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THE DEVELOPMENT OF LABORATORY-BASED EARTH AND SPACE SCIENCE LEARNING MODEL TO IMPROVE SCIENCE GENERIC SKILLS OF PRE-SERVICE TEACHERS

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ABSTRACT

This study focuses on the improvement of prospective teachers' science generic skills in learning for earth and space sciences subject using a laboratory-based model. Research methods were Research and Development used mixed methods design, i.e. Embedded Experimental models. The results showed that the structure of the learning using laboratory-based model consists of four stages, namely engagement, exploration, explanation, and elaboration; with details on description of natural phenomena, the identification of questions, linking concepts with practical topic; modeling, training, exploration, interpretation of data, conclude, and communicate the procedures and results of the investigation. Moreover, the ability of science generic skills of teacher candidates was low at 52.50%. In addition, the profile of lecturer performance in learning reached 55%. Also, the condition of the learning environment is generally sufficient in supporting the development of laboratory activities, for example: a comfortable laboratory room for conducting the practicum. Next, 75% student agreed that for understand the material; it needs a practice in lab. As many as 70% of students agreed that practicum will increase students' understanding, although students also agreed that clarification is still required by lecturers (80%). Furthermore, 69% of the students found the materials of Earth and Space Sciences ismore attractive than other materials, although 78% said material of Earth and Space Sciences is fairly complicated and abstract. The interest of students to the material of Earth and Space Sciences is because these materials can foster curiosity (88%) as well as providing benefits to their daily life (90%). Finally, three out of four students agreed that the science generic skills can develop the ability of scientific work and critical thinking.

Keywords: earth and space sciences, science generic skills, laboratory activities, prospective primary school teachers

INTRODUCTION

The challenge of new paradigm of earth and space sciences learning requires a further development of higher order thinking skills. High order of thinking is one component in intelligence issues of the 21st century (Gonzales, P. 2009). According to Bartholomew, H. (2006), high order of thinking is expected to solve new problems in life. In addition, Etkina, E. (2010) state that capability of high order of thinking includes activity analysis, synthesis, systematic evaluation, and the ability to perform a variety of helpful predictions against natural phenomena and social life of the community.

Earth and space sciences are loaded with high-level thinking activities which can be developed through the nine kinds of generic capabilities of science proposed by Aulls, M. W; and Shore, B. M. (2008), i.e. (1) direct observation, (2) indirect observation, (3) awareness of the scale of magnitude, (4) the symbolic language, (5) the framework of logic obey the principle, (6) inference logic, (7) the law of causation, (8) mathematical modeling, and (9) establish the concept.

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Hodson, D. (1996) acknowledged the importance of generic skills in earth and space sciences learning needs the support from the curriculum in higher education institutions. It should be designed to provide a learning experience for prospective teachers to understand and develop their generic skills. Besides that, Buck and Gayle A. (2007) state that the generic capability is an ability that can be applied to various fields of knowledge. Nevertheless, the results Pujani and Liliasari, 2011) found that earth and space sciences learning in schools and in universities is not yet fully organized in laboratory activities. In line with this opinion Rosnita, et al. (2011) found that earth and space learning at several high schools in Pontianak City is dominated by lectures, discussion and assignments. Lecturers and teachers have never taught earth and space sciences through laboratory activities. Previously, Cain, S. E., and Evans, J. M. (1990) found that the learning of science in schools generally in a form of theoretical through lectures, discussions and problem-solving. In relation with this case, many common reasons such as lack of laboratory space, lack of equipment, as well as teachers/ lecturers have not been trained to implement laboratory activities.

The main problem in this research isthe effect of laboratory-based learning model in earth and space sciences on the ability of pre-service teachers' science generic skills in Pontianak. To answer these problems, the research questions are generated as follows: How to structure the learning that can improve the ability of pre-service teachers' generic skills?; How the laboratory activities can improve the ability of pre-service teachers' generic skills?; What is the profile of the ability of pre-service teachers' generic skills perspective?; What is the profile of faculty performance in earth and space sciences learning?; How is the learning environment that can supports an improvement in the ability pre-service teachers' generic skills perspective?

The strategy of earth and space sciences learning using the laboratory-based methodaims to develop scientific skills, understanding of concepts, creative thinking skills, and scientific attitudes (Gangoli and Gurumurthy, 1995). In line with this opinion Coffey, X.J; Elby, A and Levin, D.M. (2009) suggested another benefit of laboratory activities as follows: (1) To motivate and strengthen the interests and the activity of prospective teachers; (2) to train the skills to work in a laboratory; (3) to assist the understanding and (4) development of concepts; (5) to inculcate the scientific attitude.Rustaman (2005) found that the type of effective laboratory activities are (1) the type of laboratory practice to develop generic skills and techniques such as using measurement and observation tools; (2) the type of experience to improve the mastery of concepts by providing real experiences directly to the students to a natural phenomenon; for example to understand the system of movement of the sun-earth-moon it can be either verified or inductived; (3) the type of investigation using the inquiry model implementation can be used; for example an investigation of factor that influence the greenhouse effect.

The ability to conduct the laboratory activities is an important element in earth and space sciences learning (Keys, C; and Bryan, L. (2004). Earth and space science learning through laboratory activities aims to give the learning experience for prospective teachers. They also can interact with the equipment to observe and understand the natural phenomena (Mao, LS and Chang, CY. (1999). Earth and space sciences learning using laboratory-based method is relevant to develop scientific skills, improve the concept understanding andcreative thinking skills, also to grow a scientific attitude as a provision for future teachers (McDermot, LC (2009). In this regard, Nugent, G; et al. (2008) assert that the purpose of the laboratory-based learning inearth and space science for prospective teachers is to give them an activities of observing the natural phenomena, to develop understanding of what is observed and connecting scientific knowledge with critical thinking skills, and also to make them feel happy and excited (joyfull) in learning.

The approaches of laboratory operations are distinguished on inductive and deductive method (Pyle, EJ (2008). The inductiveapproach is a laboratory activity to establish principles, generalizations or theory of the relation of facts. Also, the inductive approach provides the opportunity to prospective teachers to develop the concept, principles, and laws through first hand experience before finding the ideas discussed in the classroom. In the other hand, the deductive approach or verification aims to validate the principle or theory comparing with facts. Deductive activity is the most common approach in scientific lectures to confirm the concept, principles, and laws that have been discussed in class discussions (Ramsey, J. 2003).

Gautier, C and Rebich, S. (2005) found that laboratory-based science learning give the positive impact, producing a complete understanding and meaningful, both the content and skills. In addition, Hoban, G. F. (2007) argued about the characteristics of laboratory activities which are should be authentic and show the importance of data. Also, it must provide the collaboration between teachers and students, connecting students with local communities, demonstrating behavioral science, developing students' abilities, exploring the question of the students, constructing explanations and concepts based on the data, and applying the scientific knowledge.

Science generic capability is a result of a combination between intellectual abilities and the complex interaction of the knowledge and skills (Stasz, C. et al., 2001). It can be applied in every fieldto obtain knowledge and skills in a relatively long time (Drury, 1997). According to Abraham, I and Millar, R. (2008), the science generic skills can be improved in earth and space sciences learning. In line with this opinion, Gerace W.J and Beaty, I.D. (2005); Brotosiswojo, B.S. (2000); Rice, J and Neureither, B. (2006)proposed nine generic skills aspect of science, i.e. (1) direct observation, the observed object directly e.g. observation of the sun, earth, moon and other celestial objects in the sky; (2) indirect observation, i.e. the specific objects that require tools, due to the limitations of sensory organ. For example telescopes, magnifying glass, thermometer, compass, stop watch, hydrometer, and others. (3) Awareness of the scale of magnitude can be developed through investigation trial in earthquake seismograph scale reading; (4) The symbolic language, such as information from graphs, drawings, charts, or diagrams, understanding coordinate systems and symbols. For example: zenith (Z), nadir (N), the azimuth (a), high-Star (h), the declination angle (δ), the north (N), South (S), East (E) and West (W); (5) inference logic, which concluded activities or suspect using the logic of the data or the results of observation; (6) The framework of logic obey the principle is the ability to think systematically based on the regularity of natural phenomena. Example: Pluto is no longer included as a planet where its orbit is known cutting the Neptune orbit. (7) The causal link, the belief that natural phenomena are interrelated in a pattern of cause and effect. Example: an earthquake due to the movement of lithospheric plates; (8) Modelling, namely simplification efforts on something that is expected to help understand it better. For example the use of the earth as a globe, Stellarium as a model of the universe, weather and atmospheric models. The mathematical model of Newton's Law of Universal Gravitation ; (9) Developing the concept, i.e. theability to interpret the laws, rules, concepts based on observational data, and others

METHOD

This study used the development of research from Gall, M.D; Gall, J.P; and Borg, W.R., in four stages, namely the preliminary study stage, designing, development of design, and phases testing. Also, this study was a preliminary study to design the learning models. This research was held on the Program of Primary School Teacher Education Degree students in the Faculty of Teaching and Education University Tanjongpura. A total of 30 students at sixth semesterwere testedfor their science generic skills, and 50 students were tested for questionnaire. The data collection was performed by testing the generic science skills using the instruments such as multiple choice, questionnaires, and interviews. Data were analyzed using triangulation mixed-methods design (Creswell, 2008) which was to simultaneously analyze the quantitative and qualitative data as well as aggregated data.

The operational definition: science generic skills are the result of a complex interaction between knowledge (knowledge) and skills (skills) required for mastery of interaction repeatedly and relatively last in a long period. Science generic skills are developed including direct observation, indirect observation, and awareness of the scale of magnitude, symbolic language, logical inference, causality, and modeling. This research variables captured by the science generic skills tests.

RESULT AND DISCUSSION

Structural model of earth and space sciences learning using laboratory-based isshown in the following figure.

Figure 1. Structure of earth and space sciences learning for science generic skills improvement

Six laboratory activities were set in addition to compliance with the curriculum, considering the recommendations of the experts as well as the equipment available in the laboratory and also contextual aspects. The following topics were described with learning goals. 1) Global warming: the student investigation can conclude that global warming is caused by the greenhouse effect because of the concentration levels of carbon dioxide (CO_2) in the atmosphere has exceeded the tolerance threshold; 2) weather and climate: through observation to BMKG of West Kalimantan province, students get to know the means of measuring the rainfall pattern, evaporation, temperature, humidity, wind direction and speed, as well as the basic of measuring equipment; 3) The water cycle: through student inquiry, it can be concluded that the process of water cycle affected by solar radiation, the source of water, evaporation of cloud formation, and rainfall; 4) weathering and erosion: through student inquiry, it can be concluded that the weathering and erosion are caused by fluctuating climatic factors such as temperature, wind, humidity, and precipitation; 5) miraculously the sun: through student inquiry, it can be concluded that the sun do daily apparent motion that causes day and night; 6) equinox: through the investigation to the Equator Monument, the student can prove that on the day of culmination (equinox) every March 21 at 12.00 there is no shadow of the sun, since the sun's position is directly above the equator.

Profile of Science Generic Skills on Prospective teachers is shown in Figure 2. The mastery of prospective teachers in the topic of laboratory activities is shown in Figure 3. In Figure 2, it is shown that the highest score was in the topic of water cycle and green hous effect reaching 80 and 70, respectively; whereas the rocks, rainfall pattern, and erosion reached 60.

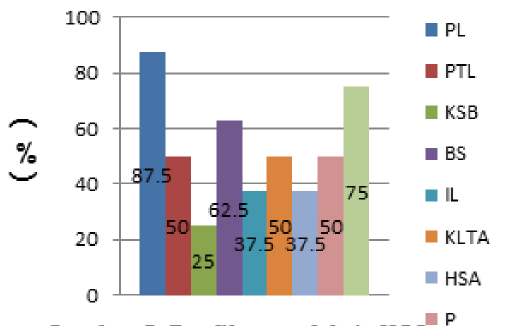

Figure 2. Perspective profil of Science Generic Skills.

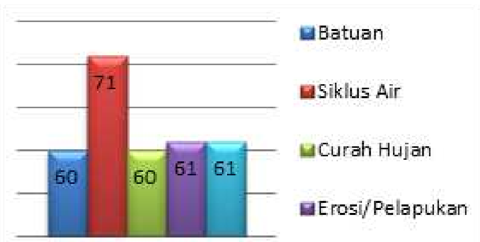

Figure 3. Mastery of materials or topic (score).

Figure 2 shows the low level on science generic skills of prospective teacherswith an average percentage of 52.80%. Two observations on rocky material and water cycle shows the highest average score direct observation and applying the concept which reached 87.5% and 75%, respectively. The other science generic skills while others were still under 65%, science generic skills on the awareness of the magnitude scale only reached 25%. The indirect observation of science generic skills showed 50%, symbolic language at 62.5%, inference logic at 37.5%, frame logic obey the principle at 50%, causality at 37.5%, and modeling at 50%. The low science generic skills of the prospective teachers are possible when the learning process is conducted with lecturer as the center of learning.

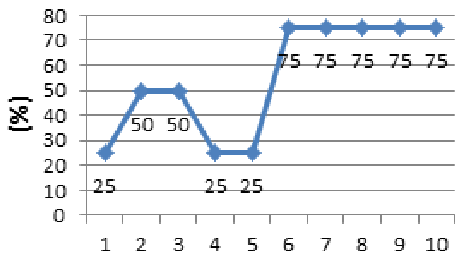

Figure 4. Lecturer performance profile

Description:

1. Opening
2. Information of learning purposes
3. Asking questions
4. Enable MHS
5. Involve MHS
6. Mastering the material
7. The effectiveness of the media / resources
8. Strategy
9. Disclosure
10. Clarification

Figure 4 shows that the performance of lecturers, especially in developing the liveliness for pre-service teachers needs to be improved. Meanwhile, the profile of lecturer performance based on the development efforts on science generic skills of prospective teachers; it shows almost all the lecturers never conduct the laboratory activities on earth and space sciences subject. The overall learning models for this subject use lectures, assignments, presentations for delivering the information.

CONCLUSION

Earth and space sciences subject structure in this study consists of four stages, i.e. 1) engagement, 2) exploration, 3) explanation, and 4) elaboration; with details of indicator for teacher candidates include: to describe of natural phenomena, toidentify the questions, linking the concepts with practical topic; modeling, training, exploration, interpretation of data, to conclude, and to communicate the procedures and results of the investigation.

The profile of generic science skills of pre-service teacher was still low with an average percentage at 52.50%. The low result is probably due to lecturers' dominance in learning activities. Profile of lecturer performance earth and space science subject was low. Almost all lecturers never conduct the laboratory activities in this subject. The obstacles faced by lecturers caused by several things, for example, (1) small portion of the earth and space sciences study materials, (2) the lack of supporting facilities, (3) the lack of skills of lecturers to conduct laboratory activities, and (4) lecturers are less motivated to make the teaching props.

Generally, the environmental conditions with adequate learning support is needed for the development of laboratory activities, for example a comfortable laboratoryroom that allows to perform group activities. Three out of four students agreed that in order to understand the material, earth and space sciences practicum is needed, thus they are not only memorize but also practicing using interactive media. More than half of students agreed that the practicum will increasethe students' understanding, although students also agreed that clarification is still required by the lecturers (80%).

The attitude of students to the lecture material was at 69%, the students found that the earth and space sciences material is more attractive than other materials, although 78% students said that this subject is quite complicated and abstract. However, the interest of students to this subject fosters their curiosity (88%) and providesbenefits for their daily life (90%). 75% students agreed that earth and space sciencesdeveloped the ability of scientific work and critical thinking skills.

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