Building creative disposition and creative thinking skills of high school students through biological laboratory work activities based on creative research projects

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Building Creative Disposition and Creative Thinking Skills of High School Students Through Biological Laboratory Work Activities Based on Creative Research Projects

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Abstract. Research has been carried out that aims to investigate the effect of the Biology laboratory activities model based on creative research projects on high school students' creative disposition and creative thinking skills. The study used an experimental method on as many as 66 high school students in class X MIPA at one of the senior high schools in Mataram, West Nusa Tenggara. A total of 32 students were grouped as the experimental class and 34 students in the control class. The Experimental class students learn with a Biology laboratory work model based on a creative research project and a control class with a verification laboratory work model. The research data were collected using a creative disposition questionnaire and a biological creative thinking skill test. The results showed that the creative research project-based laboratory work was more evocative and significantly different from the creative biological disposition than the verification laboratory work. This laboratory work model is also better and significantly different in improving creative thinking skills than verified laboratory work. The research concludes that creative disposition and creative thinking skills can be improved through a research project-based laboratory work model. Based on these results, it is recommended for high school biology teachers to apply it in learning to foster students' scientific creativity.

INTRODUCTION

Creativity is the main component of new abilities needed in work and many other activities. Education plays a role in giving birth to creative students who will bring up innovations. Creative students will be able to provide new,

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original solutions as products of higher-order thinking. Higher-order thinking skills such as creative thinking describe a core aspect of human adaptability [1] and affect the performance of a society [2,3]. Therefore students must learn to think creatively and be creative because creativity is a demand in seeing student success in society [4].

Responding to such demands, education reform policies in Indonesia have tried to make students more creative. The KTSP curriculum was replaced with the 2013 curriculum to accommodate students' creative potential as 21st-century competencies and skills are needed today. Unfortunately, the policy has not run well, and teaching is still in the old pattern as it is also an obstacle in many other countries. In reality, learning still places a lot of emphasis on the domain of knowledge and less emphasis on creative teaching skills [5], the assessment system prefers the correct answer [6] and gives less opportunity to think about different solutions [7]. Many schools do not develop students' creative potential [8] and even suppress or turn off creativity [4]. Such habits will cause stagnation in the ability to think with a variety of answers and blunt the courage of students to have different opinions [9].

The results of the 2015 International Global Creativity Index survey indicate that the creativity of Indonesian children is very low, ranking below the countries involved in the survey [10]. Local research results also indicated that creative thinking skills as the basis for students' creativity are still far from satisfactory [7, 11, 12]. It is suspected that the trigger is related to the assessment model developed in schools. This assumption is corroborated by the results of PISA and TIMSS, which indicate that most students in Indonesia are very familiar with evaluations that use structured questions and rarely practice ill-structured problem-solving skills [13].

Science has a wide range of activities to foster creativity [14], and therefore, the science classroom should be a place where students' creativity grows [15]. Teachers must facilitate science classes in exploring students' creative potential to develop. Creative disposition as a portrait of students' creative potential can be triggered and raised through learning designed by the teacher. Therefore, every teacher needs to know and consider the creative disposition of students before designing their teaching.

Research on students' creative disposition and creative thinking skills in teaching science, especially biological science, has not been the focus of much attention. Biology learning activities through laboratory work are routine activities in schools. However, it is not able to develop students' creativity. Improvement efforts must be made so that the laboratory work does not verify facts or concepts but more than one. Science education should emphasize the importance of inquiry, and teachers should be encouraged to engage students in authentic scientific inquiry [16]. Scientific inquiry activities apply the principles of inquiry that will familiarize students with thinking and acting in diverse and different patterns.

The creative research project-based laboratory work program in biology teaching in high school is designed to provide opportunities to build students' creative dispositions. Inquiry activities familiarize students with thinking and acting as creative individuals. The laboratory work program was adapted, modified, and synthesized from the Inquiry laboratory work model [17] and project learning [18]. The program developed includes seven process stages and is characterized by a free inquiry laboratory model, providing autonomy and a social climate that supports students' creative thinking practices. Laboratory work provides a social climate and opens exploration opportunities, thus allowing students to be free and safe in exploring their creative potential [19]. The research laboratory work model developed and used to build students' scientific creativity is still rarely done, and reports are found.

RESEARCH METHOD

This research was conducted using an experimental design on 66 students of class X MIPA in one of the public high schools in Mataram, West Nusa Tenggara. Students were divided into two classes, namely the experimental class and the control class. After sampling, the experimental and control groups were given a creative disposition questionnaire and a creative thinking skills test (pretest). Furthermore, the experimental class students studied the laboratory work model based on the creative research project, and the control class students did the verification model laboratory work. The experimental class conducts laboratory work based on student worksheets in work guides for creative research projects. Students must develop and organize their group project plans and activities. Creative projects developed for practical activities result from group decisions and agreements from ideas proposed by each group member. The experimental class laboratory work model activity stage includes the following seven steps: 1) problem orientation or research questions, 2) determining the field of creative research projects, 3) proposing alternative solution ideas, 4) determining alternative group research project solutions, 5) designing and communicate creative research project plans, 6) carry out creative research project laboratory work, and 7) evaluate creative research project processes and products. This model results from adaptation, modification, and synthesis of the Inquiry laboratory work model [17] and project learning [18]. Meanwhile, the control class conducts practical learning using a verification model; students carry out practical activities using student worksheets with instructions and activity steps prepared and prepared by the teacher. After the treatment, the two groups of students were again given a creative disposition questionnaire and a creative thinking skills test as posttest.

The creative disposition questionnaire instrument was developed, covering five dimensions, namely: inquisitive, persistent, imaginative, collaboration, and disciplined [20], which are packaged in 30 questionnaire statements of the Likert scale type. The questionnaire has been tested for reliability and consistency index; each is classified as having a very high level of reliability (0.88) and an internal consistency index of 0.35-0.68; all items are consistent. Meanwhile, the test instrument for biological creative thinking skills was developed by adopting the Torrance Test for Creative Thinking [21], which includes fluency, flexibility, originality, elaboration, and synthesis. The questions were developed for the material about Bacteria with six items and had a high-reliability coefficient (0.71) and an index of consistency of items in the consistent category.

Biological creative disposition data are quantified into nominal scores ranging from 0-5 then categorized into five categories [22]. Creative thinking skills data obtained in the form of scores (0-3) are converted into values 0-100 and further categorized into five categories [23]. Changes in creative disposition and creative thinking skills are expressed as N-gain. Furthermore, the two data above are statistically tested using an independent t-test to see the differences between the experimental and control classes. All tests were carried out using software assistance from SPSS version 23.

RESULTS AND DISCUSSION

Changes in Student Biology Creative Disposition

Creative disposition is defined as a habit of thinking in students' creative thinking tendencies when facing questions or problems whose answers are not immediately known. Whether or not creative thinking behaviors appear or are shown by students in dealing with and solving problems are interpreted as the level of their creative disposition. The results of research on changes in students' creative dispositions are presented in Table 1 below.

TABLE 1. Recapitulation of pretest and posttest scores, N-Gain creative disposition of students' biology laboratory work

Components	Experiment class		Control class	
	Pre test	Post test	Pre test	Post test
Numbers of student	32	32	34	34
Mean score	3.22	3.96	3.25	3.68
Standard Deviation	0.46	0.40	0.40	0.36
Minimum score	2.03	2.83	2.33	3.03
Maximum Score	4.17	4.58	3.70	4.33
N-gain	0.38		0.24	
Independent Samples Test scores posttest creative disposition experimental and control classes (significance 0.05)			Sig. (2-tailed) = 0.002 a < 0.05 H_0 rejected	

Based on Table 1 above, the experimental and control class students had the same biological creative disposition scores before the intervention. They increased in the medium category (n-gain 0.38) in the experimental class and low (n-gain 0.24) in the post-intervention control class. The t-test results Sig. (2-tailed) 0.002 < 0.05 means that the creative research project-based laboratory work learning intervention causes changes in creative dispositions that are significantly different from changes in creative dispositions of students in the verification laboratory work class. Thus, it can be inferred that laboratory work learning activities based on creative research projects tend to arouse students' creative dispositions more than verification laboratory work activities. This result supports the previous finding that the use of the investigative laboratory work model enhances students' creative scientific thinking [24]. Studies on problem-based solving that lack definite answers foster students' creative thinking [25]. Project-based learning can stimulate the growth of creative thinking skills [26]. Creative disposition is importance to design creative learning [27].

The improvement of students' biological creative dispositions in this study cannot be separated from giving students broad learning authority so that they are really active and directly involved in every step of project activities. Students do learning while working to find and obtain solutions to the problems presented in practical activities. Students design plans and carries out their laboratory work with minimal teacher intervention. The challenging ill-defined problems as a feature of this project's laboratory work activities arouse students' curiosity. Students respond to project challenges by thinking, asking questions, and reading more literature in questioning assumptions or answering their curiosity. The ill-defined problems in learning could develop creative thinking and solve problems that require uncertainty [28]. Giving ill-defined issues in this research often brings obstacles and failures. This obstacle trains students' courage in taking risks and fosters dissatisfaction. These two things have a positive impact because they can train students to be tenacious and not give up easily. Another sign of constructive dissatisfaction is the challenge. Solving problems, generating hypotheses, designing experiments, and innovating require scientific creativity [29]. Designing experiments can increase understanding and creative freedom, which rarely occurs in cookbook model laboratory work activities [30], and is positively correlated with the emergence of new ideas [31]. It is very beneficial for students and rarely occurs in verification laboratory work classes because students are only required to solve problems whose answers already exist and can be predicted in advance. This event then affects the underdevelopment of the creative disposition of the control class students.

The two dimensions of creative disposition that experienced the highest changes, namely disciplined and inquisitive in experimental class students, showed that creative research project-based laboratory work sparked students' curiosity and encouraged students to master the content of the knowledge they were studying as shown in Fig 1. Students are encouraged to explore a lot of knowledge by reading a lot, discussing, and looking for sources of informants who are considered to know knowledge related to the problems they face. The results of previous studies also indicate the same thing that project-based learning can develop higher-order thinking skills such as creating [32], applying previously learned material [33], and is often interdisciplinary [34]. Curiosity encourages students' proactive behavior, namely deliberate actions to respond to stimuli or activities that contain novelty, complexity, uncertainty, or conflict [35].

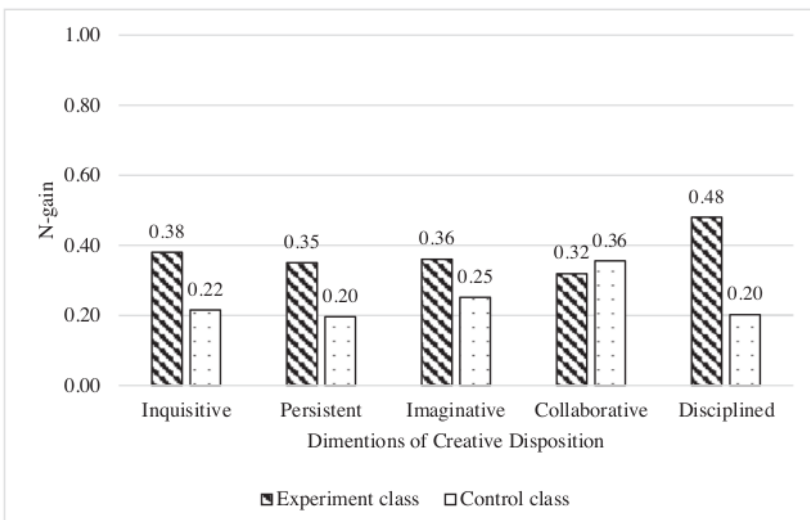

FIGURE 1. Comparison of changes in each dimension of the creative disposition

The ill-defined problem of how to process food ingredients by utilizing the services of bacteria into creative products in the project laboratory work activities in this research has actually succeeded in triggering students' curiosity. Limited knowledge of the students while doing practical projects, forcing students to try to improve their knowledge by seeking other sources of information, print and non-print, reading, searching the internet, asking questions, and discussing. This action is predicted to do repeated, and without realizing it continues to be the pattern of new habits. This habit pattern will be repeated and maintained in the next student's life.

Creative Thinking Skills

One indicator of the effectiveness of implementing creative research project-based laboratory work learning and verification laboratory work learning can be seen from the increase in creative thinking skills after learning compared to before learning. The improvement of creative thinking skills shown in this study is summarized and shown in Figure 2.

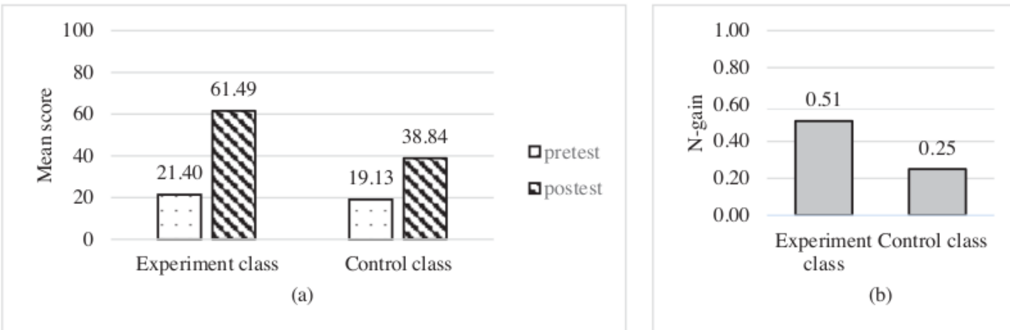

FIGURE 2. (a) Comparison of the mean value of initial and final creative thinking skills, and (b) N-gain for the laboratory work

The creative thinking skills of the experimental class students increased almost two times higher than the control class after the laboratory work learning activities took place. The average posttest score of the experimental class increased three times higher than the average pretest score, with an N-gain of 0.51 in the medium category (Fig. 2b). The control class only caused an increase in the average posttest score twice higher than the pretest score with an N-gain of 0.25 in the low category (Fig. 2b). The value of t Sig corroborates this result. (2 tailed) 0.000 < 0.05 which means significantly different.

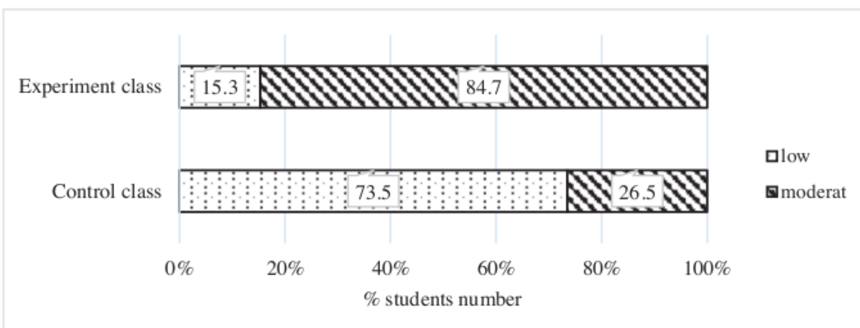

FIGURE 3. Percentage of number students according to the N-gain criteria for students' creative thinking skills

Another indicator for the study results is that almost 85% of the experimental class students have more achievements because they are in the category of moderate quality. On the other hand, 74% of control class students are in a low category (Fig. 3). Thus, it can be inferred that laboratory work activities based on creative research projects play a better role in improving creative thinking skills. The results of this study corroborate the previous research that investigative laboratory activities made significant progress on students' scientific inquiry performance and creative thinking, effective in enhancing the biological scientific creativity of Middle School students [36]. Several related research results also indicate that project-based learning is effective for improving achievement, logical thinking skills, creative thinking, and mastery of concepts [19, 28, 37], correlated positively with effect size in increasing creative thinking and problem solving [38].

Although students' creative thinking skills have increased significantly, especially for the experimental class, the average score is still unsatisfactory. Building creative thinking skills does not seem to be possible in a short period. This phenomenon is also related to students' previous study habits; students tend to be more conditioned to teaching practices where the transfer of knowledge from teacher to student is still dominant. Such teaching methods can deprive students of opportunities to think creatively [39]. There are still many teachers who do not fully understand the creative potential of their students well, so the teacher's learning design still ignores the possibility of students. Another study reported that most teachers agree that every student has creative potential, but they do not believe that students can think creatively [40]. In many other reports, this phenomenon was found in many places, including the subjects in this previous study. These findings are essential information for teachers to realize that students can be creative through innovative learning touches. For that reason, teachers must dare to leave the pragmatic and comfortable teaching habits for themselves, towards dynamic teaching following the demands and needs of students' lives that will come.

CONCLUSION

The results showed that students' biological creative dispositions were encouraged to appear more frequently, especially after conducting practical research based on creative research projects. Inquisitive and disciplined are the two dimensions of creative disposition with the highest level of improvement in this research intervention. Creative thinking skill scores also increased significantly in the group of creative research project-based laboratory work students. However, the average achievement score was still in the moderate category. Based on these results, it is recommended that teachers develop this kind of laboratory work model to train students to be creative.

REFERENCES

1. M. A. Runco, "Creative and Imaginative Thinking" in *Encyclopedia of Human Behavior: Second Edition,* edited by V. S. Ramachandran (Elsevier Inc., Athens, 2012) pp. 602-605.
2. S. Lamb, E. Doecke, & Q. Maire, *Key Skills for the 21st Century: An evidence-based review* (Department of Education, New South Wales, 2017) pp. 1-70.
3. G. Rodríguez, N. Pérez, G. Núñez, J. E. Baños, & M. Carrió, BMC Medical Education **19**, 1–13 (2019).
4. J. K. Robinson, Anal Bional Chem **405**, 7–13 (2013).
5. E. Trnova, "Hands-on Experiments and Creativity", in Hands-on Science Brightening our Future, HSCI Proceeding-2015, edited by M. F. P. C. M. Costa and J. B. V. Dorrio (Hands-on Science Network, Vila Verde, 2015) pp. 103–109.
6. T. K. Kettler, K. N. Lamb, A. Willerson, D. R. Mullet, Creat. Res. J. **30,** 164-171 (2018).
7. A. Sukarso, A. Widodo, D. Rochintaniawati, & W. Purwianingsih, J. Phys. Conf. Ser., **1157** 022092 (2019).
8. M. A. Runco, J. Creat. Behav. **51**, 308–313 (2017).
9. W. Hu, & P. Adey, Int. J. Sci. Educ **24**, 389–403 (2002).
10. R. Florida, C. Mellander, & K. King, *The Global Creativity Index 2015* (Martin Prosperity Institute, Ontario, 2015), pp. 68.
11. A. Widodo, B. Waldrip and D. Herawati, Jurnal Pendidikan IPA Indonesia **5**, 199–208 (2016).
12. S. Marwiyah, K. Kamid and R. Risnita, J Edu Sains **4**, 26-31 (2015).
13. OECD, *PISA 2018 Results. Combined Executive Summaries*. Volume I, II, & III (2018).
14. E. P. Torrance, "The nature of creativity as manifest in its testing", in *The nature of creativity* edited by R. J. Sternberg (Cambridge University Press, Cambridge, 1988), pp.43-47.
15. NRC, *National Science Education Standards* (National Academy Press, Washington, 1996) pp. 272.
16. NRC, *Inquiry and The National Science Education Standards: A Guide for Teaching and Learning* (National Academic Press, Washington DC, 2000) pp. 222.
17. J. F. Ault, B. M. Renfro and A. K. White, J. Microbiol. Biol. Educ. **12**, 185–193 (2011).
18. Y. Doppelt, Journal of Technology Education **16**, 7–24 (2005).
19. K. Yang, L. Lee, Z. R. Hong and H. S. Lin, Int. J. Sci. Educ. **38**, 2133–2151 (2016).
20. B. Lucas, G. Claxton and L. Spencer, OECD Education Working Papers, No. 86 (2013).

21. E. P. Torrance, *Torrance tests of creative thinking* (Personnel Press, Lexington, 1974) pp. 79.
22. Sugiyono, *Metode Penelitian Kuantitatif, Kualitatif dan R&D* (CV Alfabeta, Bandung, 2017) pp. 456.
23. Riduwan, *Skala Pengukuran Variabel-variabel Penelitian* (CV Alfabeta, Bandung, 2012) pp. 288.
24. M. Haigh, Res. Sci. Technol. **37**, 123–140 (2007).
25. D. H. Pink, *A whole new mind* (Riverhead Books, New York, 2005) pp. 255.
26. G. S. Selçuk, Phys. Sci. Int. J. **5**, 711–723 (2010).
27. U. Hanke, The Open Education Journal **4**, 113–119 (2011).
28. K. Ulger, IJPBL **12**, 3–6 (2018).
29. M. C. Linn, E. Palmer, A. Baranger, E. Gerard and E. Stone, Science **347**, 1-6 (2015).
30. D. B. Luckie, J. R. Aubry, B. J. Marengo, A. M. Rivkin, L. A. Foos and J. J. Maleszewski, Am. J. Physiol. Adv. Physiol. Educ. **36**, 325–335 (2012).
31. B. M. Kudrowitz and D. Wallace, J. Eng. Des. **24**, 120–139 (2013).
32. S. K. W. Chu, Y. Zhang, K. Chen, C. K. Chan, C. W. Y. Lee, E. Zou and W. Lau, IHE **33**, 49–60 (2017).
33. S. Han, R. Capraro and M. M. Capraro, How Science, Int. J. Sci. Math. Educ. **13**, 1089–1113 (2015).
34. S. Y. Lee and J. Min, Creat. Res. J. **28**, 298–309 (2016).
35. T. B. Kashdan, P. Rose and F. D. Fincham, J Pers Assess **82**, 291–305 (2004).
36. C. Chelang, JEP **5**, 43–51 (2014).
37. E. Karademir, IJRES **2**, 416-427 (2016).
38. R. L. De Haan, Science **334**, 1499–1500 (2011).
39. V. T. Kudryavtsev, Int. J. Early Years Educ. **19**, 45–53 (2011).
40. C. Ching Leen, H. Hong, F. Ning Hoi Kwan and T. Wan Ying, NIE Working Paper Series Vol. 2, 2016.

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