divided into two mainstream state urban (Ur 1 and Ur 2) and two rural ones (Ru 1 and Ru 2) with the fifth one being urban but unlike all others its students were selected based on very demanding written exams. This school was also ranked top in the last evaluation. For the purposes of the study this school will be called the model urban school (M.Ur). The reason for this classification was that rural school students are often not as privileged as urban ones.

Teacher selection was not definitive but random due to the limited amount of applicant schools so no selection criteria were applied, other than having two science teachers in each participating school. Teacher educators were both PhD holders involved extensively in research projects with a contemporary view of scientific inquiry along with extensive up-to-date teaching experience in local secondary schools. Teacher educators' main role was to facilitate the process and clarify teachers' questions regarding implementation.

The technical board of the University of Crete translated and adapted curricula (EUPRBs) on four distinct topics, most of which integrated and required knowledge from disciplines such as Chemistry, Physics, Biology, Earth Sciences and Geology. EUPRBs' topics included:

1. "Plants in Space" investigating the factors which are important in making a life sustaining unit for use on long space flights

2. "Out of site out of Mind", investigating the lining material for a landfill site

3. "Feed the World", investigating fertilizers and producing educational leaflets for use in developing countries

4. "Green light", on the use of a low energy compact fluorescent light bulb.

Context was achieved through real world settings and challenges that called upon students' active involvement in order to be resolved. The project management and teacher educators held the view that the principles of social constructivism were compatible with the chosen curricula, which could serve as a scaffold for student learning.

3.3. Data Collection and Analysis

The study was based on quantitative data derived from questionnaires, and qualitative data derived from transcribed semi-structured interviews. The student questionnaires were designed taking into account project management and teachers' suggested questions to be answered by students. Among other issues, they aim to draw on perspectives regarding the nature of science, student challenges during the inquiry process, team-work, and teacher evaluation. The same questionnaires were then revised and adapted to bring to light teacher beliefs and challenges on the nature of science and inquiry, inquiry teaching, and teacher-student and teacher-teacher educator collaboration. Teachers, teacher educators and management also answered a questionnaire designed by the coordinator of the project, which was also taken into account. Eventually, Teacher educators and management Interviews took place given the questionnaire results in attempt to shed light on ambiguous results and explain possible reasons for setbacks and suggest alternative courses of action.

Teacher questionnaires were answered by email directly to the administrator, whereas student questionnaires were presented to the students by their Headmasters ensuring anonymity, and upon completion, dispatched by the Headmasters of the Schools to ensure that the teachers involved did not interfere.

Concurrent- mixed methods were used in which quantitative and qualitative data were merged in order to provide a comprehensive analysis of the research question. Both forms of data were collected at the same time and then integrated in the interpretation of the overall results. Also, in this design, the researcher embedded one smaller form of data within another larger data collection in order to analyze different types of questions.

4. Results

The following table summarises nine teacher responses in nine questions (Table 1) and the graphs (Figure 1- Figure 16) summarise the mean percentile of the corresponding responses by boys and girls, and schools, respectively. In an attempt to highlight different parameters reported in the literature [1,2,8,21] that affect the project's success, student gender differences, student urban and rural schools, and teachers' relevant experience were examined. Two inexperienced teachers worked in the same urban school (Ur 1) and the third one in the model urban school (Mur) (Figure 1). So, for the purposes of this study, school Ur 1 can be an indicator for science teachers without experience on research projects.

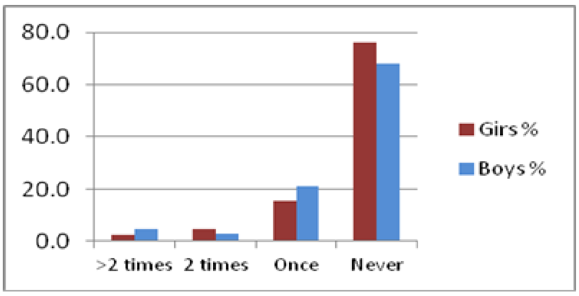

Figure 1a. Responses on how many times before students had taken part in a similar project

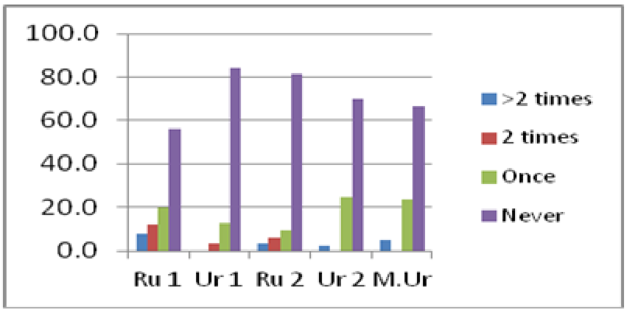

Figure 1b. Responses on how many times before students had taken part in a similar project

Table 1. Mean percentile of teacher responses in nine questions

1. Previous teacher experience in a similar project			
>2 times	*2 times*	*Once Before*	*Never before*
44.4%	22.2%	0.0%	33.3%
2. Did your students take up the role of a scientist/researcher successfully?			
Yes	*To some extent*	*No*	*I do not know*
22.2%	77.8%	0.0%	0.0%
3. Were EUPRBs easy to understand?			
Yes	*To some extent*	*No*	*I do not know*
66.7	33.3	0.0	0.0
4. Were EUPRB tasks interesting?			
Yes	*To some extent*	*No*	*I do not know*
100.0%	0.0%	0.0%	0.0%
5. How do you evaluate this project?			
Effective	*Not Effective*	*Not different from other lessons*	*Other*
77.8%	0.0%	0.0%	22.2%
6. Which diagram reflects better your students' research path?			
Arrow	*Inverted Pyramid*	*Steps*	*Circle*
0.0%	0.0%	33.3%	11.1%
7. Will you use group work /team work in the next project?			
Yes	*Perhaps*	*No*	
100.0%	0.0%	0.0%	
8. Did you follow the EUPRB suggested route to the letter?			
Yes	*To some extent*	*No*	
22.2%	77.8%	0.0%	
9. If you could, would you participate in this project again?			
Yes	*To some extent*	*No*	
77.8%	22.2%	0.0%	

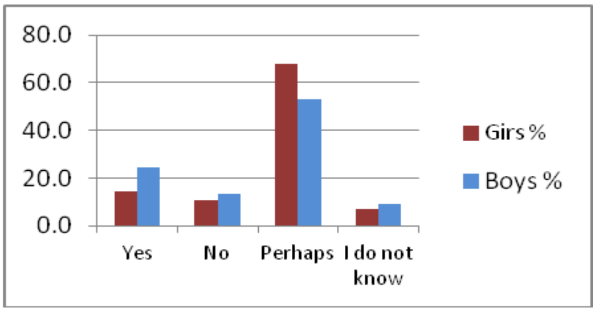

Figure 2a. Responses on whether students could identify themselves as a scientist/researcher

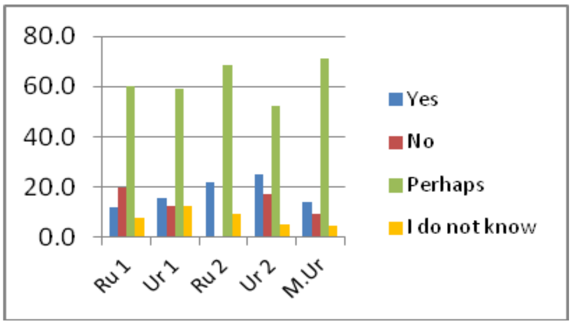

Figure 2b. Responses on whether students could identify themselves as a scientist/researcher

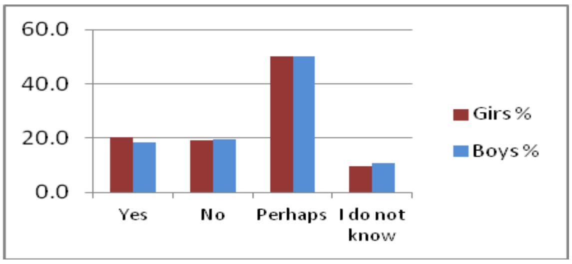

Figure 3a. Responses on whether students would pursue the career of a scientist

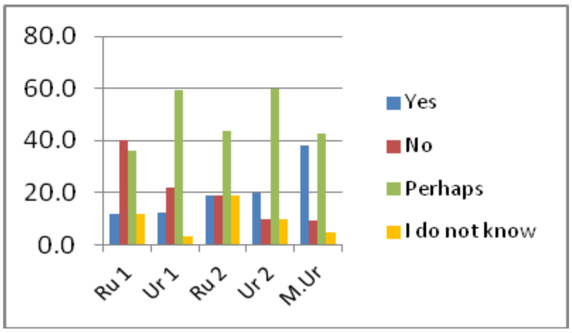

Figure 3b. Responses on whether students would pursue the career of a scientist

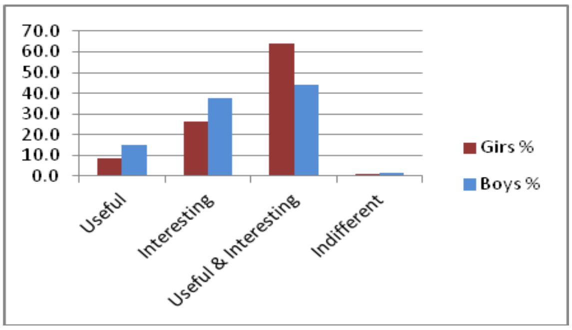

Figure 4a. Responses on student opinion of Physical sciences

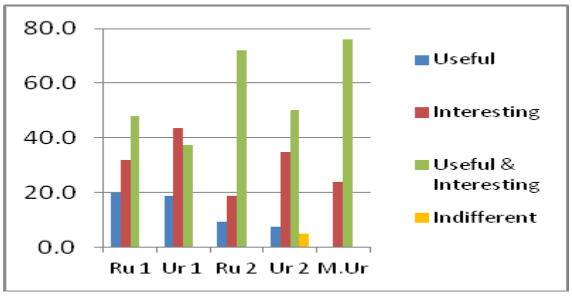

Figure 4b. Responses on student opinion of Physical sciences

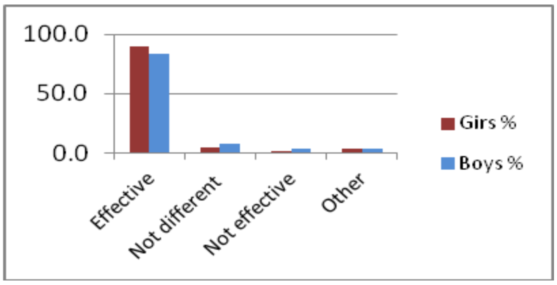

Figure 5a. Responses on how students evaluate the project

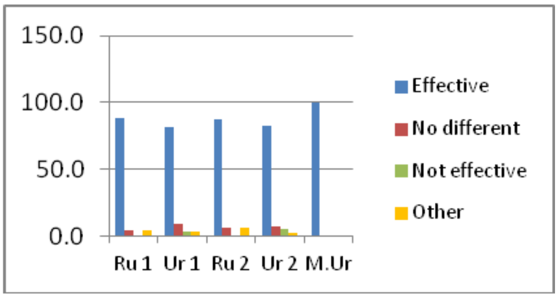

Figure 5b. Responses on how students evaluate the project

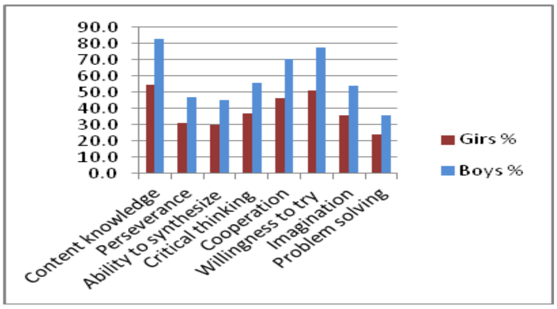

Figure 6a. Responses on three scientist traits

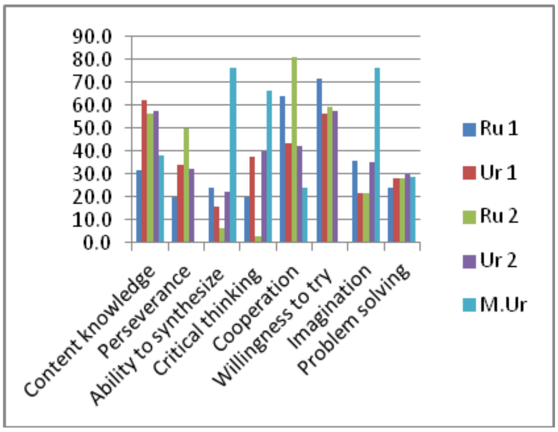

Figure 6b. Responses on three scientist traits

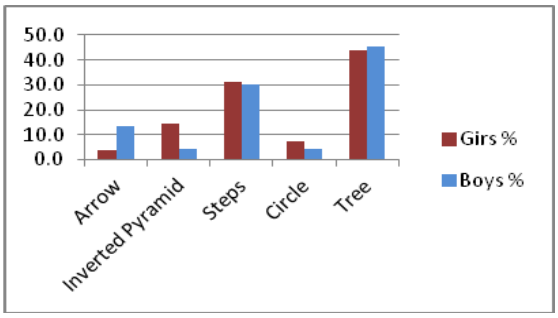

Figure 7a. Responses on a shape that reflect their research path

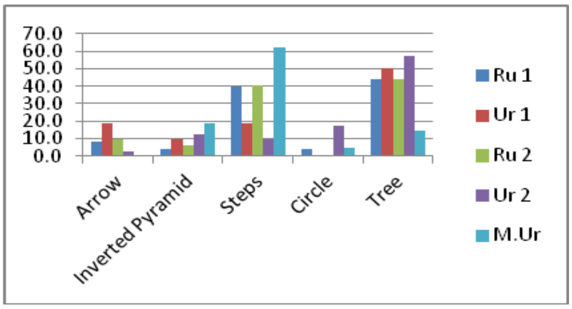

Figure 7b. Responses on a shape that reflect their research path

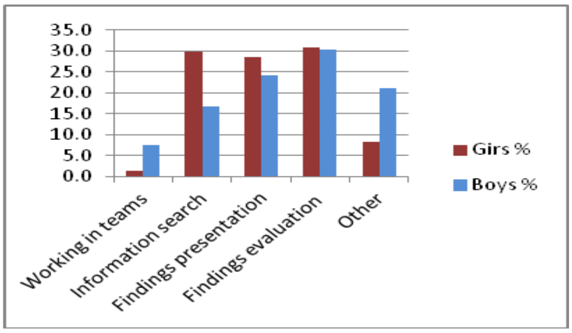

Figure 8a. Responses on what students liked the least in the project

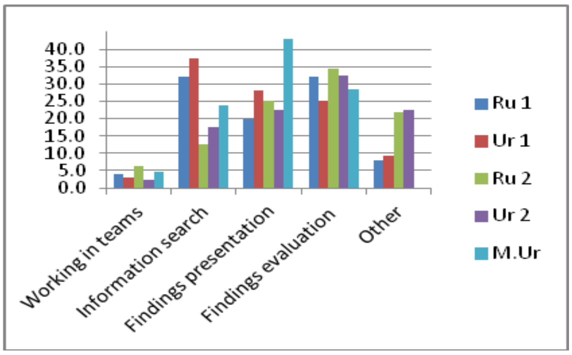

Figure 8b. Responses on what students liked the least in the project

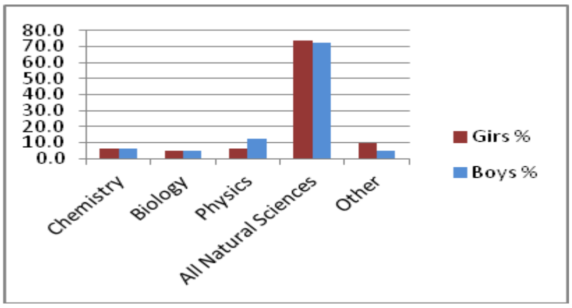

Figure 9a. Responses on which discipline-related knowledge was improved most

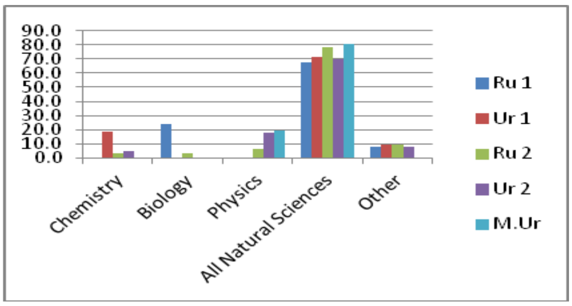

Figure 9b. Responses on which discipline-related knowledge was improved most

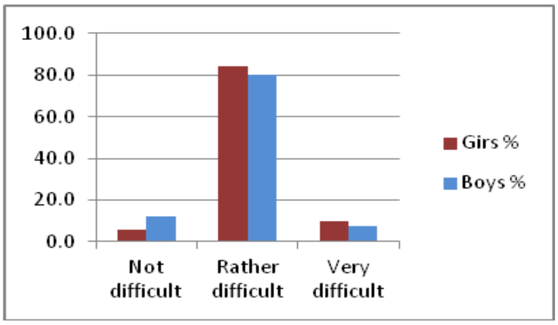

Figure 10a. Responses on posing specific and focused research questions

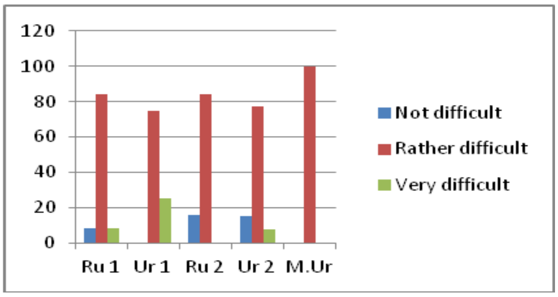

Figure 10b. Responses on posing specific and focused research questions

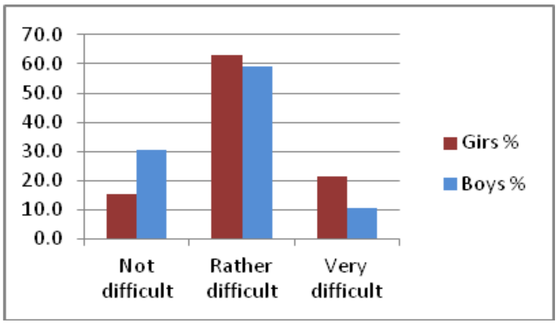

Figure 11a. Responses on the degree of difficulty in researching something previously unknown

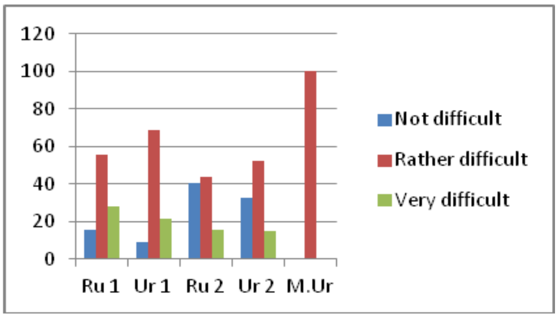

Figure 11b. Responses on the degree of difficulty in researching something previously unknown

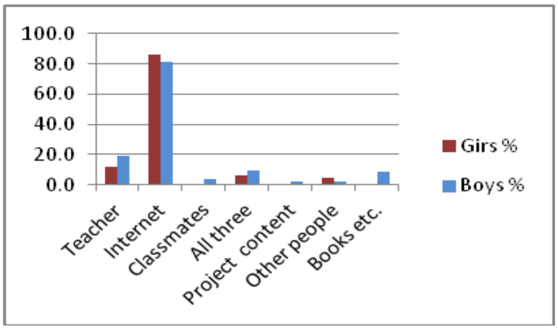

Figure 12a. Responses on what was the main source of information

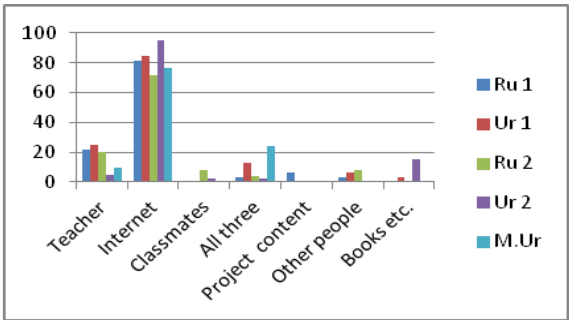

Figure 12b. Responses on what was the main source of information

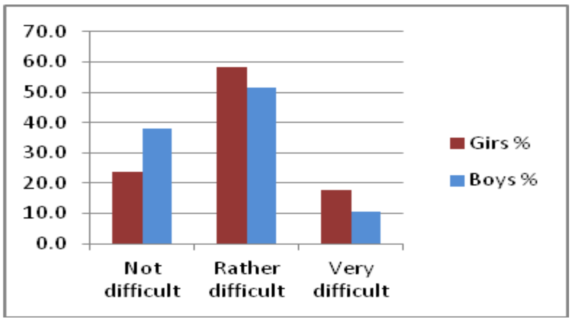

Figure 13a. Responses on the degree of difficulty when designing an experiment

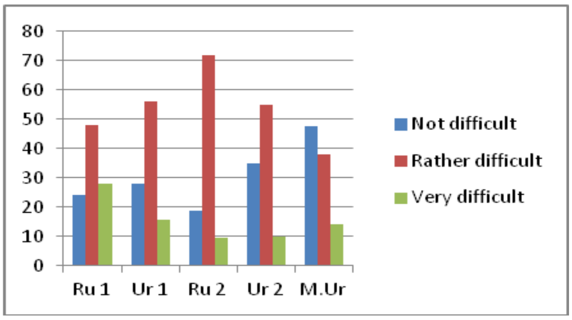

Figure 13b. Responses on the degree of difficulty when designing an experiment

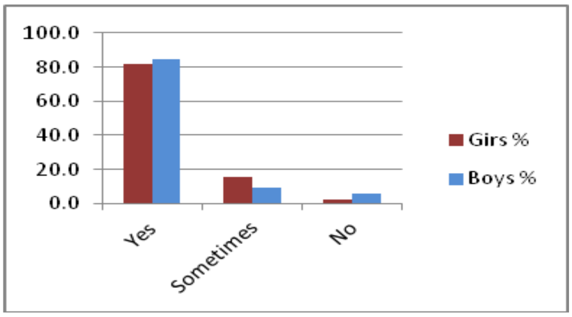

Figure 14a. Responses on whether students enjoyed working in a team

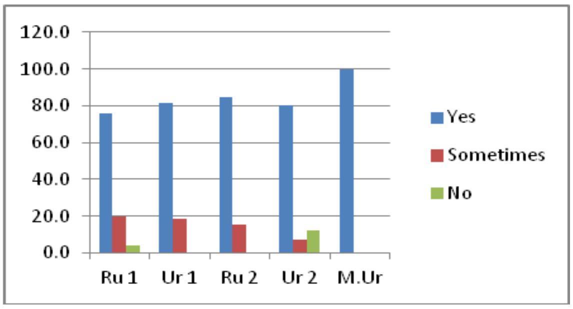

Figure 14b. Responses on whether students enjoyed working in a team

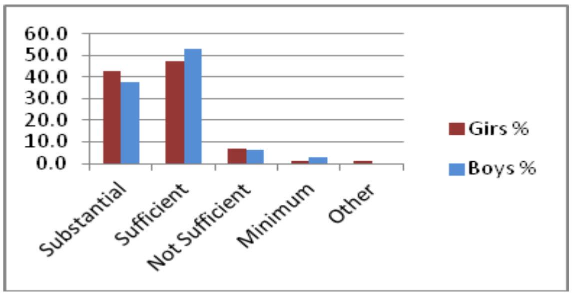

Figure 15a. Responses on students own contribution in the research activities of their team

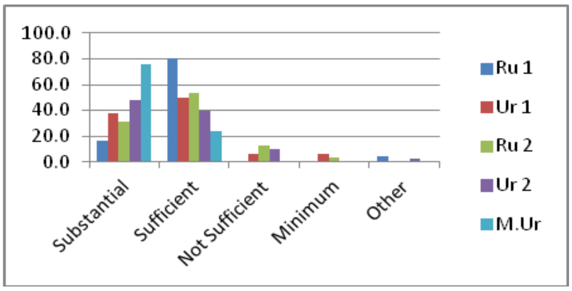

Figure 15b. Responses on students own contribution in the research activities of their team

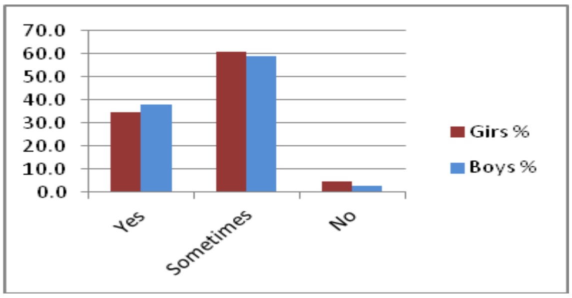

Figure 16a. Responses on whether their ideas or suggestions were used in class

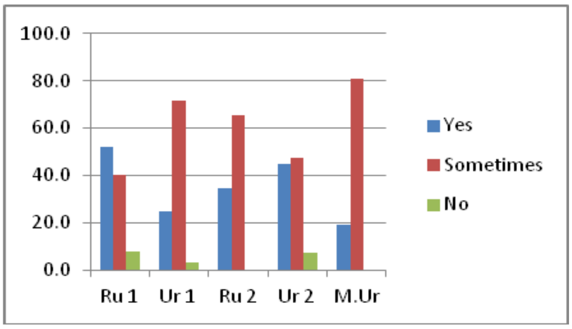

Figure 16b. Responses on whether their ideas or suggestions were used in class

5. Discussion

It was discernible from data collected during the interview and the questionnaires that this IBSE project and the materials were deemed effective by 86.7% of the students (Figure 5a) and 77.8% of teachers (Table 1), physical sciences were interesting and useful by 55.3% (Figure 4a) of students. Likewise, student worksheets (EUPRBs) were found interesting by 100% of teachers, teacher educators and management alike. Also, 73.3% of students found that their content knowledge improved within the realm of all physical sciences (physics, chemistry and biology) (Figure 9a). Teachers' comments in the interviews indicated that they were surprised by their students "taking initiatives", "active involvement" and "thinking outside the box".

Regarding relevant student experience and familiarity with such a project, the vast majority of students (72.7%) had never taken part in a research project (Fig. 1a). However, urban school students were found to have be slightly more equipped and have more experience than rural school ones (Figure 1b). It has been reported that rural students experience discouraging low achievement and attitude setbacks [12]; our findings are in agreement with this, but rural school student experience approached that of urban ones in our sample.

When in comes to teacher level, experience and familiarity with this teaching approach, less than half of the teachers involved had limited experience as two thirds had run student projects in class at least once before. We must note here though that they were only involved in guided inquiry activities that did not observe to the IBSE principles. Not, surprisingly, the teachers (22.2%) who claimed to have followed the recommended route of action in the EUPRBs to the letter happened to be the experienced ones. The rest of the teachers claimed to have incorporated the suggested activities to a degree, either by modifying, adding or skipping parts of them.

When students were asked to give a scientist's profile, boys and girls seemed to rank content knowledge first, willingness to try something in order to test it (even if it is wrong) second, ability to cooperate with others third and critical thinking fourth (Figure 6a). Succeeding parameters mentioned (with no marked differences) were imagination, perseverance, ability to synthesize information and ability to solve problems. Comparing schools, it was noticed that students of the model urban school, unlike all others (Figure 6b), opted for imagination (76%), synthesis (76%) and critical thinking (67%). This could be attributed to requirements of the tasks assigned to students which included the design and production of an advertising brochure. This finding did not agree with a survey on undergraduate biology students who ranked persistence (perseverance) first [22].

When students were asked whether they had successfully undertaken the role of a researcher-scientist, girls in both urban and rural areas appeared slightly more hesitant to identify with this role (Figure 2a). When asked though whether they would pursue this career, only students of the model urban school, boys and girls, showed a clear positive predisposition (38.1%) (Figure 2b). This trend agreed with the vast majority of teachers (77.7%) who found their students to have partially executed this role. Interestingly, both teachers of an urban school ranked the students' role as scientists successful.

What was also clear was that the impact of the programme on boys was higher than that of girls, with similar trends being noticed in all schools. However, when students were asked about whether scientific research (in the disciplines of Biology, Chemistry, Geology and Physics) is interesting, useful or indifferent, an interesting trend was discernible; the majority of girls (63.4%) regardless the school found scientific research both interesting and useful (Figure 4a). However, their positive perceptions did not seem to change their future professional aspirations considerably as both boys and girls did not have a consolidated opinion regarding this matter (Figure 3a).

The way students and teachers perceive the nature of science (NoS) appears to be a strong indicator of a programme's success according to literature [4,21]. Thus, teacher beliefs of teaching science as inquiry, being a cluster of his and her knowledge of scientific inquiry and of inquiry-based pedagogy and his or her beliefs of teaching and learning, can be a strong predictor of his or her actual practice of teaching science [4] (p. 638). When students were asked to describe the stages a scientist goes through when conducting scientific research, they seemed to include the majority of stages that could generally describe a research path such as observation, hypothesis, experimentation, and findings, representing "a formulaic linear scientific method" [22] which could imply that students of this age group might lack the metacognitive awareness that undergraduate students possess or that their inquiry lessons were conducted in a prescribed manner. In line with this, only few students mentioned evaluation, trial and error or replication as part of that process, despite having reported them later on in the survey. The last finding agreed with three teachers' comments in the interview concerning the difficulty of students to evaluate their peers.

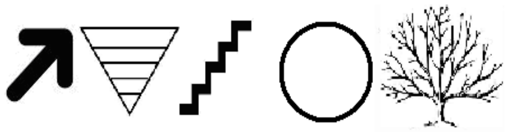

Figure 17. Shapes reflecting a research path

This was also indicated in the question asking students to identify a symbol (Figure 7a) that reflected scientific research; the majority of students (44.7%) and teachers (55%) selected a tree indicating a researcher's path towards specific and idiosyncratic contexts or possibly uncharted paths. We could infer from this that teachers allowed room for creativity and did not encourage a prescribed learning route. According to literature, researchers' perception of their trajectory is often symbolised by a circle [22]. Unfortunately, a mere 6% and 12% of students and teachers, respectively, chose the circle as representative of a researcher's typical route which entails reflecting and revisiting previous observations and hypothesis, experimental methods and analyses of their findings. The same trend was apparent in the next question with 'Evaluation of Findings' being the lowest of students' preferences (6.7%). The second highest trend regarding the symbols that represent a researcher's path was that of steps (30%) with the model urban school ranking a high 61% (Fig 7b), suggesting that teachers that took part in this project may have perceived scientific method comprising of concrete inter-related steps sequenced in a specific order perhaps "allowing little room for creativity" [4] or leaning towards a more guided approach to inquiry.

Another strong indicator of teacher or learner practices regarding inquiry based learning is whether or not the teacher was perceived to be the sole source of information. We assumed that if this was true, it would be incongruent with recent literature on the Nature of Science or scientific inquiry in which investigation and research is a key component, [1-8,22]. Luckily, the main source of information for 83.3% of students was the internet with the lowest rates in a rural school (Figure 12b) which confirms recent literature on students in rural schools being underprivileged [8,12,14]. Teachers also confirmed this rating the internet as the main resource. In the same question, only 2% of information was disseminated by classmates, which could imply either that student discussions between groups did not take place during plenary classroom sessions or that they were not effective.

There is extensive literature on the importance of driving questions in an inquiry project [8] and teachers' difficulty in asking questions that facilitate inquiry without being prescriptive in nature [11,23]. In agreement with this, most students (82.7%), regardless whether boys or girls, found somewhat difficult to ask specific and focused questions before conducting an investigation (Figure 10a). Also, more girls (21.4%) than boys (10.6%) found it more difficult to research a topic previously unknown to them (Figure 11a). In the same vein, girls (17.9%) seemed less at ease when designing or planning an experiment than boys did (10.6%) (Figure 13a). Similar trends were noticed by Wolf and Fraser [23] in which males were keener on devising their own experiment taking experimental process and scope one step further.

When students were asked if their ideas or suggestions were taken into account in the classroom, 60% of them said sometimes and 36% gave positive answers. Student responses from the model urban school were interesting here (Fig. 16 b). Nineteen percent of them only felt their suggestions were taken into account. This could be attributed to poor student-student cooperation or dominating teacher-centered approaches.

Not surprisingly, the majority of students highlighted the positive impact of team-work in agreement with previous surveys [8,17]. Students seemed to enjoy team-work most (83.3%) (Figure 14a) and all teachers involved seemed eager to employ group-work in future lessons (Table 1, question 9). The affective and social benefits of team work were also mentioned by some teachers who noticed that student-student relationships improved and this facilitated their learning. Working in teams, however, did not seem to come without challenges as adjustment to learning through collaboration may prove difficult [8]. When asked what they disliked most during the project, most students raised the issue of time-management and uneven work load in a team, lack of or little cooperation, difficulty in completing a task when in a team due time-consuming meetings. Not surprisingly, the same issues were raised by their teachers. When asked what their contribution was in the research process, 40.7% of students claimed it to be substantial and 50% ranked it as sufficient (Figure 15a). In this question, it was the model urban school students that ranked the highest score of substantial contribution (76.2%) (Figure 15b).

During the interview, teachers were asked to suggest ways of dealing with issues that came up during the project. One of the issues that came up was that of students' prerequisite content knowledge. It was suggested that students should have adequate prior knowledge before commencing the investigations and experiments. Another interesting suggestion by the teachers included the need for more time and further training as they did not feel equipped to cope with the challenges of inquiry-based approaches. This is in line with recent literature which supports that before students understand inquiry to learn science, their science teachers need to be trained until they are adept in inquiry-based methods [4,21,24]. In the same vein, guidelines as to what additional experiments could be employed in each EUPRB were also deemed necessary by some teachers, especially when teacher discipline differed from the ones drawn on the EUPRBs. For example, one teacher asked for instructions as to how she could use a biology microscope. Last but not least, teachers urged for more school visits by scientists and more student visits in a real research setting i.e. university.

Generally, both teacher educators and teachers implied the need for a more detailed plan of action, briefing or training. Despite the challenges, however, when asked whether they would participate in this project again, the vast majority of teachers (77.7%) and teacher educators (100%) responded in a positive way.

6. Conclusion

All in all, the data suggest that as long as this project is tailored to each partner's individual cultural and curricular needs, all stakeholders had a positive experience, despite the setbacks, which constitutes IBSE as an optimal learning mode with positive contribution to the educational process. Our findings show that students enjoyed and benefited by learning science in teams and in a real world context through IBSE. Also, student and teacher perceptions were positive despite the challenges in both rural and urban schools. Teachers and students acquired a better sense of accomplishment regarding their ability to coordinate and pursue science related course of action, respectively, and students' perception of physical sciences improved notably.

Acknowledgements

"The research leading to these results has received funding from the European Community's Seventh Framework Programme fp7/2007-2013 under grant agreement No [321278]."

We thank the participating science teachers Kyriaki Alysavaki, Nectaria Archontaki, Eleni Korakaki, Dimitra Lampou, Aleka Mpakou, Maria Rapti, Kalliopi Saloustrou, Aristea Simantiraki, and Panagiotis Toumpaniaris for providing sufficient input to facilitate this research.

References

[1] National Research Council. National science education standards. Washington: National Academy Press; 1996.

[2] National Research Council. A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas. Committee on a Conceptual Framework for New K - 12 Science Education Standards. Board on Science Education, Division of Behavioral and Social Sciences and Education. Washington, DC: The National Academies Press; 2012

[3] Saltiel E. Inquiry-Based Science Education: Applying it in the Classroom. Methodological Guide; 2005.

[4] Capps K, Crawford BA. Inquiry-based instruction and teaching about nature of science: Are they happening? Journal of Science Teacher Education. Springer; 2012. Published online 26.08.12.

[5] Anderson R. Inquiry as an organizing theme for science curricula. In: S. Abell & N. Lederman (Eds.), Handbook of research on science education (pp. 807-830). Mahwah, NJ: Lawrence Erlbaum Associates; 2007.

[6] Bodzin AM, Beerer KM. Promoting inquiry-based science instruction: The validation of the Ccience Teacher Inquiry Rubric (STIR) Journal of Elementary Science Education 2003; 15 (2): 39-49.

[7] Crawford, BA. Embracing the essence of inquiry: New roles for science teachers Journal of Research in Science Teaching; 2000; 37: 916-937.

[8] Tali T, Geier R, Krajcik J. Urban students' beliefs about science in an inquiry-based classrooms Paper presented at AERA conference New Orleans; 2000.

[9] Hayes, MT. Elementary Pre-service Teachers' Struggles to Define Inquiry-Based Science Teaching. Journal of Science Teacher Education 2002; 13 (2): 147-165.

[10] Jeanpierre B, Oberhauser K, Freeman C. Characteristics of Professional Development That Effect Change in Secondary Science Teachers' Classroom Practices Journal of Research in Science Teaching 2005; 42: 668-690.

[11] Keys CW, Bryan LA. Co-Constructing Inquiry-Based Science with Teachers: Essential Research for Lasting Reform Journal of Research in Science Teaching 2001; 38(6): 631-645.

[12] Atwater, M.M. Research on curricular diversity in the Classroom. In: D.L. Gabel (Ed.), handbook of Research on Science Teaching and Learning. New York: Macmillan; 1994.

[13] Levy P, Lameras P, McKinney P, Ford N. The features of inquiry learning: theory, research and practice. Pathway to Inquiry Based Science Teaching, (Deliverable 2.1). European Commission: CSA-SA Support Actions, Project Number 266624. Retrieved from http://www.pathwayuk.org.uk/what-is-ibse.html; 2011.

[14] Linn MC, Bell P, Davis EA. Internet environments for science education (pp. 315-339) in Mahwah, NJ, US: Lawrence Erlbaum Associates Publishers, xxviii, p.412; 2004.

[15] Tseng C-H, Tuan H-L, Chin C-C. How to help Teachers Develop Inquiry Teaching: perspectives from experienced Science teachers Research in Science Education 2013; 43: 809-825

[16] Vygotsky LS. Mind in society, Harvard University Press Cambridge 1978.

[17] Hutchings W. Enquiry-Based Learning:Definitions and Rationale 2007.

[18] Loucks-Horsley S, Love N, Stiles KE, Mundry S, Hewson PW. Designing professional development for teachers of science and mathematics. Thousand Oaks, CA: Corwin Press 2003.

[19] Zadeh I, Zion M. Which Type of Inquiry Project Do High School Biology Students Prefer: Open or Guided? Research in Science Education 2012; 42:831-848.

[20] Maor D, Fraser BJ, Use of classroom environment perceptions in evaluating inquiry-based computer-assisted learning International Journal Science Education 1996; 18(4): 401-421.

[21] Crawford BA, Learning to Teach Science as Inquiry in the Rough and Tumble of Practice Journal of Research in Science Teaching 2007; 44(4): 613-642.

[22] Kazempour M, Amirshokoohi A , and Harbour W, Exploring Students' Perceptions of Science and Inquiry in a Reform-Based Undergraduate Biology Course. Journal of College Science Teaching 2012; 42 (2): 38-42.

[23] Wolf S.J. & Fraser B. J. Learning Environment, Attitudes and Achievement among Middle-school Science Students Using Inquiry-based Laboratory Activities Research in Science Education 2008 (38):321-341.

[24] Vasconcelos C, Amador F and Torres J. Students' perceptions of the implementations of science curriculum in Portugal**:** Rethinking paths, reinventing ways…Proceedings of ICERI2012 Conference, Madrid, Spain; 19th-21st November 2012**.**