



STUDENTS' ABILITY OF SCIENTIFIC INQUIRY WITH MULTIMEDIA IN CELL REPRODUCTION MATERIALS

R. Cahyani*¹, Y. Hendriani²

¹Universitas Islam Nusantara, Indonesia

²Pusat Pengembangan dan Pemberdayaan Pendidik dan Tenaga Kependidikan, Bandung, Indonesia

DOI: 10.15294/jpii.v6i2.9484

Accepted: April 17th, 2017. Approved: July 30th, 2017. Published: October 17th, 2017.

ABSTRACT

This study aims to: (1) explore students' learning achievement based on scientific inquiry learning on the materials of cell reproduction reflected on pre-test and post-test; (2) obtain the achievements of scientific inquiry activity based on the different time of problem distribution; and (3) analyze students' ability in scientific inquiry activities based on the indicators of scientific inquiry in the different time of problem distribution. The design was research & development. The participants were two classes of PGMI. The research data were pre-test and posttest obtained from close-ended test and scientific inquiry activities obtained from student worksheet. Research shows that learning outcomes of students in each class increases, though there is not any significant difference in the increase indicated in the learning outcomes between the two classes. The technique of distributing students' work in different time influence the students' scientific inquiry activity. Communication is a dominant indicator of the successful scientific inquiry activities in both classes. Using the data and creating an image are other indicators affecting the scientific activity.

© 2017 Science Education Study Program FMIPA UNNES Semarang

Keywords: scientific inquiry; cell reproduction

INTRODUCTION

Cells are the smallest parts that make up human bodies. Each cell can multiply by forming new cells through a process called cell division or cell reproduction. In single-cell organisms (unicellular), such as bacteria and protozoa, the process of cell division is a way to multiply. In multicellular organisms, cell division leads to increased body cells. Cell division is an important factor in our lives (Campbell et al., 2002; Pelczar, 2008). The study of cell reproduction mainly related to microorganisms is important to do because it is closely associated with the quality of human life that is the spread of disease. Attitudes toward science in understanding environmental, medical, and social issues are essential to the prosperity of society (Shah & Khan, 2015).

Teaching effective science depends on the availability and organization of materials, tools, media, and technology. The National Research Council (NRC) recommends that teachers have the authority to choose the right materials, media, tools, and technology in teaching their students. Students are also taught to evaluate and interpret the information they gain through many resources in order to develop their scientific understanding. Meanwhile, Thoron & Myers (2012) said that teachers should be able to create a learning environment based on real life problems, to ask questions from learners and to expand their thinking outside the context of the lesson.

Cell reproduction materials can be learned with the help of multimedia to improve students' understanding. A conventional teaching method that occurs in the classroom is monotonous, less participatory and often unable to arouse students' curiosity and interest, especially in science sub-

*Address Correspondence:
E-mail: cahyanirianti@yahoo.com

jects such as Biology (Aggarwal & Dutt, 2014). Mayer (2003) suggests that students learn from well-designed multimedia presentations rather than just traditional oral or text presentations. Aggarwal & Dutt (2014) delivering instructions through multimedia presentations offers tremendous opportunities in acquiring biological concepts as they as educators are able to present better information, examples, illustrations, to solve problems for students, and to build knowledge, which is to help to illustrate abstract conceptual principles.

Multimedia becomes an important tool in biological sciences because it has the potential to provide new learning environments and pedagogical applications to foster student interest, involve students in the research process, encourage critical thinking, problem-solving skills, and develop conceptual understanding of cell biology topics (Bockholt et al., 2003). The results of study concluded that the potential of multimedia related to the cancer cell in Biology could facilitate student learning. Multimedia is able to present active learning towards different learning styles and the most effective pedagogy for learning science. Various designs of multimedia can serve as developers, enthusiastic feedback from teachers and students, learning motivation and a sense of responsibility in educational and research development innovation (Liu et al., 2014).

Science as a process is related to the way of working to gain products. It is called scientific process from which scientific products can be gained. Science is an empirical knowledge discussing facts and environmental phenomena. That is why the learning process should provide facts which means that the learning process does not only provide verbal process like what happens in traditional learning. Teaching science in elementary school means teaching the mastery of products and process as well as teaching the scientific attitude (Yuhanna & Retno, 2016). Ideally, all teachers should have all competencies in the scientific work to improve the quality of learning both in knowledge and social life. This is because the teachers are the head spears of teaching. Started from studying in a teacher department, scientific work should be taught in solving the faced problems (Ariesta, 2011).

Meanwhile, the Indonesian government through the 2013 curriculum emphasizes the learning process at the school to implement a student-centered learning scientific method. Through the implementation of scientific methods inquiry, problem-based learning, project-based learning, and discovery learning, Natural Science and So-

cial Science subjects are developed as an integrative science and integrative social studies, not as a separate disciplinary education. Learning is applicative and potential to improve thinking ability, learning ability, curiosity, and to foster a caring and responsible attitude towards social and natural environment.

The emphasis of this learning method is in line with the National Research Council (1996). Standard B of the National Research Council (1996) states that science educators should encourage Scientific Inquiry Skill, as well as curiosity, openness to new ideas and data, and skepticism that characterizes science. Furthermore, National Research Council (1996) states that scientific inquiry is a multiphase activity involving observation; asking question; examining books and other sources of information to see what is already known; planning an investigation; reviewing what is already known in experimental evidence; using tools to collect, analyze and interpret data; proposing answers, explanations, predictions; and, communicating the results. Scientific inquiry requires the identification of assumptions, the use of critical and logical thinking, and considerations of the explanation.

Many educators are less likely to adopt inquiry learning on the consideration that it is still difficult to apply it to learning materials. Edelson et al. (1999) in their research suggests that the implementation of inquiry learning in the classroom presents a number of significant challenges. The challenges are: (1) lack of motivation; (2) low accessibility; (3) low knowledge background that makes investigation becomes less meaningful; (4) activity management capability; and (5) practical constraints of the learning environment. Other reasons that often arise include the lack of time to conduct an investigation. The use of multimedia is expected to streamline time and as a source of practical information to conduct investigations.

Referring to the usefulness of multimedia and inquiry model in the learning process, it is necessary to conduct a study about students' multimedia-assisted scientific inquiry ability on learning cell reproduction. The objectives of the research are: (1) to investigate the results of student learning on scientific inquiry on cell reproduction material based on the pre-test and post-test; (2) to investigate the results of scientific inquiry activities based on the time of giving different problems; and (3) to analyze students' scientific inquiry ability based on scientific inquiry activity indicator with problems distributed in different time.

METHODS

The type of research is Research and Development (R&D) because this study developed the program and implemented it in several classes. The research implementation used quasi-experimental design because there was no randomness in involving the participants. The subject of the research consisted of two classes of PGMI (Islamic elementary school teacher preparatory program) students who took IPA 2 subject on the topic of Cell Reproduction. The research design is pre-test post-test nonequivalent control group design (Creswell, 2016).

The selection of the classes is based on the equal abilities among them. One class is used as an experimental class consisting of 38 students, and the other class of 35 students as a control group. Both classes use scientific inquiry learning with multimedia on cell reproduction materials. The difference is that the student worksheet given to the Experimental class is given prior to multimedia viewing (Before Watching=BW). In the control class, student worksheet is given after multimedia viewing (After Watching=AW). The learning stages in the study: (1) conducting a pre-test in both classes to determine the initial ability of students; (2) implementing scientific inquiry works on the students worksheet; and (3) implementing post-test in both classes.

The research parameters are learning outcomes obtained from pre-test and post-test in the form of multiple choice questions based on scientific inquiry, while scientific inquiry activities are obtained from the work of the student worksheet during the learning process. Scientific Inquiry in-

dicator refers to what National Research Council (1996) offers, which includes collecting information/data, solving problems, creating variables, formulating hypotheses, graphs/tables, calculating, communicating, predicting and making conclusions. Multimedia is used as a source to explore the data. The assessment on student worksheet used a 0-5 rubric score adapted from the National Research Council (1996) and Popham (2011).

The data were analyzed by using SPSS 17 with $\alpha = .05$. The data obtained were averaged, then were described. Pre-test and post-test data from the two subsequent classes were compared with the Independent Sample t-Test. To test the significance of each learning technique, one sample t-test was used (Uyanto, 2009). Data on scientific work activities through student worksheet were analyzed on the basis of their respective indicators offered by National Research Council.

RESULTS AND DISCUSSIONS

This study obtained the data from pretest and posttest as well as learning outcomes from the two classes with different learning techniques as presented in Table 1.

The table shows that the value of pre-test in the control class (AW) is slightly more varied compared with the experimental class (BW). This is indicated by the standard deviation values of each class on $sd=6.78$ and $sd=5.23$. The difference also occurs in the post-test, which indicated that the students' ability in the control class (AW) is slightly more variable than the experimental class (BW).

Table 1. Description of Pretest and Posttest Data Learning Outcomes on Scientific Ability

Description	Pre-Test		Post-Test	
	BW N=38	AW N=35	BW N=38	AW N=35
Mean	55,74	56,23	80,71	78,03
Min	50,00	44,00	72,00	67,00
Max	67,00	67,00	89,00	89,00
St. Dev.	5,23	6,78	4,13	4,97
t-test	P= 0,655>0,05		P=0,15>0,05	

The description on the pre-test and post-test of the experimental class (BW) is presented in Table 2, while in the control class (AW) is presented in Table 3. The data in Table 2 and Table 3 are used to find out the comparison of the learning outcomes based on the teaching method delivered during the lesson.

There was an increase in the learning outcomes of the experimental class (BW) from 55.74 to 80.71 (which improved by 24.97). Increased learning results also occur in the control class (AW) from 56.23 to 78.03 (which improved by 21.8).

Table 2. Description of Pretest and Postes Learning Outcomes BW Class

Description	Pretest	Postest	N
Mean	55,74	80,71	Sig 0,00<0,05
Min	50,00	72,00	Berbeda
Max	67,00	89,00	N= 38
St. Dev.	5,23	4,13	

Table 3. Description of Pretest and Postest Data of AW Class Learning Outcomes

Description	Pretest	Postest	Note
Mean	56,23	78,03	Sig 0,00<0,05
Min	44,00	67,00	Berbeda
Max	67,00	89,00	N =35
St. Dev.	6,78	4,97	

Table 4. Description of the Results of Scientific Work Activities during Learning (Max value=45)

Description	BW	AW	Note
Mean	35,13	32,09	Berbeda
Min	32,00	30,00	
Max	38,00	34,00	
St. Dev.	1,29	1,04	

Table 5. Results of Scientific Inquiry Activities during the learning process on the basis of indicators

Indicators	BW	AW	Note
Using Data	4,26	3,09	Different
Formulating Problems	3,00	3,06	Same
Defining Variables	4,47	4,26	Same
Formulating Hypotheses	3,63	3,66	Same
Communicating	4,63	4,60	Same
Creating Images/Tables	4,29	2,71	Different
Calculating	3,71	3,66	Same
Predicting	3,89	3,80	Same
Concluding	3,24	3,26	Same

Data on the results of scientific inquiry activities obtained from the student worksheet during the learning process are presented in Table 4. The assessment was made on the basis of rubric ranging from 0 to 5. The maximum value of scientific inquiry activity is 45. In contrast to the achieved learning outcomes, the results of scientific inquiry activities in

the experimental class (BW) is more diverse than the control class. The data on the diversity of outcomes on the basis of scientific inquiry indicators in the activities are explained and shown in Table 5. The lowest achievements on the scientific inquiry activity are in the experimental class (BW), indicated on the indicator of formulating the problem (3.00) and the highest value is in the indicator of communicating (4.63). For the control class (AW), the lowest result of scientific inquiry activity is on making the image/table (2.71), and the highest indicator is the indicator of communicating.

Based on the objectives of the study, there are three issues that need to be addressed: (1) the comparison between pretest and post-test of learning outcomes in both classes and in each class; (2) comparison of scientific inquiry activities based on learning methods; (3) comparison of scientific inquiry activities based on the respective indicators. Based on the data in Table 1, the pre-test of the experimental class (BW) and control class (AW) were 55.74 and 56.23. The result of statistical analysis on the comparison of pretest between the two classes shows the value of $p = .655 > .05$, so there is no statistically difference of the result in the pre-test of both classes. It shows that the initial ability of learning outcomes of both classes is equivalent. Early equal capacity became capital to compare post-test results in both classes (Creswell, 2016: 234). The result of statistic analysis on the post-test concluded at $p = .15 > .05$.

The result shows that there is no statistical difference in the result of post-test in both classes. Both classes show the same competition and have the same opportunities in working on the posttest. Although results of post-test in the two classes did not indicate any difference, when reviewing the results of pre-test and post-test in each class, there was a significant improvement in learning outcomes, indicated at $p = .00 < .05$. It indicates that during the learning process with the inquiry model, there is a change of learning process, that is the increase of memory activity, motivation and reflexion (Wijaya, 2012). The inquiry learning model encourages students to learn to construct and build their knowledge from their own learning experiences.

The data on the scientific inquiry activities obtained from the student worksheet in Table 4 indicate that different techniques show significantly different results of scientific work activity with the Wilcoxon Test, $p = .00 < .05$. The experimental class encountered problems from the student worksheet before using multimedia (BW). The condition of students in BW class was at an advantage in that they have an earlier opportunity to learn the problems first. They have the opportunity to organize and make strategies to solve problems well, have the opportunity to

compile information or data needed more accurately, relevantly, according to the content of the film in the scientific inquiry activity. Inquiry learning encourages students to think critically. Probosari et al. (2012) add that critical thinking is a well-organized mental process and plays a role in the decision-making process to solve problems by analyzing and interpreting data in scientific inquiry activities. In the control class, students obtain student worksheet after the multimedia was used (AW). In this class, students did not have the opportunity to arrange the information as needed, which is accurate, precise, and short according to the content of the film. This lack of opportunity is because students are not challenged to solve the problems they face, so their mental process to organizing does not arise.

Activities to compile data/information and to interpret data become an important part of solving problems in the inquiry activities. Using accurate factual information and interpreting scientific explanations helps students to find a deeper understanding of the natural phenomena they are studying (Harris & Rooks, 2010). The activities of compiling both the data and the information of the two classes are revealed in Table 5. The ability to organize data or use data well and appropriately in the experimental class (BW) is better and significantly different ($p = .00 < .005$) than the control class (AW). This capability has implications on overall scientific inquiry activities (Table 4). In addition to the implications of the results of scientific inquiry activities as a whole, it also implicates the ability to create images/tables. The ability to create reproduction images sexually and asexually in BW class is better and is significantly different ($p = .00 < .05$) than the AW class.

Students' ability to formulate problems; to determine variables; to formulate hypotheses; to communicate; to calculate; to predict and to communicate between two classes equally were examined. The ability of inquiry activities that are not dissimilar to some of the scientific inquiry indicators in the two classes is because the lecturers facilitate the students and provide equal guided opportunities in both classes, allowing them to ask questions about issues they have not understood and later discuss it in pairs. The ability to construct, analyze, and cooperate is important and is necessary for inquiry activities (Harris & Rooks, 2010), to foster responsibility for the tasks/problems facing students. To make changes in the classroom, the lecturer should be involved in the performance, taking part in discussions, brainstorming, practicing, analyzing and reflecting. This not only gives an effect to the progress of student learning but also lecturer as a teacher. In order to facilitate professional growth, lecturers need to make observations and exchange

opinions. It is very important for lecturers to improve the learning quality, especially when lecturers aim to apply innovation in the classroom (Volkinsteine & Namsone, 2016). Based on Table 5 the highest scientific inquiry activities on the inquiry learning in both classes are in communicating. The inquiry learning model encourages many students to perform various scientific inquiry activities. The ability to ask questions, discuss, analyze data and interpret science learning is part of communicating activity. The research conducted by Familiar et al. (2013) in measuring scientific inquiry skills in Biology subject showed the ability to communicate was the second dominant activity (95%) after the activity of understanding of Biology content (100%). The lowest scientific work activity in the BW class is formulating the problem and in the AW class is creating images/tables and formulating the problem. Formulating the problem is the lowest ability in both classes. The assessment rubric for formulating the problem is:

- (5) The problem is expressed in the form of a sentence, the sentence is not double, and it contains the corresponding variable appropriately.
- (4) The problem is expressed in the form of a sentence question, the sentence is not double, and it contains less relevant/exact variables.
- (3) The problems are expressed in a sentence, double sentence, and it contains less related/exact variables.
- (2) The problem is expressed in regular expressions, in the form of multiple sentences, and it has less obvious variables.
- (1) The problems are expressed in regular expressions, multiple sentences, and it does not contain any related variables.
- (0) There are no details of the problem.

Based on the rubric, the student's weakness is to determine the variables associated with the film content. Associating the specified variable in the form of a sentence and a sentence is often found twice. The research finding is the students' learning achievement increased significantly in each class. Different learning methods on the inquiry model do not affect the improvement of student learning outcomes but affect the overall results of students' scientific inquiry activities. The dominant activity in scientific inquiry is communicating. There are two indicators of scientific inquiry that distinguish the results of scientific inquiry activities, namely communicating and creating images/tables. Scientific inquiry activities on these indicators have implications on the overall results of scientific inquiry activities.

CONCLUSION

The research produces five conclusions. First, inquiry learning with BW technique can improve the result of students' final learning and student's scientific activity. Second, inquiry learning with AW technique can improve students' results on the end of the sessions and student's scientific inquiry activity. Third, different learning techniques do not affect the improvement of students' learning outcomes. Fourth, inquiry learning produces the dominant scientific inquiry activity, which is communicating. Fifth, activities employing the use of data have implications on the overall results of scientific inquiry activities and affect the activity of making images/tables.

ACKNOWLEDGEMENT

The researchers would like to express their gratitude to the Ministry of Research, Technology and Higher Education of Republic of Indonesia, which had provided financial support through the grant of Applied Product Research no. 0299/E3/2016.

REFERENCES

- Aggarwal, V., & Dutt, S. (2014). Effectiveness of Multimedia Presentations in Acquisition of Biological Concepts. *International Journal of Education*, 3(1), 74–83.
- Ariesta, R. (2011). Pengembangan Perangkat Perkuliahan Kegiatan Laboratorium Fisika Dasar II Berbasis Inkuiri Terbimbing untuk Meningkatkan Kerja Ilmiah Mahasiswa. *Jurnal Pendidikan Fisika Indonesia*, 7(1), 62–68.
- Bockholt, S. M., West, J. P., & Bollenbacher, W. E. (2003). Cancer Cell Biology: A Student-Centered Instructional Module Exploring the Use of Multimedia to Enrich Interactive, Constructivist Learning of Science. *Cell Biology Education*, 2(1), 35–50.
- Campbell, N. A., Reece, J. B., & Mitchell, L. G. (2002). *Biologi* (5th ed.). Jakarta: Penerbit Erlangga.
- Creswell, J. W. (2016). *Research Design Pendekatan Metode Kualitatif, Kuantitatif dan Campuran*. Yogyakarta: Pustaka Pelajar.
- Edelson, D. C., Gordin, D. N. & Pea, R. D. (1999). Addressing the Challenges of Inquiry-Based Learning through Technology and Curriculum Design. *The Journal of the Learning Sciences*, 8(1), 391–450.
- Familari, M., Da Silva, K. B., Rayner, G., Young, J., Cross, A., & Blanksby, T. (2013). Scientific Inquiry Skills in First Year Biology: Building on Pre-Tertiary Skills or Back to Basics?. *International Journal of Innovation in Science and Mathematics Education (Formerly CAL-Laborate International)*, 21(1), 23–28.
- Harris, C. J., & Rooks, D. L. (2010). Managing Inquiry-Based Science: Challenges in Enacting Complex Science Instruction in Elementary and Middle School Classrooms. *Journal of Science Teacher Education*, 21(2), 227–240.
- Liu, M., Horton, L., Lee, J., Kang, J., Rosenblum, J., O'Hair, M., & Lu, C.-W. (2014). Creating A Multimedia Enhanced Problem-Based Learning Environment for Middle School Science: Voices from The Developers. *Interdisciplinary Journal of Problem-Based Learning*, 8(1), 8–16.
- Mayer, R. E. (2003). The Promise of Multimedia Learning: Using The Same Instructional Design Methods Across Different Media. *Learning and Instruction*, 13(2), 125–139.
- National Research Council. (1996). *National Science Education Standards*. Washington DC: National Academy Press.
- Pelczar, M. J. (2008). *Dasar-dasar Mikrobiologi*. Jakarta: UI Press.
- Popham, W. J. (2011). *Classroom Assessment What Teachers Need to Know*. Boston: Pearson Education.
- Probosari, R. M., Nurmiyati, N., Suciati, S., Indrowati, M., & Adi Baskoro. (2012). Peningkatan Aktivitas Belajar Mahasiswa Melalui Lesson Study pada Mata Kuliah Anatomi dan Morfologi Tumbuhan. In *Prosiding Seminar Biologi* (Vol. 9).
- Shah, I., & Khan, M. (2015). Impact of Multimedia-Aided Teaching on Students' Academic Achievement and Attitude at Elementary Level. *US-China Education Review A*, 5(5), 349–360.
- Thoron, A., & Myers, B. (2012). Effects of Inquiry-based Agriscience Instruction on Student Scientific Reasoning. *Journal of Agricultural Education*, 53(4), 156–170.
- Uyanto, S. S. (2009). *Pedoman Analisis Data dengan SPSS* (3rd ed.). Yogyakarta: Graha Ilmu.
- Volkinstein, J., & Namsone, D. L. (2016). Science Teacher Experience in Learning Team for Improvement of Inquiry Teaching Practice. In *Proceedings of ICERI 2016 Conference*.
- Wijaya, M. (2012). Pengembangan Model Pembelajaran e-Learning Berbasis Web dengan Prinsip e-Pedagogy dalam Meningkatkan Hasil Belajar. *Jurnal Pendidikan Penabur*, 19(1), 20–37.
- Yuhanna, W. L., & Retno, R. S. (2016). The Learning of Science Basic Concept by Using Scientific Inquiry to Improve Student's Thinking, Working, and Scientific Attitude Abilities. *Jurnal Pendidikan Biologi Indonesia*, 2(1), 1–9.