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PRIMARY SCIENCE STUDENTS' APPROACHES TO INQUIRY-BASED LEARNING

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ABSTRACT
Pri-Sci-Net,an EU funded FP7, is a project that promotes inquiry-based learning in science at the primary education level through developing activities for teachers to use as well as setting up a Europe-wide network for professionals and academics in the area of Primary Science Education. In this context, two science activities, '*The secret of the human body*' and '*Pigment research*', were developed for the 9-11 age group and were applied to the students in this study.An observation protocol and semi-structured interviews with students were used for collecting data. The results of the study showed that students were convinced about, and realized the importance of, doing inquiry-based activities in learning science. Activities were mediated to create an inquiry-based social science environment. Even poor academic performance students were very active during the activities since all thoughts were considered valuable.
Keywords: Inquiry-based learning, primary level students, inquiry-based science activities.

INTRODUCTION

As a learning activity, inquiry-based learning (IBL) refers to the activities of students in which they develop knowledge and understanding of scientific ideas as well as an understanding of how scientists study the natural world (Anderson, 2002). Inquiry is based on scientific investigation through classroom practices such as posing questions, and it is concerned with knowledge acquisition and development (Blanchard, Southerland, & Granger, 2008). The main reason for its widespread acceptance and usefulness in science teaching is that it is compatible with human nature. From the moment we open our eyes to nature, all of our learning, except our instinctive behaviors, is based on our observations and inquiries. Therefore, all of our observations, learning needs, and inquiries require asking the right questions. IBL begins with questions based on real observations, and then proceeds through discussions and explanations based on evidence (Cuevas, Lee, Hart, &Deaktor, 2005). Consequently, it can be said that inquiry is the art of questioning and the art of raising questions.

Most instructors match IBL with hands on activities. This is a correct approach to some extent, but IBL learners are not just active learners; the activation is also in the learners' minds. IBL is in the learner's mind because the main knowledge construction is part of the learner's thinking. In this method, the learner is asking and refining questions, planning and designing how to answer their ideas, sharing ideas, making sense of data and designing and conducting experimental work. All these activities are mental processes and engage learners to become active learners.

The research on IBL in terms of implementing this theory in education varies according to different topics. It includes work on conceptual understanding (e.g., Anderson, 2002;Dalton and Morocco, 1997), attitudes and perceptions toward science (e.g., Anderson, 2002; Shymansky, Kyle, &Alport, 1983; Spronken-Smith,2012), critical thinking (e.g., Anderson, 2002; Panasan&Nuangchalerm, 2010), academic achievements (e.g., Marx et. al., 2004; Wolf and Fraser, 2008) scientific processing skills, cognitive achievement (e.g., Anderson, 2002;Krajcik, et. al., 1998; Panasan&Nuangchalerm, 2010;

Shymansky et. al., 1983, Lawson, 2010; Wu, et. al., 2006)and learning content as well as discipline-specific reasoning skills and practices (e.g., Hmelo-Silver et. al., 2007; Khishfe and Abd-El-Khalick, 2002).In addition, to address the impact of inquiry-based science instruction on K–12 students,Minner et al. (2010) synthesized the findings from research conducted between 1984 and 2002.Overall, research suggests that using IBL with students can help them become more creative, more positive and more independent. A systematic approach to the development of IBL skills is essential to prepare students both for problem solving and lifelong learning.

The Pri-Sci-NetVision of IBL for Children

Pri-Sci-Netis an EU fundedFP7supporting and coordinating action (Call SiS-2010-2.2.1.1) on innovative methods in science education: teacher training on inquiry-based teaching methods on a large scale in Europe.The project is coordinated by the Malta Council for Science and Technology (MCST) and has 17 partners from 14 countries.

Within the vision offered by the Pri-Sci-Net Project,inquiry-based science at the elementary school level involves a framework of teaching and learning that comprises applications for learning science, learning to do science, and learning about science (National Research Council, 2000).

In this framework:

Children:
- engage activelyin the learning process with an emphasis on observationsand experiences as sources of evidence;
- tackle authentic and problem-based learning activities, where the correctness of an answer is evaluated only with respect to the available evidence and getting to a correct answer may not bethe main priority;
- practice and develop the skills of systematic observation, questioning, planning and recording to obtain evidence;
- participate in collaborative group work, interact in a social context, construct discursive argumentation and communicate with others as the main process of learning;
- developautonomyand self-regulation through experience.

Purpose of the research

Since the school programs are promoting IBL in science at the primary level, it is important to provide professional support to both students and teachers to help them use inquiry based learning in their teaching and learning. Pri-Sci-Net is one of the projects that promotes inquiry-based learning in science at the primary level of education, both through developing activities for teachers to use with students, and through the setting up of a Europe-wide network for professionals and academics in the area of Primary Science Education. In this context, two science activities were developed for the 9-11 year old age group and were applied to the students in this study. Since many studies on the impact of IBL activities on students' thoughtsare purely descriptive,the main aim of this study was to gain an understanding of students' approaches to IBL.

MATERIALS AND METHODS

Participants

This study was restricted to two urban public elementary schools located in the Mediterranean region of Turkey.The study used purposeful and convenience sampling procedures (Johnson & Christensen 2004), which offer a non-random method of sampling where the researcher selects information-rich cases for study in depth. The study was conducted with sixty fifth grade elementary school students (32 male and 28 female, mean-age 11), and the interviews were held with eight volunteer students (5 female and 3 male)from among these participants.

Data collection instruments

An observation protocol and semi-structured interviews with students were used for collecting data. The observation protocol consists of three main parts and sub-divisions. These three main parts were also coding schemes for qualitative data analyses which were conducted by two researchers. The level of students' engagement in scientific thinking and discourse, the level of students' work with evidence and formulation of explanations, and the level of students' reflection on the process of their inquiry were observed and noted.
Semi-structured interviews were framed around three questions: whether the students enjoy the activity, what did they like or not like; whether they had previously done science activities in this way and whether they like to work with their friends.

Activities used in this research

Teachers generally claim that science classesassociated with the use of inquiry is time consuming since the activities span several classsessions, which conflicts with the complete core curriculum. Therefore, this study used two small-scale inquiry activities that only required 2 or 3 class sessions for completion, and which utilizedonly the key aspects of inquiry that challenge students. Both activities were applied to two different classes from two different schools that participated in this study.

The first activity,'The secret of the human body' (Author: Mgr. Dagmar Kubátová, PhD),encourages students to formulate a hypothesis about changes in heart rate intensity during various activities and to verify it experimentally. Students were then asked to compare the established results among themselves and explain the differences between individuals in the group. The second activity,'Pigment research' (Authors: JiříŠkoda, PavelDoulík),stimulated the students to observe the separation of colors and to reason based on their evidence. The activities used in this study were developed for the Pri-Sci-Net project.

RESULTS AND DISCUSSION

The results of classroom observation

Before doing the activities, questions that enable students to discover answers through their own hands-on experiments or through their own observation were asked. The goal was to encourage students to go beyond the idea of just memorizing facts and move them toward taking the initiative and responsibility for their own learning. The classroom observation is reported in terms of the observation protocol.

The level of students' engagement in scientific thinking and discourse

Before starting the pigment activity, the instructor asked the children whether the color of black ink in the pen contains different colors. The students started questioning and came up with several ideas. The

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instructor wrote all the ideas on the board without judging. This encourages students to talk more. The ideas of the students were as follows:

- *black consist of only primary colosr (yellow, red, blue),*
- *there are no primary colors in black (dark blue, brown, gray),*
- *One cannot say whether there are primary colors in black since black is the combination of all colors,*
- *black contains only dark colors,*
- *black contains only light colors,*
- *There may be some dark and some light colors in black, since dark and light colors complement each other,*
- *black has only its own color.*
-

At this point, the students were ready to hear the teacher's answer since they thought that, after this brainstorming, their job was finished; now, they thought, it was time to get answer.

One student asked: *"Teache,r what is the answer"*
Instructor: *"I am not sure. We should find a way to discover that"*

Students were surprised since this was not the teaching approach they were used to. Many of them were extremely curios about which answer on the board was right. Consequently, theywere already engaging in scientific thinking and discourse even despite some of the students claiming that science is boring.

During the other activity, 'The secret of the human body', the students decided to measure their heartbeat not only after the activities, but also before the activities since this meant they could make a comparison. This was a significant decision in terms of IBL since the students found the activity interesting (engaging) and dynamic. They formed predictions, collected data, worked together, recordedthe data anddrew conclusionsthrough discussion.

The level of students' working with evidence and formulating explanations

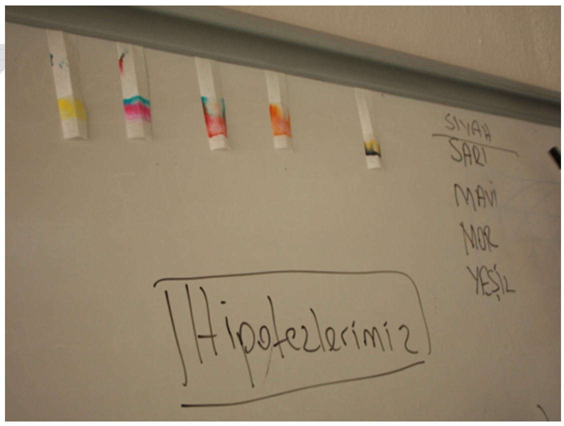
In terms of developing explanations(*e.g. How changes in heart rate intensity during various activities?*), it is the instructor who leads the discourse and stimulates the students to formulate predictions and explanations. In addition, the instructor took the lead in creating a challenging situation such as by creating the bar graphs and guiding children to reason based on their evidence. At the end of the activity, the instructor told the students that they had worked as scientists and gavethem scientific explanations based on their evidence.Students did their observation in terms of their hypothesis and decided whether it wascorrect or not, and they also discussed contradictory situations with their friends.

Student e.g. "We shared our observation results, and different stuff. We looked at the results of the other groups"

In 'the secret of the human body' activities, students worked as a group (See picture 1). In each group there were five students. One student was counting the sounds of a heartbeat per minute using a stethoscope, one was responsible for the timing, and the others were doing the activities. Having a real stethoscope to use made the children very excited. They immediately became engaged with the activity. It should be noted, however, that in some cases some students missed counting the heartbeat because of the crowded environment and the noise. The classroom was not big enough for 5 groups which had 5 students in each. Therefore, by the end of the activity the instructor had to explain that some data should be ignored because of observer error. Nevertheless, the students were having the chance to do real science, and their interest and excitement contributed to the noise level in the room. During the pigment research activity, there were also problems because students became tired or lost interested while waiting for the separation of the pigment (which takes approximately 15 minutes.See picture 2). However, the instructor immediately found a solution by motivating students throughout the experiment by asking questions and encouraging the students to do observations and take notes. Tosum up, during the activities the teacher wrote all the results on the board and had students communicate procedures, evidence and explanations. The instructor guided the studentsthrough questioning. The activity's data allowed students to make actual comparisons(See picture 3).

Picture 1. Students are working together

Picture 2. Students are observing pigment separation



Picture 3. The activity's data allowed students to make actual comparisons

The level of students' reflection on the process of their inquiry

The students had a chance to behave as real researchers and do hands on experiments. Using real tools like a stethoscope, chromatography paper,a chronometer etc. excited and motivated them as the comment of one student shows:

> *"This experiment was quite different. It was like a real experiment, I mean, I felt like I was anproper researcher. We collected information through research in that experiment"*

The results of the observationssuggest that, that since the students are used to taking more traditional courses, they are much closer to structured inquiry (Staver and Bay, 1987), where teachers provide an issue or problem and an outline for addressing it. However, an assumption can be made that students would like to move to guided inquiry (Staver and Bay, 1987), where teachers provide questions to stimulate inquiry, but students are self-directed in terms of exploring these questions. Finally, very structured curriculums and exam systems (like those in Turkey, for example) make it difficult to apply open inquiry (Justice et al., 2002) where students formulate the questions themselves as well as going through the full inquiry cycle.

The results of semi-structured interviews

Semi-structured individual interviews wereused to establish the validity of the observation by ensuring that the researchers' interpretationscorresponded to those of the participants. During the interviews, follow-up questions were used to probe students' ideas in-depth, and to explore the relationships between these ideas. The interviewer avoided directivecues, and limited her discourse to encouraging participants to elaborate and clarify their ideas.All interviews, which typically lasted for about 15 minutes, were videotaped and transcribedverbatim for analysis.The categories and examples drawn fromthe interview data are reported as follows:
Students expressed their thoughts on how they faced questions with more than one possible answer.

Student 7: *During the pigment research, I assumed that there was only one answer. But the teacher wrote all the answers on the blackboard.*

Student 4: *…We could not count the heartbeat properly because of the noise in the classroom. Yet the teacher still wrote our result on the board. We discussed why our result is different from the others. The teacher thanked our group for bringing 'observer error' to our friends' attention. I learned that it is very important to minimize observer error while doing experiments…*

Students stated that they learned how to solve problems and answer questions. They reflected on how they feel like real researchers. In addition, many of the students in the classrooms were from different schools. Thus, the researchers had an opportunity to learn more about the profile of science classes in the town generally. The results showed that students have little experience of doing experiments. What is more, many of them were of the opinionthat science means rote learning without asking questions:.

Student 2: *Teacher!This experiment was different. It was like a real experiment, I was like a real researcher…*

Interviewer: *…I would like to ask you whether you used to do experiments like this.*
Student 1: *When I was in 3rd grade we did experiments.*
Interviewer: *Do you remember how you did the experiments?*
Student 1: *For example, we measured the temperature with a thermometer or something, but didn't do anything like this.*
Interviewer:*… the teacher was measuring or eachone of you had a thermometer?*
Student 1: *The teacher was measuring, and we were watching. He did not allow us to touch anything.*

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…
Interviewer: *Well where do you feel you are a scientist? In the activity you did in 3rd grade or here?*
Student 1: *Absolutely here.*
Interviewer: *Why?*
Student 1: *Because we were not doing research there. Our teacher was doing most of the things, and we were watching. But here, we are doing all the things by ourselves, even the experiments. We did everything by ourselves. That feels good!*

Interviewer: *What were you doing in science classes last year?*
Student 8: *Our teacher was very authoritarian, he was reading from the book and we were writing what he says. Then…he never ever made us do experiments. He always talked like that. You know,without doing anything visually.*

Students expressed their thoughts on how they discussed things with others and learned more than they had expected.

Student 3: *…let's say I talked with some friends from other groups. For instance they were thinking there is only black in black color. Then I said there are other colors in black. After the experiment they said I was right…And then I also learned from the experiments about drawing graphs, measuring, using different tools, how to do experiments at home and how to do research.*

Student 5: *…I learned about working as a group since everyone has their own responsibility.*

Overall,the results of the study showed that students were convinced about, and realized the importance of, doing inquiry-based activities when learning science. Activities were mediated to create an inquiry-based social science environment. Even poor academic performance students were very active during the activities since all of the students' thoughts were valued.

CONCLUSION AND FURTHER IMPLICATIONS

The aim of this research was to understand students' approaches to inquiry based learning.The research showed that students feel as if they are real researchers while doing the activities. Moreover, they were more creative, more positive and more independent throughusing IBL. In addition, students were involved in their learning and developed solutions. However, students were in need of more inquiry-based style classes for further, higher-order learning. IBL was a new approach for many of the students in this research. Therefore, they had difficulties in synthesizing findings, relating to new questions, and going through the full inquiry cycle.

Each stage of the activities done in this research contributes to the creation of scientific knowledge. The skills acquired during the execution of the activitieswill lead to *learning to do science*; the students who find answers to their questions at the end of the activity will gain knowledge *learning about science*, and those who make use of the process to solve ordinary everyday problems internalize the experience of *learning science* andbenefiting from what they have learned. Choosing activities from everyday life that have been designed within this basic framework provides motivation for both students and teachers. Moreover, when knowledge acquired in school can be used in solving problems encountered in everyday life, that knowledge becomes all the more meaningful for the individual learner. Our research involved only two classrooms and eight cases, which meant small sample sizes. Thus, further research should be conducted using a bigger sample with demographic subgroups. Furthermore, research should be undertaken regarding what kinds of designneeds exist for learning environments in order to foster science inquiry among all elementary students.

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REFERENCES

Anderson, R. D. (2002). Reforming science teaching: What research says about inquiry? *Journal of Science Teacher Education, 13*(1), 1-12.

Blanchard, M. R., Southerland, S. A., & Granger, E. M. (2008). No silver bullet for inquiry: Making sense of teacher change following an inquiry-based research experience for teachers. *Science Teacher Education, 93,* 322-360.

Cuevas, P., Lee, O., Hart, J., &Deaktor, R. (2005).Improving science inquiry with elementary students of diverse backgrounds.*Journal of Research in Science Teaching, 42*(3), 337-357.

Dalton, B., & Morocco, C. C. (1997). Supported inquiry science: Teaching for conceptual change in urban and suburban science classrooms. *Journal of Learning Disabilities*, *30*, 670–685.

Hmelo-Silver, C. E., Duncan, R. G., & Chinn, C. A. (2007). Scaffolding and achievement in problem based and inquiry learning: A response to Kirschner, Sweller, and Clark (2006). *Education Psychologist, 42*(2), 99-107.

Johnson, B. & Christensen, L. (2004).*Educational Research: Quantitative, Qualitative and Mixed Approaches.*Pearson Education, Inc., Second Edition, 562 p, Boston.

Justice, C., Warry,W., Cuneo, C., Inglis, S., Miller, S., Rice, J., & Sammon, S. (2002). *A grammar for inquiry: Linking goals and methods in a collaboratively taught social sciences inquiry course.* The Alan Blizzard Award Paper: The Award Winning Papers. Windsor: Special Publication of the Society for Teaching and Learning in Higher Education/McGraw-Hill Ryerson.

Khishfe, R., &Abd-El-Khalick, F. (2002).Influence of explicit and reflective versus implicit inquiry-oriented instructionon sixth graders' views of nature of science.*Journal of Research in Science Teaching, 39*(7), 551–578.

Krajcik, J., Blumenfeld, P. C., Marx, R. W., Bass, K. B., & Fredericks, J. (1998). Inquiry in project-based science classrooms: Initial attempts by middle school students. *Journal of the Learning Sciences*, *7*, 313–350.

Lawson, A.E. (2010). *Teaching inquiry science in middle and secondary schools.* Los Angeles: Sage.

Marx, R. W., Blumenfeld, P. C., Krajcik, J. S., Fishman, B., Soloway, E., Geier, R., & Tal R. T. (2004). Inquiry-Based Science in the Middle Grades: Assessment of Learning in Urban Systemic Reform. *Journal of Research in Science Teaching*, *41*(10), 1063–1080.

Minner, D. D., Levy, A. J., & Century, J. (2010). Inquiry-based science instruction—What is it and does it matter? Results from a research synthesis years 1984 to 2002.*Journal of Research in Science Teaching, 47*(4), 474–496.

National Research Council. (2000). *Inquiry and the national science education standards: A guide for teaching and learning*. Washington, DC: National Academy Press.

Panasan, M., &Nuangchalerm, P. (2010).Learning outcomes of project-based and inquiry-based learning activities.*Journal of Social Sciences, 6*(2), 252-255.

Shymansky, J. A., Kyle, W. C., &Alport, J. M. (1983). The effects of new science curricula on students performance. *Journal of Research in Science Teaching, 20*(5), 387-404.

Spronken-Smitha, R., Walkera, R., Batchelorb, J., O'Steenc, B., &Angelod, T. (2012). Evaluating student perceptions of learning processes and intended learning outcomes under inquiry approaches. *Assessment & Evaluation in Higher Education, 37*(1), 57-72.

Staver, J.R., & Bay, M. (1987). Analysis of the project synthesis goal cluster orientation and inquiry emphasis of elementary science textbooks. *Journal of Research in Science Teaching, 24*, 629–43.

Wolf, S. J. &. Fraser, B. J. (2008). Learning environment, attitudes and achievement among middle-school science students using ınquiry-based laboratory activities.*Research in Science Education*, *38*, 321-341.

Wu, H., &Hsiehb, C. (2006).Developing sixth graders' ınquiry skills to construct explanations in ınquiry-based learning environments.*International Journal of Science Education, 28*(11), 1289–1313.