Available online at www.sciencedirect.com

ScienceDirect

Procedia - Social and Behavioral Sciences 141 (2014) 407 – 412

Procedia
Social and Behavioral Sciences

WCLTA 2013

# Transition between Open and Guided Inquiry Instruction

Arzu ARSLAN*

*Marmara University, İstanbul, Turkiye*

**Abstract**

Scientific inquiry refers to activities in which knowledge and understanding of how scientists study the natural world. Depending on how much teacher structure is supplied and whether there is an already existing solution to the problem or question, inquiry was classified as confirmation, structured, guided and open inquiry. The research aims at presenting the instance of transition between guided and open inquiry. This study was carried out with 25 pre-service teachers at a state university. Two activities were practiced. During the activities, pre-service teachers designed their own experiments, made researches about their concepts and made argumentation about experiments. When applying open inquiry appeared difficulty, guided inquiry was applied. These difficulties were 1) Absence of science process skills as formulating hypotheses, research questions and defining variables. 2) Pre-service teachers met for the first time with an inquiry based laboratory. 3) When researching about concepts and associating their experiments with works of scientists, they did not know where and how to start research.



*Keywords:* Open inquiry, guided inquiry, physics education, pre-service teachers;

## 1. Introduction

Inquiry based teaching requires students to develop questions and hypotheses, collect data, analyse data, draw and test conclusions (NRC, 1996). Scientific inquiry refers to activities in which knowledge and understanding of how scientists study the natural world (NRC, 1996).
Inquiry-oriented instruction is described as an active process involving making observations, posing questions, examining books and other sources of information to see what is known, planning investigations, reviewing what is already known in light of experimental evidence, using tools to gather, analyse and interpret data; proposing answers, explanations and predictions and communicating the results; in contrast to instruction in which students

* Corresponding Author: Arzu Arslan
*E-mail address*: arzfizik@gmail.com


doi:10.1016/j.sbspro.2014.05.071

record information presented by teachers and memorize scientific facts and formulas (Smith, Desimone, Zeidner, Dunn, Bhatt & Rumyantseva, 2007).

Inquiry includes cognitive and sociocultural views of knowledge construction (Anderson, 2002; Cakir, 2011). It is supported with four items specified by Anderson (2002):

- Learning is an active process of individuals constructing meaning for them; significant understandings are not just received.
- The meanings each individual constructs are dependent upon the prior conceptions this individual already has. In the process, these prior conceptions may be modified.
- The understandings each individual develops are dependent upon the contexts in which these contexts are, the richer are the understandings acquired.
- Meanings are socially constructed; understanding is enriched by engagement of ideas in concert with other people.

These factors are understood as learning process by using constructivist terminology (Anderson, 2002; Cakir, 2011). In inquiry, it is essential that students should manage their own learning process.

### *1.1. Inquiry Openness Levels*

Depending on how much teacher structure is supplied and whether there is an already existing solution to the problem or question, laboratory activities can be classified by level of openness to inquiry. According to whether the teacher prescribes the problem, the apparatus to be used, the procedure to be followed and the expected answer, or the students are required to make these decisions for themselves, a scale of openness to inquiry has been developed to classify laboratory activity (Baillie & Hazel, 2003; Kılınc, 2002). The scale was first formed by Schwab (Kılınc, 2002) and then four-level categorization was described by Herron (Smithenry, 2010). In the first level, confirmation inquiry; a question and a procedure which to answer it are given to students, they follow the procedure and confirm an answer which they knew beforehand. In the second level, structured inquiry; a question, a problem or and an outline are provided by teachers, but students do not know their answers (Smithenry, 2010; Spronker- Smith, Walker, Batchelor, O'Steen & Angelo, 2012). In the third level, guided inquiry; the problem is given to students, but they are self-directed in terms of designing procedure and exploring the answers (Smithenry, 2010; Spronker- Smith et al, 2012). In the fourth level, open inquiry; students formulate the complete project; they develop a question, identify what must be known, design their own experiments, interpret results, and evaluate reliability and validity of the study (Baseya & Francis, 2011; Smithenry, 2010; Spronker-Smith et al, 2012).

It should be understood that all inquiry levels are not same and equal. A important question is ''How much information is given to the student? '', in the openness scale of inquiry, activities can range from teacher-centred to student-centred (Bell, Smetana & Binns, 2005). The openness scale was shown in the Table 1.

Table 1. Four-Level Model of Inquiry (adapted from Bell et.al)

| Level of inquiry | Question | Method | Solution |
|---|---|---|---|
| Confirmation Inq (1) | Given | Given | Given |
| Structured Inq.(2) | Given | Given | Open |
| Guided Inq (3) | Given | Open | Open |
| Open Inq.(4) | Open | Open | Open |

In table 1, confirmation and structured inquiry can be described as ''cookbook laboratory', because all procedures are given to students like recipe. In contrast, guided and open inquiries are more complex for students because students design their own experiments and procedures (Smithenry, 2010). Students who engage in guided inquiry may get little practice in designing their own investigations; this inquiry level prepares students to open inquiry and requires students to formulate their own procedure (Bell et. al, 2005). In open inquiry, a subject matter area for investigation is circumscribed by the teacher; students find a problem from this subject and produce their own research questions which are meaningful, testable and consistent with existing theories (Windschitl, 2001). It is

thought that open inquiry allows to the students experience science like a scientist' idea and provides them with the opportunity to construct their knowledge by actually doing scientific work (Hofstein, Shore & Kipnis, 2004).

*1.2. Purpose and Methods*

The study presented in this paper examines the work which is an instance of transition between open and guided inquiry. The aim of this study is to show that transition to guided inquiry can be useful if open inquiry is difficult for student and teachers in terms of managing inquiry process. And another aim is to find these difficulties which are obstacles to open inquiry. This study was carried out with 25 physics pre-service teachers at a state university. Inquiry-oriented two physics education activities were practiced during 14 weeks. In these activities, a subject-matter area was given, pre-service teachers were asked to formulate their own questions and design their own experiments.

Pre-service teachers were asked to prepare four reports for one activity. These reports were;

Draft report: Before beginning the experiments, they had to submit draft report which included design of experiment, research questions, hypotheses and variables.

Experiment report: After the experiments, they had to submit experiment report which included the data collected, measures, error calculations, graphics and conclusions.

Self-assessment report: In this report, they wrote their thoughts about their experiment. They argued about the question ''How this experiment could have been nicer?''

Associating report: In this report, pre-service teachers had to search about examples of daily life or history of science and associate with their experiments and these examples.

These reports and audio-video records during the activities were used to collect data. In the following, information about two activities can be seen:

*Activity 1:* This activity was about ''how can a ball at the beginning of inclined plane reach to other side in the easiest way?'' The figure of inclined plane could be changed by pre-service teachers. And they were free about determining the environment (such as friction, wind, mass, surface). But their research questions and hypotheses had to be coherent with their experiments.

*Activity 2:* This activity included a dialogue between three friends about duration of falling of the heavy and light objects. Pre-service teachers first had to find the problem from this dialogue and then formulate their own questions and hypotheses, design their own experiments.

*1.3. Data Analysis*

Table 2, according to sessions of activities, it was stated where guided inquiry and open inquiry were used.

Table 2. The sessions of laboratory

| Activity Sessions | Activity 1 | Activity 2 | Reason* |
|---|---|---|---|
| Problem | O.I** | O.I | - |
| Hypotheses/ Prediction | G.I*** | O.I | Pre-service teachers had difficulty formulating hypotheses. |
| Variables | G.I | O.I | They had confusion about independent, dependent and control variables. |
| Materials | O.I | O.I | - |

| | | | |
|---|---|---|---|
| Methods | O.I | O.I | - |
| Analysis | G.I | O.I | They had difficulty choosing right error calculating. |
| Conclusions | O.I | O.I | - |
| Associating | G.I | G.I | They had difficulty associating their experiments with scientists'. |

*Reason: Why was guided inquiry used instead open inquiry?
**Open Inquiry: Full student-centred, student directed this session themselves.
***Guided Inquiry: Students could not manage this season themselves; students recognized and learned the process with investigating.

At the beginning of the study, it was intended to implement open inquiry. But occasionally it was necessary to transition to guided inquiry. In the following, it was stated using of guided and open inquiry according to activity sessions.

Problem: In both two activities, pre-service teachers were able to describe a problem. In the first activity, pre-service teachers identified the obstacles which prevented the ball from reaching across of inclined plane. In the second activity, they recognized that the dialog was about duration of falling of heavy and light masses. But they had to determine how could the falling environment be, then they observed durations of falling in different environments.

Hypotheses: In the first activity, pre-service teachers were able to design an experiment but they wanted to measure more than one thing at a time. But it was necessary that the measures were regular and sequent. The researcher asked questions to pre-service teachers. They began to recognize the importance of a hypotheses and formulating a research question and hypotheses. For example in the following dialog;

' *'The researcher*: Can you tell me your experiment design? *The pre-service teacher3*: The ball will fall from the inclined plane, but another ball will from the inclined ball? *The res*: Well, will the height or friction change in your design? *The pt3*: (The quiet..) Yes, height of inclined plane will change? *The res*: What do you intend to measure in your design? *The pt3*: (The quiet..) a ball falling from different heights, then another ball falling. *The res*: What is your prediction? What will happen in your experiment? *The pt3*: (think.) *The res*: If you formulate hypotheses, you can regulate your experiment. Scientists formulate hypothesis before beginning an experiment. *The pt3*: What can a hypothesis formulate? *The res*: I think, you should make a research about hypothesis.''

Variables: In a design of an experiment, it is necessary to determine independent, dependent and control variables. At the beginning of first activity, pre-service teachers had not determined their variables, so they tried to measure more than one thing at a time. When the researcher asked a question, they had confusion about their experiments. Because, their variables were not clear and they had difficulty making a decision what must be measured in their experiment. Which one was independent, which one was dependent? When they stated their experiments with variables, they began to make better measures. For example;

'' *Res*: You don't change height and slope of plane, you put big ball, then small ball, and you measure the duration of falling? What are your independent and dependent variables? And control? *pt4*: Independent: duration. *Pt3*: the way of ball is dependent variable. *Res*: Why do you think that duration of ball is independent? *Pt3*: Whenever I want, I can change the duration. *Pt5*: Whenever you want, you can change mass of ball. So mass is independent. ...*Res*: What are your controls? ...*Pt2*: surface. *Pt5*: Friction, wind. Res: Things which ignores are different from controls. .....''

Analysis: After collecting data in the first activity, they had to made error calculations about their data. But pre-service teachers had difficulty choosing the right calculation. They didn't determine to use standard error or relative error. The researcher gave a task to them, they searched the error calculations. In the classroom discussions they found the error calculation which was appropriate for their data.

Associating: Pre-service teachers had to associate their experiments with scientists' experiments; they had to

found same and different features of their experiments with scientists'. In this session, they were able to find the scientist who had made same experiment beforehand, but pre-service teachers had difficulty in recognizing the investigating process of scientist. For example, about the inclined plane and free falling experiments, pre-service teachers found that Galilei made these experiments. But investigating Galilei' experiments, they didn't found the questions which Galilei had asked himself before beginning experiment. Pre-service teachers only found Galilei biography. Even they talked over Galilei 'astronomy observations although the subject of experiment was irrelevant. The researcher asked the questions which Galilei asked himself to pre-service teachers without saying something about Galilei. So this session was labelled guided inquiry.

*1.4. Conclusions*

In this study, it had been intended to practice open inquiry in all sessions of activities. But in hypothesis, variables, analysis and associating sessions guided inquiry had to be practiced. The reasons for guided inquiry instead open inquiry can be listed as follows: First, pre-service teachers had been making experiments in confirmation laboratories, their procedures and their materials had been given. But with these activities pre-service teachers were introduced with inquiry-oriented laboratory. At the beginning of activity, guided inquiry was practiced, because it was necessary them to learn managing their own learning process. Second, inquiry requires students to follow the way of scientists. Pre-service teachers tried to design their experiments without formulating a research question, a hypothesis and defining variables. It was not enough to find necessary materials for a good experiment; if experiments had included a prediction or a hypothesis, they would have been better. Pre-service teachers learnt formulating a hypothesis and defining variables. These science process skills were important to practice guided inquiry instead open inquiry. Third, pre-service teachers didn't know investigating process of scientists. They searched biographies of scientists, but they didn't find the questions that scientists asked themselves before beginning the experiment.

In the first activity, guided inquiry was used more than open inquiry. But second activity, open inquiry was used more. Because pre-service teachers were aware of inquiry processes and they improved their science process skills.

If science process skills are known and scientific inquiry process was described, open inquiry can be practiced easily. When open inquiry is difficult to be practiced, it can be made a transition into guided inquiry.

**References**

Anderson, R.D (2002). Inquiry as an organizing theme for science curricula, Abell, S.K & Lederman, N.G (Ed) Handbook of Research of Science Education, 807-830. New Jersey: Lawrence Erlbaum Associates.

Bailie,C & Hazel, E (2003). Teaching Materials Laboratory Classes, The UK Centre for Materials Education, edited by Caroline Baillie and Leone Burton.

Baseya, J.M & Francis, C.D (2011). Design of inquiry-oriented science labs: impacts on students' attitudes, Research in Science & Technological Education, Vol. 29, No.3, 241-255.

Bell, R.L., Smetana,L & Binns, I (2005). Simplifying inquiry instruction , The Science Teacher, 72, no 7, 30-33.

Cakir, M (2011). Enhancing mendelian genetics concepts using a guided computer-mediated inquiry. Journal of Baltic Science Education, Vol. 10, No. 3.

Hofstein, A., Shore, R & Kipnis, M (2004). Providing high school chemistry students with opportunities to develop learning skills in an inquiry-type laboratory: a case study., International Journal of Science Education, Vol.26, No.1, 47-62.

Kılınc,A (2007). The opinions of Turkish high school pupils on inquiry based laboratory activities, The Turkish Online Journal of Educational Technology, ISSN 1303-6521, Vol.6, Issue 4, 56-72.

National Research Council. (1996).National science education standards. Washington, DC: National Academy Press.

Smith, T.M., Desimone, L.M, Zeidner, T.L.,Dunn,A.C.,Bhatt, M & Rumyantseva, N.L (2007). Inquiry oriented instruction in science : who teaches that way?., Educational Evaluation and Policy Analysis, September 2007, Vol 29, No. 3, pp. 169-199.

Smithenry, D.W (2010). Integrating guided inquiry into a traditional chemistry curricular framework, International Journal of Science Education, Vol.32, No.13, 1689-1714.

Spronker-Smith, R.., Walker, R., Batchelor, J., O'Steen, B & Angelo, T (2012). Evaluating student perceptions of learning processes and intended learning outcomes under inquiry approaches, Assessment & Evaluation in

Higher Education, Vol.37, No.1, 57-72.
Windschitl, M (2003). Inquiry projects in science teacher education: what can investigative experiences reveal about teacher thinking and eventual classroom practice?, Science Teacher Education, 87: 112-143.