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Biology Teachers' Inquiry Abilities When Preparing in Inquiry-Based Teaching By Mentoring Program

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***Abstract*—The major purpose of this study was to investigate the abilities of inquiry biology teachers when they were preparing inquiry-based teaching trough mentoring program. First, 9 biology teachers from different high school was analyzing biological content potential to inquiry, then they found their inquiry activities by mini research (Starting from the planning, presenting the design, conducting experiments and reporting the results). They made lesson plan and student worksheets from what they found in their mini research. This program it takes place for 12 weeks. The abilities of inquiry and dynamic of inquiry examined as long as they did inquiry in the program through observation sheet, questionnaires and interviews. The results showed that average of biology teachers' was reaching of 'develop' in inquiry ability, while the dynamics of inquiry performances have 56 performances on the understanding of procedural and 15 performances of the changes that occur during the inquiry. Teachers' held good ability in identifying questions and concepts that guide scientific investigations also in communicating and defend a scientific argument, but very poor using technology and mathematics to improve investigations and communications, using and searching literature, and make a physical, conceptual, and mathematical models.**

Keywords—abilities of inquiry; mentoring program; inquiry based teaching; biology teachers

I. INTRODUCTION

Inquiry is a pedagogical method that allows students to discover or construct information for themselves instead of an instructor simply telling them that information [1]. Inquiry is central to science learning. Inquiry is multifaceted activity that involves making observation, posing questions, examining books and other sources of information, planning investigation, using tools to gather, analyze, and interpret data propose answers, explanations, and predictions; and communicating the results [2]. [3] Recommended inquiry-based learning because according to the results of research significance increase student outcomes.

The teacher is the leader of inquiry in the science classroom. Teachers of science impart the excitement and value of science to their students. They are facilitators and role models of the inquiry process in the classrooms. The teacher creates a learning environment that will encourage and challenge students to develop their sense of inquiry. Teaching and learning approaches centre around the student as an inquirer [4]. Science is an active process that must be experienced to be fully understood. Just reading about science is inadequate and cannot be substituted for effective science instruction [5].

Teachers are generally not much familiar with learning by inquiry even especially to do the subject specific pedagogy for biological content to inquiry. This happens because at the time both studying at college or during school they rarely feel the learning by inquiry approaches' so that they do not feel confidents to implement learning by inquiry in the classroom. Reference [6] said that most teachers have not had opportunities to learn science through inquiry or to conduct scientific inquiries themselves, nor do many teachers have the understanding and skills that they need to use inquiry thoughtfully and appropriately in their classroom.

Many university science programs appear to regard laboratory experiences as ancillary to lecture, useful primarily to knowledge delivered validate by lecture and reading. Teachers who learn science didactically and abstractly cannot be expected to teach children constructively and concretely. Teacher, who have never conducted an investigation and research are unlikely to model investigative behaviors for their students [7]. If the situation continues to be maintained, then the prospective teacher will get less prepare for their work later, so important that the teachers can feel Inquiry experience, like to be a scientist. Reference [7] stated that individual preparing to be teachers should have significant and substantial involvement in laboratory, including actively inquiry that goes beyond traditional validation activities. Science education reform documents emphasize the importance of inquiry experiences for young learners. This means that teachers must be prepared with the knowledge, skills, and habits of thinking to mentor their students through authentic investigations [8]. Teacher should present science as

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inquiry and that students should use inquiry to learn science subject matter [6]. Most science educators agree on the importance of providing teachers with experiences that allow them to do the same kind of scientific inquiry that is expected of their students [9].

Mentoring is traditionally a process in which an experienced person (the mentor) guides another person (the mentee or protégé) in the development of her or his own ideas, learning, and personal/professional competence [10]. In this study, mentoring program was intended to increase teachers' inquiry abilities. In this program, the teachers have coaching, starting from what is inquiry learning, how to find important or potential of biological concepts for inquiry learning, and how conducting scientific method in mini research. They were planning inquiry activities for their student through develop mini research and conducting in their schools, and then planning the inquiry lesson from this activity. Their mini research is limited in scope of biology school content, time, schools instruments and material. While this process takes place, teachers' inquiry abilities and dynamics of inquiry were examined.

Abilities of inquiry as according to [6] 'cognitive abilities' go beyond what have been termed science 'process' skills, such as observation, inference, and experimentation. Inquiry abilities require students or teachers mesh these processes with scientific knowledge as they use scientific reasoning and critical thinking to develop their understanding of science. The categories of inquiry ability i.e. identify questions and concepts that guide scientific investigations, design and conduct scientific investigations, use technology and mathematics to improve investigations and communications, formulate and revise scientific explanations and models, using logic and evidence, recognize and analyze alternative explanations and models, communicate and defend a scientific argument [6].

Moreover, performance of inquiry ability can be identified as the characterizing of dynamic inquiry process. Dynamic inquiry were grouped into four main criteria changes occurring the inquiry (such as changes in the course of conducting an inquiry as a consequence of field conditions or a literature search, new ideas that emerged and result in changes, and understanding the need to solve technical problems); learning as a process (such as documentation, researching additional professional literature, and devoting time throughout the course of inquiry); procedural understanding (such as understanding the importance of controlling variables, applying a different method of measurement on dependent variables and working methods, control, repetitions, and statistics); and affective points of view (such as curiosity, frustration, surprise, perseverance, and coping with unexpected results) [11]. In this study, the dynamic inquiry have examined in two performance of four criteria i.e. 'changes occurring during inquiry' and 'procedural understanding'.

The results of teachers' mini research can be acts as a material to create their 'student worksheet activity' and lesson plan for inquiry based teaching. The abilities of inquiry can be examined too at their worksheet and lesson plan by using some criteria i.e. the ability of teachers in presenting the material to be delivered through inquiry learning, like a choosing suitable indicator with inquiry-based learning, conforming learning outcomes with inquiry-based learning, describing biological material in phenomena that invite questions, providing material the opportunity for students to develop the ability inquiry, designing a delivery of material into an inquiry learning [6] but not shown in this report.

II. RESEARCH METHOD

Ability of inquiry biology teachers' was investigated when they are preparing an inquiry based teaching through a mentoring program. We used descriptive mode of inquiry. There is simply an existing phenomenon by using numbers to characterize individual or group. It assesses the nature existing conditions. The purpose is limited to characterizing something as it is [12].

The study was conducted in the working group of Biology teacher in Bandung. Subject in this study were 9 in-service biology teachers from different high school. The facilitators in mentoring program were three university researchers in science education with experience in designing and facilitating professional development programs for high school teachers. They guided them in inquiry based teaching for 12 weeks. They met every weekend to guide the teachers how to analyze biological content standard and planning the inquiry activities.

In this program, teachers found the best inquiry activity through mini research with issues that interest them, especially in the scope of school biology content or biology in everyday life. Starting from the planning, presenting the design, conducting experiments and reporting the results (as seen in Table 1). Their report presented to their friends and facilitator. Data collection used several instruments like as observation sheets, video recorders, questionnaires and interview guides. We developed some observation sheets and rubrics too. Video from the oral report changed to transcript. Then, the transcription and written teacher's mini research report we were coding it into inquiry ability categories and then interpreted by a rubric.

TABLE I. MENTORING PROGRAM DESIGN FOR TEACHER WHEN THEY PREPARING INQUIRY- BASED LEARNING

The goal : biology teachers should can do	**Activity**	**Time**	**Description**
Analyze subject matter	workshop	Two weeks	Analyze subject matter from standard that potentially to inquiry
Experience to inquiry	Mini research	Six weeks	Teachers planning, presenting the design, conducting experiments and reporting the results
Create a lesson plan	workshop	Two weeks	Create a lesson plan, learning outcome, the instructional inquiry models and assessments
Create inquiry worksheet design	workshop	Two weeks	Create inquiry worksheet design and pilot testing the worksheet

We examined teachers' performance when they are conducting mini research by dynamics of inquiry performance i.e. procedural understanding and changes occurring during the inquiry. The relative frequencies of the different dynamic of inquiry categories were expressed during the teachers' mini research processes. The term performance in this article refers to different activities conducted by the teachers performing the inquiry. We examined the performances, matching different categories of dynamic inquiry. Performance on both aspects, each of them consisting of 11 categories of performance, so if all the mini research raises all performance categories the total performance will be appears 99 performances.

Inquiry abilities consist of six categories and 34 topics. We used 'ethic' categories [12]. This category comes from researcher are taken from literature, that is [6]. We are coding the transcripts of a mini research report from these categories and then we selected, classified and make an average. We used the number, i.e. 1 = for perfect/completed ability, 0.8 = good, 0.6 – 0.5 = develop, and 0.4 – 0.2 = beginning/novices and 0.1 – 0 = no reach criteria.

III. RESULT AND DISCUSSION

Achievements 'inquiry abilities' of teachers through mentoring program, in general have mean score 0.45 that is reached the level of 'develop' ability (as seen in Figure 1). Only one teacher reach 'good' criteria, but one teacher did still in not reach the criteria. Based on the questionnaire results, teachers' previous knowledge about the inquiry was limited to the terminology did not yet know or understand how to practice, but after conducting their own mini research, teachers feel the benefits of knowing how doing the process of inquiry.

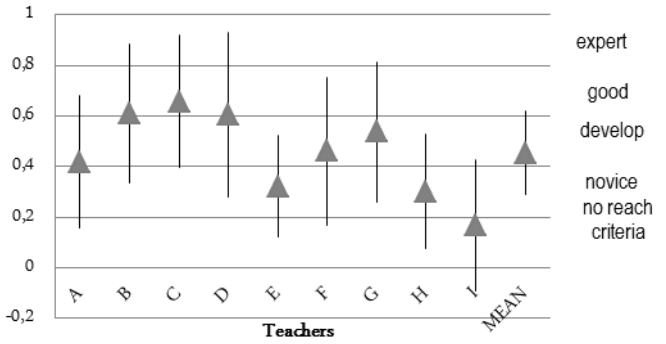

Fig. 1. Score and Criteria of Inquiry ability of teacher.

Some teachers' have novice inquiry ability; it is not surprising because teachers weren't experiences in conducting inquiry, even some of them as a first experience. One of teachers doesn't reach the criteria. She looks hard to follow the mentoring program. She is a veteran teacher (have 32 years teaching experience), a diligent participant, but not skillful to get investigative problematic, her idea of mini research, title and procedure followed closely with her friends. Other participants, who have the postgraduates of biology education, have developed in inquiry ability.

After doing mini research, teachers seem eager to continue the research, almost all said that they found the questions to be investigated further, one of the teachers wrote in her logbook: 'At first I was not confident, but after trying, it can! so arises a new spirit to investigate another idea, I want a more accurate'.

This mini research looks like successful to increase teacher's curiosity, confident, and careful.

The results identified that, teacher held good ability in identifying questions and concepts that guide scientific investigations (QC) also in communicating and defend a scientific argument (C), but very poor use technology and mathematics to improve investigations and communications.

Some scientific questions have proposed by teacher like this:

Teacher A : is there any part starch deposit besides cotyledon in *Phaseolus angularis* seed?

Teacher C : is lichen and moss has a same composition of color (pigment) with another plant?

Teacher D : how influence salt concentration to initial of plasmolysis cell in *Rhoeo discolor*?

Teacher H : Are any bulb plants having peroxide enzyme?

This question saw guided by concepts. Teacher H proposed this question because she argue that the plant commonly have this enzyme.

In the communicating process teacher having a good score, ultimately in speaking like using language appropriately, speaking clearly and logically, responding appropriately, and summarizing data, but not in developing diagrams and charts and explaining statistical analysis. Indeed, it seems hard for teachers to use technology and mathematics to improve investigations and communications, no one used computers for the collection, analysis, and display of data, or mathematics.

In discussion, there is some debate. Teachers engage in discussions and arguments that result in the revision of their explanations. It showed like this: Mr. A did a mini research examining the content of starch in a seed. Mrs. D asking question to Mr. A, for what benefits his research. Mr. A look confused and said maybe didn't signify to our content standard, but Mrs. B denies:

> "No, I think this would be a more contribution than just theoretical concepts. Because especially in grade 12, there is development concept, in the grade 11 students learn Plantae, and in grade 10, students learn about cells. The growth process starts from a seed. Seed also important for breeding and crops. The seed has an important role so students should know the part where the seeds most responsible.The cotyledons are food reserves for the development of the embryo. The results of this experiment indicated that the endosperm are parts of food for the embryo. Embryo food did not (indirect) result from photosynthesis, but very dependent on what is contained in the cotyledons."

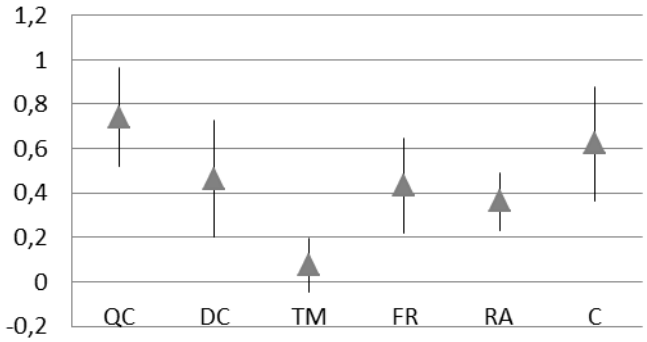

Fig. 2. Means score of teachers' inquiry ability for each component .
QC = indentify questions and concepts;
DC = designing and conducting Investigation;
TM = use technology and mathematics;
FR = formulate and revise scientific explanation;
RA = Recognize and analyze an alternative explanation;
C = communicating.

Designing, conducting experiments, formulating and revising scientific explanation, and recognizing and analyse alternative explanation ability of teachers is still in beginning criteria of inquiry ability.

The dynamics of inquiry performance were examined based on observation as long as the mini research conducted by biology teacher (as seen in Table 2). There were found 73 performances with details as follows, 56 performances on 'procedural understanding' and 17 performances about 'changes that occur during the inquiry'.

Asking questions and hypothesis were the highest performance. The teacher wasn't using statistics, but only using a simple quantitative data. Teachers' procedural understanding, it seem was suitable with the fundamental inquiry ability that got from the teacher mini research report observation.

Changing as long as they conduct mini-research causes most of technical problem, and the experimental results. Changing in the experiment is a challenge for teachers, but in this study did not happen in connection to organism, habitat, and searching the literature. The result showed that 'Changing in inquiry' performance fewer than 'procedural understanding' performance. These performances contribute to the knowledge and understanding of the learning processes of teachers' inquiry.

Based on 'Fundamental of inquiry abilities [6], teacher held good ability in identifying questions and concepts that guide scientific investigations and in communicating and defend a scientific argument, but very poor at using technology and mathematics to improve investigations and communications.

Teachers using a variety of technologies, such as hand tools (TLC chromatography, titration, loupe, light and electric microscope) measuring instruments (balance, ruler), and calculators, were as an integral component of scientific investigations. Teachers also were using computers, but not for the collection, analysis, and display of data, teachers using computer only for writing a report or create a power point. Maybe teachers should engage with more task and work collaboratively in a team like to [11] study in Dynamic Inquiry Performance that on average, students learning with computers in small teams attempted more tasks, used more learning strategies and had more positive attitudes toward small team learning, but needed more task completion time compared to students learning individually with computers. Teachers shy away from mathematics and statistics and tend to less use of quantitative data.

TABLE II. TEACHERS' PERFORMANCES OF PROCEDURAL UNDERSTANDING AND CHANGING IN INQUIRY

Categories	Number of performance	Frequency of performance (%)
1) Procedural understanding		
• Asking the question	9	100
• Developing hypothesis	9	100
• Replicating	9	100
• Determining the size / number of samples	9	100
• Controlling variable	5	55.55
• Using statistics	0	0
• Difine control	4	44.44
• Controlling variable in field study	3	33.33
• Changing the relative scale of the independent variables	2	22.22
• Field Observation	1	11.11
• Applying different methods of measurement on the dependent variable	1	11.11
Total	**56**	
2) Changes in inquiry		
• Understanding the need to solve technical problems and suggest practical and creative ideas	5	55.55
• Changes due to the experimental results	4	44.44
• Changes as a result of field conditions or field observations	2	22.22
• Financial reasons	2	22.22
• Conduct preliminary experiments to establish an experimental system	2	22.22
• Changes in the research process as a result of a searching literature	1	11.11
• Changes in the research question because of the need	1	11.11
• Changes due to habitat change	0	0
• Changes due to the organism disappears or not found	0	0
• Additional ideas emerge and change the initial research question	0	0
Total	**17**	

Teachers' performances as long as they conducted the mini research could be showed at the dynamics of inquiry (as shown at Table 2). The procedural understanding achievement, almost suitable results with the teachers' fundamental inquiry abilities. Procedural understanding of the question, developing hypotheses, replicating, determining the size/number of samples, was higher as the identifying question, designing, and conducting ability. Thinking behind doing' is a phrase commonly used when referring to pupils' or teachers' procedural understanding in science [13]. Procedural understanding contributes to the performance of an open ended investigation, to conduct investigation competently.

Procedural understanding has understood the importance of controlling variables, approaching a question with multiple research perspectives or methods and maintaining accurate statistics.

The changing in inquiry less than procedural understanding, but changing in understanding the need to solve technical problems and suggest practical and creative ideas and changes due to the experimental results indicated that is not also an investigative or a scientific process but that is a tentative process too. Look at to the changing in relative scale from independent variables (teacher C):

> Initially I read an article that plasmolysis cells has occurred in the salt solution with a concentration of 2%, so in the design of the study, we determined the concentration of saline solution ranging from 1% - 10%, but then we changed because of the trials showed at 1% concentration has occurred plasmolysis (occurs in almost half of the cells). Therefore, we decided to examine the concentration of salt solution at 0, .. up to 1.0%.

In this study, teachers novices in learning of inquiry that it can indentify from a minim activity of changing in the searching literature. Changing in inquiry adapted to field conditions or literature search. Reference [17] said that in the inquiry new ideas can emerge, understanding the need to solve technical problems.

When creating design and conducting scientific investigations ability of teachers good enough in made introduction to the major concepts in the area being investigated, to select proper equipment, clarification of ideas that guide the inquiry, no assistance with methodological problems, not require clarification of the question, method, controls, and variables, organize and display of data. In a presentation of the results with a critical response from peers, and also the scientific investigation performed, using evidence, apply logic, and construct an argument for their proposed explanations. They have a weak ability in safety precautions, using of technologies, using scientific knowledge obtained from sources other than the actual investigation, and have no a revision of methods and explanation.

Teacher inquiries should culminate in formulating an explanation or model [6]. In this study, teachers made explanation for answering the question, engaged in discussions and arguments that result in the revision of their explanations, and based on scientific knowledge, the use of logic, and evidence from their investigation, but no one of the teachers made a physical, conceptual, and mathematical models.

In analyzing argument ability, teachers did by weighing the evidence and examining the logic, using scientific criteria to find the preferred explanation, but poor by reviewing current scientific understanding. Based on the interview, mostly teachers agree that they have handicaps in searching and using scientific literature.

These fundamental inquiry abilities of teachers were an integrated science process skills, this is an important skill for inquiry based teaching. Skills in inquiry are one of the four important dimensions of science literacy referenced in the Standards, along with learning of science content ("subject matter"), understanding of the nature of science, and ability to view science in a greater social and personal context [14]. A skilled teacher remains the key to effective instruction [6].

When teachers preparing inquiry based teaching in their lesson plan (still in this program). They preparing lesson plan in some phases i.e. engaging, exploring, analyzing, extending, and communicating phase. Some of them look presented engaging phase with phenomena or facts. As an example, one of them presented a *Carica papaya* leaf that contain protease enzyme (preparing the traditional cooking) in the daily life. In this engaging phase teacher asks students to give a prediction, and then she asks a question: does all the leaves can be used to soften meats? This is focus question because she asks the students to investigate and identify the protease enzyme in some plant extracts (*Zingiber officinale*, *Carica papaya*, *Ananas sativus*, and *Caloptropis gigantea*). Her instructional was a 'structured inquiry', teachers slightly shifted from traditional lab. Her student worksheets have a good introduction which problem exposed, asking prediction to student and prove their prediction, but the procedure still gifted in the worksheet. Reference [2] said that effective science teaching depends on the availability and organization of materials, equipment, media, and technology. Why the procedure to answer the focus question still gifted in the worksheet?. It is because the teacher not confident to give free inquiry or their students still have little experience in conducting scientific inquiries so require more structured activity [6].

Inquiry differs from more traditional lab approaches in a number of ways. In the traditional lab activity, the focus is more heavily to learning the content. Processes of investigation tend to be limited to manipulative and data collection skills. Lab and field activities are usually prescriptive (sometimes called "cookbook labs") and are intended to lead students to correctly understand the phenomenon under study, which has usually already been discussed in class. For the most part, the students are not creatively involved in the development of the activity. Often they simply fill in the blanks on a printed sheet to complete their lab. Inquiry, in contrast, focuses more on the development of the scientific process skills. Content is developed with a conscious focus on developing a conceptual network, Rather than being given as information [14]. In this study not many of teachers create lesson in guided inquiry, although guided inquiry, which involves teacher participation, is most common in schools [14].

In analyzing phase, teachers lower expressed because in their lesson plan most teachers did guided students analyze and interpret data and clarify concepts and explanations together, but lower guided students synthesize their ideas, or build a model, or clarify concepts and explanations with other sources of scientific knowledge. These were looked weak too, in their inquiry abilities. In extend phase, no one of teachers reaches this criteria, they doesn't know or unusual how to implement this phase. In communicating phase, they have good ability similar in their inquiry ability. Referenced [14] consider that one of some principles in inquiry lesson plan is always refer to the nature and context of science during

discussion (always have in mind that you are teaching about science and not just science content).

Inquiry-based teaching is a complex and sophisticated activity that demands a real professional development. It appears that the key to change is in providing innovative science teacher education for both pre-service and in-service teachers. Unless teachers are supported in developing an understanding of science subject matter, the nature of inquiry science, and how to create an inquiry-based learning environment in the classroom, it is unlikely there will shifts in teaching. Thus, a major challenge in the field of science teacher education is to assist teachers in understanding how to enact inquiry-based instruction in their classrooms [15]. Professional development for teachers of science requires learning essential science content through the perspectives and methods of inquiry. Science learning experiences for teachers must involve teachers in actively investigating phenomena that can be studied scientifically, interpreting results, and making sense of findings consistent with currently accepted scientific understanding. Address issues, events, problems, or topics significant in science and of interest to participants [2]. Knowledge of research within the content discipline is required as the basis for conducting instruction through inquiry and engaging students in effective inquiry [16]. It is important to support pre-service and in-service teacher to constantly improve professionalism for inquiry-based learning. This is an act of positive and promising to improve the quality of science teaching.

IV. CONCLUSION

Mentoring program for biology teachers when they prepare inquiry based teaching generated some fundamental inquiry abilities. On average, teachers have the develop ability. Teachers' held good ability in identifying questions and concepts that guide scientific investigations also in communicating and defend a scientific argument, but very poor in use technology and mathematics to improve investigations and communications, using and searching literature, and make a physical, conceptual, and mathematical models. Teacher's performance results showed similar with inquiry ability achievements. Teachers good in engaging students by scientific question, event, or phenomena and explore students' ideas by hands on experiences similar as their fundamental inquiry abilities. Some teachers did a mini research that a first experience, but this is very exciting or promising to increase their ability to be able to perform inquiry-based learning.

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References

[1] G.E. Uno. Handbook on Teaching Undergraduate Science Courses. A Survival training Manual**.** Orlando : Saunders College Publishing. 1999

[2] National Research Council. National Science Education Standards. Washington DC: National Academy Press. 1996

[3] A. D. Johnson, 40 Inquiry Exercises for the College Biology Lab, Arlington Virginia : NSTA Press, 2009

[4] Curriculum Planning & Development Division. Science Syllabus Lower Secondary. Singapore: Ministry of Education Singapore.2007

[5] J.F. Geither, & Terry Shiverdecker, Inquiring Scientists, Inquiring Readers, Using on fiction to promote Science literacy, grades 3-5. Arlington : NSTA Press.2013.

[6] National Research Council. Inquiry and the National Science Education Standards: A Guide for Teaching and Learning. Washington, DC: National Academy Press. http://books.nap.edu/html/inquiry. 2001

[7] NSTA & AETS. Standards for Science Teacher Preparation**.** https://www.nsta.org. 1998.Accessed November 2005.

[8] M. Windschitl. Inquiry Projects in Science Teacher Education: What Can Investigative Experiences Reveal About Teacher Thinking and Eventual Classroom Practice?. *Science Education* 87:112-147. Wiley Periodicals, Inc. 2002.

[9] Jeanpierre, B, Karen Oberhauser, Carol Freeman. Characteristics of Professional Development That Effect Change in Secondary Science Teachers' Classroom Practices. *Journal of Research in Science Teaching* . 42 : p. 668–690. 2005.

[10] C.M. Klinge. A conceptual framework for mentoring in a learning organization. adult learning. 26 : 160 -166. 2015

[11] M . Zion, & Sadeh, I. Dynamic Open Inquiry Performance of High-School Biology Students. *Eurasia Journal of Mathematics, Science & Technology Education*. 6(3), p.199-214. 2010.

[12] J.H. Mc Millan & Sally Schumacher. Research in Education. US. Addison Wesley Longman. Inc. 2001.

[13] R. Roberts. Procedural understanding in biology: the 'thinking behind the doing'. Journal of Biological Education. 35(3) : 113 -117. Published online: 13 Dec 2010. http://www.tandfonline.com/.2001.

[14] S.W. Gilbert. Models Based Science Teaching. Arlington : NSTA Press. 2011.

[15] D.K.Capps, , Barbara A. Crawford, Mark A. Constas. A Review of Empirical Literature on Inquiry Professional Development: Alignment with Best Practices and a Critique of the Findings. *Journals Science Teacher Education* 23:291– 318. 2012.

[16] National Sience Teachers Association Standards for Science Teacher Preparation**.** https://www.nsta.org/preservice/docs/NSTA**.** (2003). Accessed 25 July 2015

[17] Perin, Suzanne. Comparison of guided and open inquiry methods. Reseach brief. 2015. Retrieved from http://www.relatingresearchtopractice.org/article/205