Measuring Students' Science Inquiry Skills through Designing and Experimenting on Ecosystem Materials: A Quasi-Experiment

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Research Article

Measuring Students' Science Inquiry Skills through Designing and Experimenting on Ecosystem Materials: A Quasi-Experiment

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Abstract

A one-group quasi-experimental design was used to investigate the effect of the inquiry model on students' science process skills (N=70) through experimental planning and experiment execution. Hence, the Posttest Only Control Design was determined to answer the research questions. Seventy students were selected by random cluster sampling. Data were collected with multiple-choice questions (n=23) which were integrated with two indicators, namely experimental planning and research implementation. The results significantly impacted planning experiments and conducting student experiments by using the research learning model. The average post-test score for practical class science process skills was 79.6, while the control class was 65.34. In addition, t(count) = 4.96 while t(table) = 2.385 obtained t(count) when testing the hypothesis by t-test (0.1%). Overall, our research provides clear evidence of the importance of research models in science learning and suggests the need for assessment methods to investigate student science process skills.

Keywords

Ecosystem; Experiment; Inquiry model; Science process skills

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Introduction

Natural Science is one of the subjects in school that contains abstract theories, facts, concepts, processes, and laws (Chiappin, 2018; Dilworth, 1994). As part of science, the learning process of biology emphasizes science process skills (Addis & Powell-Coffman, 2018; McComas, 2003). Science process skills as an approach to learning are essential because they foster experiences other than learning (Dikici, Özdemir, & Clark, 2020). Given the increasing number of biology laboratories, it is necessary to increase learning effectiveness, especially cognitive learning outcomes supported by good skills and attitudes and behaviour. Downing and Filer (1999) It is crucial to master science process skills because as science develops, it is no longer possible to teach facts and concepts to students. Students find it easier to understand abstract concepts if the learning process uses concrete objects and can directly experiment independently (Downing & Gifford, 1996).

PISA (Program for International Student Assessment) data shows that Indonesia is in the 70th rank out of 78 countries in science (OECD, 2019). These data show that Indonesia is still lagging in science and requires special attention and strategies to increase its science ranking. The inquiry learning model can encourage students to take an active role in the learning process and solve problems themselves with scientific steps and improve students' science process skills (Shahali et al., 2017). The inquiry learning model is a series of learning activities that emphasize critical and analytical thinking processes to seek answers to a question in question (Martín-Gámez, Acebal, & Prieto, 2020; Stylinski et al., 2020). The inquiry learning model can build a constructivist paradigm that emphasizes the active learning of students (Arsal, 2017). Furthermore, inquiry learning can provoke students 'critical thinking by asking several questions that can confuse and make students interested in answering questions and can lead to hypothesis submission, from submitting these hypotheses can be tested through experiments and can develop students' science process skills (Gyllenpalm & Wickman, 2011; Weaver & Tuten, 2014).

From the aspect of the process, science is essentially a method to acquire knowledge in a certain way. The process is performed by scientific steps to experiment (Reith & Nehring, 2020). In the scientific step, research design skills are required to produce something valuable and meaningful. Science process skills have been described as mental, physical, and competency skills that serve as tools for problem-solving in science learning (Shahali et al., 2017). The syntax in the inquiry learning model consists of an orientation, formulating problems, proposing hypotheses, collecting data, testing hypotheses, and formulating conclusions (Reith & Nehring, 2020).

Experimental activities are activities of testing hypotheses or predictions so that the related variables must be maintained and controlled to remain the same, except for the independent variables (Reith & Nehring, 2020). In addition, the hypothesis being tested must be sourced from existing facts, concepts, and scientific principles so that information can be obtained that the hypothesis is rejected or accepted (Gyllenpalm & Wickman, 2011). Science process skills play a role in developing students' potential and scientific concepts in the learning process. Here, the teacher also develops students' science process skills with all their experiences (McComas, 2003; Shahali et al., 2017). Despite the many reform efforts made by teachers, there are still many unclear understandings of inquiry in science education (Capps & Crawford, 2013). Inquiry learning model can build awareness of every discussion, communication problems can be overcome, build opinion skills, know one another and through a group, work can build students' critical thinking (Zhang, 2015). Therefore, measuring, designing, and conducting experiments is crucial to ensure that students' science processing skills occur correctly. Although science process skills are often investigated by various scientific steps, as far as we are concerned, the effects of skills in designing and conducting inquiry-based learning experiments are scanty. This study was designed to know the effect of the inquiry learning model on the science process skills of designing and conducting experiments. In this study, we combined two science skills for inquiry emphasis.

Method

Research Design and Participants

We collected data from a science program for tenth-grade high school students organized by a private school in a metropolitan city in Jakarta, Indonesia. Data were recorded in the even semester of the 2019/2020 academic year from the two treatment groups, which did not influence each other. For that matter, a Quasi-experimental design (Monroe, Hall, & Li, 2014) with pretest and post-test was used to collect data. A total of 70 participants were involved in this study. The participants were divided into two, namely the control group (n = 35) and the treatment group (n = 35). The average participant was 15 years old. All participants have experienced learning in the science program for one semester. The research sample was only taken from two science classes in one school. However, these small experiments can help future research to develop scientific insights. The characteristics of other program participants were recorded as additional data.

Analysis Data

Data was collected from the test results after the entire teaching and learning process (post-test). The instrument used was 23 multiple choice questions with five answer choice options: a, b, c, d, and e. After the score of science process skills is processed to obtain a percentage. We determined the number and percentage (relative to the total sample size) focused on skills assessment or data validation. Normality test, homogeneity test, and t-test for hypothesis testing are also applied.

Result

The results of the measurement of science process skills obtained the average value of science process skills in the control class of 65.34 with the highest score of 78 and the lowest of 52, while in the experimental class, the average value of science process skills was 79.6 with the highest score of 95 and the lowest of 65. The control class whose learning did not use the inquiry model had lower science processing skills than the experimental class. A comparison of the types of science process skills in the experimental and control classes shown in Figure 1.

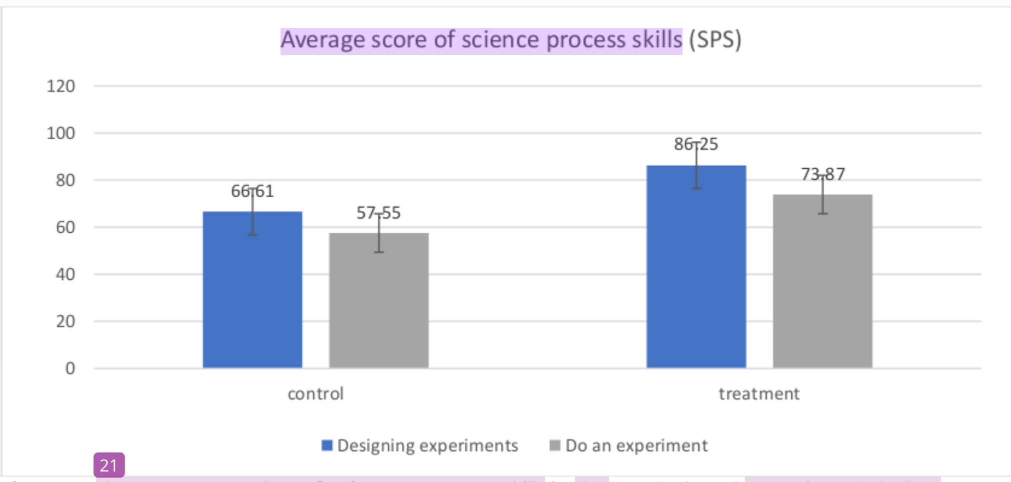

Figure 1. The average value of science process skills in the control and experimental class

Figure 1. shows the percentage of students' science process skills in the experimental class on indicators of designing experiments (86.25%) and indicators of conducting experiments (73.87%). For the record, designing an experiment in the control class is 66.61%, and the indicator is experimenting with 57.55%. The diagram shows that the experimental class has better science process skills than the control class on each indicator.

The normality test data analysis shows that the experimental class's test results are obtained X^2_{count} =5,85 and X^2_{table} = 11,3. Whereas in the control class the score was obtained X^2_{count} = 5,34 and X^2_{table}= 11,3. The results of the normality test for the two groups were classified as normal. While the homogeneity test results obtained the value of f_{count} = 1 and f_{table} = 2.264, the two variances are normal. Based on the results of the data analysis prerequisite test that has been carried out, where the two groups were normal, and the variance is homogeneous, then the hypothesis testing is carried out using the t-test with the results of t_{count} = 4.96 and $t_{0.99\ (68)}$ = 2.385 which results in very data differences significantly.

Discussion

Data analysis and hypothesis testing show that students' science process skills using the inquiry learning model has a better mastery level than using conventional learning. In all indicators of science process skills, the experimental class had better abilities than the control group. In the learning process, the experimental group carries out each syntax of the inquiry learning model, including orientation, formulating problems, proposing hypotheses, collecting data, testing hypotheses, and formulating conclusions that can train students' science process skills.
As for the control class, students tend to be passive when learning occurs because they only listen to material from the teacher and have group discussions that initially go well. Over time, it feels boring. The effectiveness of the application of the inquiry learning model that has been applied in the experimental class is in line with Arsal (2017) states that the main emphasis in the inquiry-based learning process lies in the ability of students to understand, then identify carefully and thoroughly, then end by providing answers or solutions to the problems presented.
Based on Figure 1, the experimental class and control class mean the highest percentage value on the science process skills indicator in designing the experiment. This is because the experimental class has implemented the inquiry learning model syntax that supports science process skills on indicators of designing experiments, namely in the phase of formulating problems, proposing hypotheses, and collecting data. The percentage of science process skills in planning research is low because there is the only syntax for collecting data in the control class. The syntax is still not supported for developing science process skills in planning research. Experiment planning skills are strongly influenced by the ability to formulate problems and formulate hypotheses (Gyllenpalm & Wickman, 2011).
The results of our study indicate that the experimental class has a better percentage value than the control class. This is because the experimental class in the learning process has carried out the syntax of the inquiry learning model, namely in the phase of testing hypotheses and formulating conclusions. The control class learning steps related to the skills to carry out experiments are only at the conclusion stage (Bhat, 2020; Conradie et al., 2020; Gyllenpalm & Wickman, 2011; Reith & Nehring, 2020; Stylinski et al., 2020). This is in line with the statement Gyllenpalm and Wickman (2011) that experimental activities are hypothesis testing or prediction activities. The related variables must be maintained and controlled in experimental activities to remain the same, except for the independent variables (Monroe et al., 2016). Therefore, the percentage of science process skills in researching the experimental class is higher than the control class.
Overall the indicators of science process skills planning experiments were higher than other indicators of process skills. For each indicator of science process skills, the most superior post-test results were the experimental class. Thus, we argue that inquiry learning has a good effect on improving students' science process skills, especially on ecosystems.

Conclusion

To summarise, using the inquiry learning model affects science process skills by planning experiments and conducting experiments. The percentage of science process skills indicators planning experiments and conducting experiments in the experimental class was 86.25% and 73.87%, respectively. We suggest that the inquiry model can be applied to other learning materials.

References

Addis, E. A., & Powell-Coffman, J. A. (2018). Student and faculty views on process of science skills at a large, research-intensive university. *Journal of College Science Teaching, 47*(4), 72-82. doi: http://dx.doi.org/10.2505/4/jcst18_047_04_72

Arsal, Z. (2017). The impact of inquiry-based learning on the critical thinking dispositions of pre-service science teachers. *International Journal of Science Education, 39*(10), 1326-1338. doi: https://doi.org/10.1080/09500693.2017.1329564

Bhat, M. A. (2020). Politics of Preventive Detention: A Case Study of Jammu and Kashmir Public Safety Act, 1978. *International Journal of Criminal Justice Sciences, 15*(1), 157-172. doi: http://dx.doi.org/10.5281/zenodo.3830303

Capps, D. K., & Crawford, B. A. (2013). Inquiry-based instruction and teaching about nature of science: Are they happening? *Journal of Science Teacher Education, 24*(3), 497-526. doi: https://doi.org/10.1007/s10972-012-9314-z

Chiappin, J. R. (2018). A Methodology for the Theory of Science and Its Application to the Reconstruction of the Metaphysical Level of Duhem's Theory of Science. *Revista Portuguesa de Filosofia, 74*(1), 19-58. doi: https://www.jstor.org/stable/26405917

Conradie, L., Pitchford, M., Barnes, J., & Short, E. (2020). Cyberharassment awareness course (cybac): Influences from domestic abuse perpetrator programmes for its design and function. *International Journal of Cyber Criminology, 14*(1), 220-235. doi: http://dx.doi.org/10.5281/zenodo.3750140

Dikici, A., Özdemir, G., & Clark, D. B. (2020). The relationship between demographic variables and scientific creativity: mediating and moderating roles of scientific process skills. *Research in Science Education, 50*(5), 2055-2079. doi: https://doi.org/10.1007/s11165-018-9763-2

Dilworth, C. (1994). Principles, laws, theories and the metaphysics of science. *Synthese: An International Journal for Epistemology, Methodology and Philosophy of Science, 101*(2), 223-247. doi: https://doi.org/10.1007/BF01064018

Downing, J. E., & Filer, J. D. (1999). Science process skills and attitudes of preservice elementary teachers. *Journal of Elementary Science Education, 11*(2), 57-64. doi: https://doi.org/10.1007/BF03173838

Downing, J. E., & Gifford, V. (1996). An investigation of preservice teachers' science process skills and questioning strategies used during a demonstration science discovery lesson. *Journal of Elementary Science Education, 8*(1), 64. doi: https://doi.org/10.1007/BF03173741

Gyllenpalm, J., & Wickman, P. O. (2011). The uses of the term hypothesis and the inquiry emphasis conflation in Science Teacher Education. *International Journal of Science Education, 33*(14), 1993-2015. doi: https://doi.org/10.1080/09500693.2010.538938

Martín-Gámez, C., Acebal, M. d. C., & Prieto, T. (2020). Developing the concept of 'ecosystem'through inquiry-based learning: a study of pre-service primary teachers. *Journal of Biological Education, 54*(2), 147-161. doi: https://doi.org/10.1080/00219266.2018.1554596

McComas, W. F. (2003). A textbook case of the nature of science: Laws and theories in the science of biology. *International Journal of Science and Mathematics Education, 1*(2), 141-155. doi: https://doi.org/10.1023/B:IJMA.0000016848.93930.9c

Monroe, M. C., Hall, S., & Li, C. J. (2016). Can climate change enhance biology lessons? A quasi-experiment. *Applied Environmental Education & Communication, 15*(2), 125-137. doi: https://doi.org/10.1080/1533015X.2016.1164095

OECD. (2019). *PISA 2018 Results (Volume III): What School Life Means for Students' Lives, PISA*. Paris: OECD Publishing doi: https://doi.org/10.1787/acd78851-en.

Reith, M., & Nehring, A. (2020). Scientific reasoning and views on the nature of scientific inquiry: testing a new framework to understand and model epistemic cognition in science. *International Journal of Science Education, 42*(16), 2716-2741. doi: https://doi.org/10.1080/09500693.2020.1834168

Shahali, E. H., Halim, L., Treagust, D. F., Won, M., & Chandrasegaran, A. (2017). Primary school teachers' understanding of science process skills in relation to their teaching qualifications and teaching experience. *Research in Science Education, 47*(2), 257-281. doi: https://doi.org/10.1007/s11165-015-9500-z

Stylinski, C. D., Peterman, K., Phillips, T., Linhart, J., & Becker-Klein, R. (2020). Assessing science inquiry skills of citizen science volunteers: a snapshot of the field. *International Journal of Science Education, Part B, 10*(1), 77-92. doi: https://doi.org/10.1080/21548455.2020.1719288

Weaver, K. D., & Tuten, J. H. (2014). The critical inquiry imperative: information literacy and critical inquiry as complementary concepts in higher education. *College & Undergraduate Libraries, 21*(2), 136-144. doi: https://doi.org/10.1080/10691316.2014.906779

Zhang, Q. (2015). *Pacific Rim Objective Measurement Symposium (PROMS) 2015 Conference Proceedings* (1 ed.). Singapore: Springer doi: https://doi.org/10.1007/978-981-10-1687-5.

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