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The effect of problem-based learning (PBL) on different academic abilities on critical thinking of grade XI students on coordination system material

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Abstract

Scientific actions related to facts and everyday problems are needed in the biology learning process to train students' thinking skills. Thinking skills are useful for facing the challenges of education and technological developments in the 21st century. However, these conditions are not optimal, especially critical thinking skills for different academic abilities. The purpose of this study was to determine the effect of the PBL model on different academic abilities on the critical thinking of class XI students on the coordination system material. This quasi-experimental research was conducted on students of class XI IPA 1 at SMAN 10 Banjarmasin and class XI IPA 3 at SMAN 12 Banjarmasin. The sample of the upper academic ability is 26 students, and the lower academic ability is 28 students. The instrument used is an essay through pretest and posttest in the experimental class and control class. Data were analyzed using Anacova after the data fulfilled the normality and homogeneity tests. The results of the analysis show that there is an influence of the PBL learning model on critical thinking in students of different academic abilities, where the class F value is 91.84 with a p value of 0.000 or less than 0.05. The academic F score is 8.26 with a p value of 0.006 or less than 0.05. This learning model can be a solution to produce graduates who are competent in critical thinking.

Abstrak

Tindakan-tindakan ilmiah yang berkaitan dengan fakta dan masalah sehari-hari diperlukan dalam proses belajar biologi untuk melatihkan kemempuan berpikir siswa. Keterampilan berpikir berguna untuk menghadapi tantangan pendidikan dan perkembangan teknologi abad 21. Namun kondisi ini belum maksimal terutama keterampilan berpikir kritis pada kemampuan akademik berbeda. Tujuan penelitian ini yaitu mengetahui pengaruh model PBL pada kemampuan akademik berbeda terhadap berpikir kritis siswa kelas XI pada materi sistem koordinasi. Penelitian quasi eksperimen ini dilaksanakan pada siswa kelas XI IPA 1 SMAN 10 Banjarmasin dan kelas XI IPA 3 SMAN 12 Banjarmasin. Sampel kemampuan akademik atas berjumlah 26 siswa, dan akademik bawah 28 siswa. Instrumen yang digunakan berupa essay melalui pretest dan postest pada kelas eksperimen dan kelas kontrol. Data dianalisis menggunakan Anacova setelah data memenuhi uji normalitas dan homogenitas. Hasil analisis menunjukkan bahwa terdapat pengaruh model pembelajaran PBL terhadap berpikir kritis pada siswa kemampuan akademik yang berbeda, dimana nilai F hitung kelas sebesar 91,84 dengan nilai p 0,000 atau kurang dari 0,05. Nilai F hitung akademik sebesar 8,26 dengan nilai p 0,006 atau kurang dari 0,05. Model pembelajaran ini bisa menjadi solusi untuk menghasilkan lulusan pendidikan yang kompeten dalam berpikir kritis.

A. Introduction

The 21st century skills globally fall into four categories: (a) ways of thinking: creativity and innovation, critical thinking, problem solving, decision making, and learning to learn; (b) ways of working: communicate and cooperate; (c) tools for work: general knowledge and skills of information and communication technology; (d) way of living: career, personal and social responsibility, including cultural awareness and competency (Binkley et al., 2012; Prayogi, 2019).

Critical thinking is one skill that students must possess (Kustiani et al., 2020; Susanti et al., 2022; Musliha et al., 2022). Critical thinking is one of the abilities that can be developed through problem solving learning process (Birgili, 2015). Critical thinking is the ability to assess circumstances on the basis of facts and evidence in order to reach a conclusion. It is also the ability to generate and explain arguments based on gathered data into a complex decision or idea (Desi, 2019).

The ability to think critically is one of the factors that contribute to successful learning (Von Colln-Appling & Giuliano, 2017). Critical thinking is a characteristic of smart people. Elvianasti et al. (2021) defined critical thinking as an active, continuous, and thorough consideration of a belief or form of knowledge that is taken for granted by including supporting reasons and rational conclusions.

Students with good academic ability will be more competent to construct ideas and solve problems logically (Karbalaei, 2012; Mahanal et al., 2019). Besides, academic ability is associated with the effect of intelligence, which is an important element in the development of students' critical thinking (Karagöl & Bekmezci, 2015; Mahanal et al., 2019; Ren et al., 2020). Students with high academic ability have better prior knowledge than students with lower academic ability (Manahal et al., 2019). This opinion showed that educators are required to be aware of the shift from traditional learning approaches to digital approaches that are deemed to be more relevant to addressing students' needs. The transition process from the traditional way to the digital way has various patterns depending on how educators and educational institutions respond and adapt. This is believed to be able to balance students' academic abilities.

Based on the results of interviews with Class XI SMA teachers in Banjarmasin, teachers continue to employ conventional learning models, which contribute to students' lack of critical thinking skills. Teachers still apply learning theoretically, using solely reference books as evidence. In addition, they have never measured students' critical thinking abilities in different academic fields. As is well known, learning biology is a process that applies facts and problems associated with students' daily lives.

Research results by Wulandari & Surjono (2013) the use of the PBL learning model is a solution for developing students' critical thinking skills in biology learning. Anazifa & Djukri (2017) also found the same results. The PBL learning affect student's critical thinking. In line with Trianto (2014), problem-based learning was developed primarily to help students develop thinking skills, problem-solving skills, and intellectual skills learn about various adult roles by involving themselves in real or simulated experiences, and become autonomous and independent learners.

Problem-based learning, namely (1) encouraging cooperation in completing assignments, (2) having elements of apprenticeship learning that can encourage observation and dialogue with others so that students can gradually understand the important roles of mental activity and learning that occur outside of school, (3) involving students in self-chosen investigations, and (4) helping students become independent and autonomous learners (Boleng & Maasawet, 2019; Widana & Diartiani, 2021).

Hence, PBL can be defined as progressive active learning and an unstructured problem-centered learning approach used as a starting point in the learning process (Rahmadani, 2020). The learning using PBL employs multiple types of intelligence required to face real-world challenges, such as the ability to deal with new and emerging problems (Sari, 2018).

Based on the identified issue, carrying out research related to critical thinking by differentiating the academic abilities of class X students, especially in the concept of coordination systems, has never been done at the high school level in Banjarmasin. On the basis of this explanation, the formulation of the research objective is to determine the effect of the PBL learning model on different academic abilities on the critical thinking of class XI students in the coordination system material.

B. Material and Method

This study employed a quasi-experimental research, with a non-equivalent pretest-posttest control group design. The research was conducted at SMAN. The research population consisted of 89 students enrolled in class XI of SMAN 10 and class XI IPS of SMAN 12. The sample was determined through the

equivalence test based on the previous semester's student report cards. Then, a sample of academic ability in both the control and experimental classes was determined, taking into account the academic ability of the upper 26 students, the middle/moderate 35 students, and the lower 28 students. Although the middle academic ability students continue to follow the learning, data from pretest and posttest results were centered on upper and lower academic abilities. Then, the normality and homogeneity tests were done to continue testing the hypothesis with Anacova. The experimental class in class XI IPA 1 SMAN 12 Banjarmasin was facilitated with PBL while the control class in class XI IPA 3 SMAN 10 Banjarmasin used conventional learning, namely learning with lectures and group discussions.

The data on critical thinking abilities was collected by administering a pretest and posttest in the form of a 10-item essay. The essay assessment referred to the Authentic Assessment rubric developed by Hart (1994), with a score range for each item ranging from 0–4. Then, the final score was converted into a score of 0–100. The values of the pretest and posttest results of the converted critical thinking skills were descriptively presented in the form of a bar chart to distinguish the two treatments given and the students' academic abilities. Hypothesis testing was carried out using covariance analysis (Anacova) at a significance level of 0.5%. However, previously, the normality test was carried out with the one-sample Kolmogorov-Smirnov test and the homogeneity test was carried out using Levene's Test of Equality of Error Variances.

C. Results and Discussion

Based on the results of the analysis that has been carried out to determine the effect of the PBL learning model on students with upper and lower academic abilities on the concept of coordination systems, the obtained information is that there are differences in critical thinking skills. The results of the analysis previously carried out were the normality test and (2) the variance homogeneity test. The normality test used the Kolmogrov-Smirnov One-Sample test with a significance result of 0.083, and the results showed that the data was normally distributed. Furthermore, the homogeneity test using Levene's Test of Equality of Error test obtained an analysis result of 0.065, which indicated that the variance between the data was homogeneous.

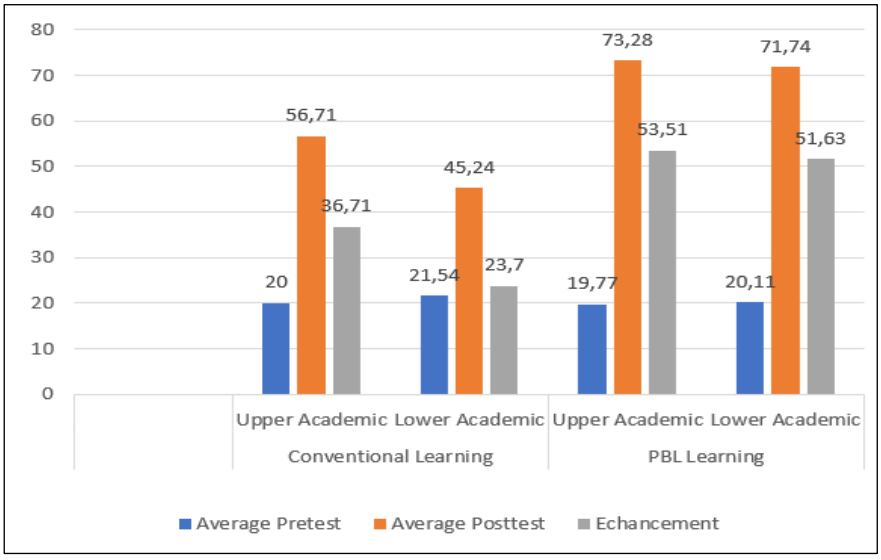

Figure 1
Bar Chart of Average Pretest and Posttest Scores of Critical Thinking Based on Learning and Academic Abilities

Critical thinking skills in this study were measured before and after the implementation of the designed learning strategy. Data between one another in the form of average values and percentages can be seen in Figure 1.

Based on Figure 1, the average student's critical thinking is good in classes facilitated by conventional learning and PBL learning. Students who were facilitated with PBL learning had higher average critical thinking than students who were facilitated with conventional learning. Upon further examination, this also has an effect on students with different academic abilities. This is evidenced by a 51.63 percent increase in the average critical thinking of low academic ability students. These findings add to information from previous studies

such as Ramdiah et al. (2018a); Ramdiah et al. (2018b); Astriani et al. (2021); Saraya & Mayasari (2017); Janah & Mayasari (2019), Ramdiah & Febrianti (2017) using the same Authentic Assessment rubric as this study. By utilizing the PBL learning model, the results of this study provide more in-depth information than prior information because it distinguished between the critical thinking abilities of high and low academic students on the concept of coordination systems at the high school level.

Based on the data from the hypothesis test results, it was determined that the PBL model had an effect on students' critical thinking at both the upper and lower levels of academic ability. The hypothesis test results of this research using Anacova can be seen in Table 1.

Based on the results of the Anacova calculations Table 1, information regarding the effect of the PBL learning model on critical thinking in students with different abilities was obtained. The data showed that the class count F value is 91.84 with a p value of 0.000 or less than 0.05, indicating that PBL learning has an effect on students' critical thinking. The academic F-count score is 8.26 with a p-value of 0.006 or less than 0.05. This reveals that there are differences in students' critical thinking in both upper and lower academic abilities. The results of the analysis of class and academic interactions also show an F count of 5.00 with a p value of 0.030 or less than 0.05. This result showed that there are differences in the critical thinking of upper and lower academic students in the implementation of PBL learning.

Table 1 Summary of Anacova test results on the effect of the PBL model on different academic abilitieson critical thinking ability of class XI students on coordination system material

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	7407.680[a]	4	1851.92	28.67	0.000
Intercept	1747.460	1	1747.46	27.06	0.000
Pretest	5.187	1	5.19	0.080	0.778
Class	5932.311	1	5932.31	91.84	0.000
Academic	533.269	1	533.27	8.26	0.006
Class* Academic	322.948	1	322.95	5.00	0.030
Error	3164.787	49	64.59		
Total	215614.250	54			
Corrected Total	10572.468	53			

It is interpreted that the implementation of the PBL learning model contributes to upper and lower academic abilities students in improving their critical thinking skills on the concept of coordination systems in class XI IPA 1 SMAN 12 Banjarmasin. This is in line with the research results of Ramdiah et al. (2018b); Ramdiah & Febrianti (2017); Ramdiah et al. (2018a); Astriani et al. (2021); Saraya & Mayasari (2017); Mahdalena & Mayasari (2019); Janah & Mayasari (2019). Biological topics can be comprehended through the use of critical thinking skills when biology is taught in accordance with the characteristics of PBL and the procedures involved. Furthermore, the implementation of PBL in this study can be an alternative that can be applied to biology subjects, especially the concept of a coordination system that requires problem solving.

In addition to this, this implementation iscarried out on the basis of the implementation of the PBL model, with both the teacher as a facilitator and the students as learners. This is in line with Kurt's explanation (2020) that in implementing PBL, the role of teaching shifts from a more traditional model that follows a linear and sequential pattern in which the teacher presents relevant material. In addition, the teacher conveys details about a concept. This is different when the PBL model is used, where the teacher acts as a facilitator and learning is driven by students with the aim of solving a given problem.

The implementation of the PBL model also affords students an opportunity to train their ways of thinking, presumably due to the learning steps taken. Based on the results of the analysis presented before, it is evident that the PBL model facilitates an increase in both upper and lower academic abilities among pupils. This situation illustrates that during the implementation of PBL learning students demonstrate critical thinking skills in various problem-solving actions, from conceptualizing, synthesizing, evaluating, reflecting, and communicating the findings. According to Lismaya (2019), critical thinking is an intellectual process that involves conceptualizing, applying, synthesizing, and evaluating information obtained from observation, interpretation, reflection, reasoning, or communication as a basis for believing and taking action. Furthermore, according to Facione (2015), critical thinking is thinking that has the goal of proving a case, interpreting what happened, and solving problems. This is corroborated by Suatini (2019), who stated that critical thinking has a meaning, namely the

power of thinking that must be built in oneself so that it can become a character or personality that is imprinted in one's life, so that one is able to solve all problems.

The PBL model is relatively effective and consistent in general, demonstrating excellence in knowledge application and long-term retention. It was further explained that although it could not be concluded which PBL component was the most significant in influencing learning, it was emphasized that all PBL steps were needed to influence student learning outcomes Yew & Goh (2016). This certainly has an effect on students' critical thinking skills in solving problems. These findings are in line with research on the implementation of PBL in learning where students independently in groups find and solve problems, check the truth to evaluate them (Dakabesi & Luoise, 2019; Saiful et al., 2020; Belwal et al., 2020; Pérez-Sánchez & López-Jiménez, 2020; Chanpet et al., 2020; Salybekova et al., 2021; Prastitasari et al., 2022).

D. Conclusion

The calculated class F value based on the results of the data analysis is 91.84 with a p value of 0.000. The academic F score is 8.26 with a p value of 0.006. The results of the analysis of class and academic interactions also showed an F count of 5.00 with a p value of 0.030. This showed that the PBL learning model affects students' critical thinking skills in different academic abilities in class XI students on the coordination system material. This learning model can be a solution to produce graduates who are competent in critical thinking.

E. References

Agnafia, D.N. (2019). Analisis kemampuan berpikir kritis siswa dalam pembelajaran biologi. *Florea 6*(1), 45-53. DOI: http://doi.org/10.25273/florea.v6i1.4369

Anazifa, R. D., & Djukri, D. (2017). Project-based learning and problem-based learning: Are they effective to improve student's thinking skills?. *Jurnal Pendidikan IPA Indonesia*, *6*(2), 346-355. DOI: https://doi.org/10.15294/jpii.v6i2.11100

Astriani, H., Ramdiah, S., & Mayasari, R. (2021). Pengaruh penerapan model pembelajaran problem based learning (PBL) terhadap hasil belajar kognitif siswa kelas VII SMP Negeri 35 Banjarmasin pada materi ketergantungan dalam ekosistem. *Jurnal Pendidikan Hayati, 7*(2), 83-92. Retrieved from https://jurnal.stkipbjm.ac.id/index.php/JPH/article/view/1576

Belwal, R., Belwal, S., Sufian, A.B., & Al Badi, A. (2020). Project-based learning (PBL): outcomes of students' engagement in an external consultancy project in Oman. *Education and Training, 63*(3), 336-359. DOI: https://doi.org/10.1108/ET-01-2020-0006

Binkley, M., Erstad, O., Herman, J., Raizen, S., Ripley, M., Miller-Ricci, M., & Rumble, M. (2012). *Defining twenty-first century skills*. In: Griffin, P., McGaw, B., Care, E. (eds) Assessment and Teaching of 21st Century Skills. Springer, Dordrecht. DOI: https://doi.org/10.1007/978-94-007-2324-5_2

Birgili, B. (2015). Creative and critical thinking skills in problem-based learning environments. *Journal of Gifted Education and Creativity, 2*(2), 71-80. Retrieved from https://dergipark.org.tr/en/pub/jgedc/issue/38680/449365

Boleng, D. T., & Maasawet, E. T. (2019). The integration of PBL and cooperative script to empower critical thinking skills of biology students. *JPBI (Jurnal Pendidikan Biologi Indonesia)*, *5*(2), 217-228. DOI: https://doi.org/10.22219/jpbi.v5i2.7952

Chanpet, P., Chomsuwan, K., & Murphy, E. (2020). Online project-based learning and formative assessment. *Technology Knowledge and Learning, 25*(3), 685-705. DOI: https://doi.org/10.1007/s10758-018-9363-2

Dakabesi, D., & Luoise, I. S. Y. (2019). The effect of problem based learning model on critical thinking skills in the context of chemical reaction rate. *Journal of Education and Learning (EduLearn), 13*(3), 395-401. DOI: http://dx.doi.org/10.11591/edulearn.v13i3.13887

Elvianasti, M., Meitiyani, M., Maesaroh, M., Irdalisa, I., & Yarza, H. N. (2021). Building Students' Critical Thinking Skills through Authentic Learning by Designing Eco-brick Social Campaigns. *AL-ISHLAH: Jurnal Pendidikan*, *13*(3), 1841-1847. DOI: https://doi.org/10.35445/alishlah.v13i3.389

Facione, P. A. (2015). *Critical thinking: What it is and why it counts.* California, Millbrae: Measured Reasons and The California Academic Press.

Hart, D. (1994). *Authentic assessment a handbook for educators*. California, New York: Addison Wesley Publishing company.

Janah, S.N., & Mayasari, R. (2019). Pengaruh model problem based learning (PBL) terhadap keterampilan berpikir kritis siswa MTs di Kecamatan Paringin Selatan pada konsep ekosistem. *Jurnal Pendidikan Hayati*, *5*(1), 16-20. DOI: https://doi.org/10.33654/jph.v5i1.617

Karagöl, İ., & Bekmezci, S. (2015). Investigating academic achievements and critical thinking dispositions of teacher candidates. *Journal of*

Education and Training Studies, 3(4), 86-92. DOI: https://doi.org/10.11114/jets.v3i4.834

Karbalaei, A. (2012). Critical thinking and academic achievement. *Ikala Revista de Lenguaje y Cultura*, *17*(2), 121-128. DOI: https://doi.org/10.17533/udea.ikala.10948

Kurt, S. (2020, January 8). Problem-based learning (PBL). *Education Technology.* Retrieved from https://educationaltechnology.net/problem-based-learning-pbl/

Kustiani, H., Zaini, M., & Mulyadi, M. (2020). Critical thinking skills of high school students in biology learning on the concept of structure and function of plant tissues. *BIO-INOVED: Jurnal Biologi-Inovasi Pendidikan*, *2*(1), 20-25. DOI: http://dx.doi.org/10.20527/bino.v2i1.7888

Lismaya, L. (2019). *Berpikir kritis & PBL.* Surabaya: Media Sahabat Cendekia.

Mahanal, S., Zubaidah, S., Sumiati, I. D., Sari, T. M., & Ismirawati, N. (2019). RICOSRE: A Learning Model to Develop Critical Thinking Skills for Students with Different Academic Abilities. *International Journal of Instruction*, *12*(2), 417-434. DOI: https://doi.org/10.29333/iji.2019.12227a

Mahanal, S., Zubaidah, S., Sumiati, I.D., Sari, T.M., & Ismirawati, N. (2019). RICOSRE: A learning model to develop critical thinking skills for students with different academic mabilities. *International Journal of Instruction*, *12*(2), 417-434. DOI: https://doi.org/10.29333/iji.2019.12227a.

Mahdalena, M. & Mayasari, R. (2019, Agustus). *Pengaruh model problem based learning (PBL) terhadap keterampilan metakognitif SMA Negeri 8 Banjarmasin*. In *Prosiding Seminar Nasional Simbiosis,* (Vol. 4, pp. 24-29). Universitas PGRI Madiun, Retrieved from http://prosiding.unipma.ac.id/index.php/simbiosis/article/view/1325

Musliha, M., Dharmono, D., & Badruzsaufari, B. (2022). The practicality of Cyperaceae popular scientific books in mangrove areas to college students' criticial thinking skill. *BIO-INOVED: Jurnal Biologi-Inovasi Pendidikan*, *4*(1), 39-45. DOI: http://dx.doi.org/10.20527/bino.v4i1.12081

Pérez-Sánchez, M., & López-Jiménez, P. A. (2020). Continuous project-based learning in fluid mechanics and hydraulic engineering subjects for different degrees. *Fluids, 5*(2), 1-15. DOI: https://doi.org/10.3390/fluids5020095

Prastitasari, H., Fitria, M., Jumadi, J., Sunarno, S., Annisa, M., & Prihandoko, Y. (2022). Peningkatan prestasi matematika siswa sekolah dasar dengan menggunakan kombinasi model pembelajaran PBL, SR, dan QOD. *Primary: Jurnal Pendidikan Guru Sekolah Dasar, 11*(6), 1792-1804. DOI: http://dx.doi.org/10.33578/jpfkip.v11i6.9250

Prayogi, R. D. (2019). Kecakapan abad 21: Kompetensi digital pendidik masa depan. *Manajemen Pendidikan*, *14*(2), 144-151. DOI: https://doi.org/10.23917/jmp.v14i2.9486

Rahmadani, D. (2020) *Implementasi problem based learning dalam materi makanan halal & haram di SMPN 03 Tangerang Selatan* (Bachelor's thesis, Jakarta: FITK UIN Syarif Hidayatullah Jakarta). Retrieved from https://repository.uinjkt.ac.id/dspace/handle/123456789/52234

Ramdiah, S. & Febrianti, F. (2017, September). *Pengaruh model pembelajaran problem based learning (PBL) keterampilan berpikir kritis siswa kelas XI SMA Negeri 12 Banjarmasin*. In *Prosiding Seminar Nasional Simbiosis,* (Vol. 2, pp. 132-139), Universitas PGRI Madiun. Retrieved from http://prosiding.unipma.ac.id/index.php/simbiosis/article/view/328

Ramdiah, S., Abidinsyah, H., & Mayasari, R. (2018a). Problem-based learning: Generates higher-order thinking skills of tenth graders in ecosystem concept. *JPBI (Jurnal Pendidikan Biologi Indonesia), 4*(1), 29-34. DOI: https://doi.org/10.22219/jpbi.v4i1.5490

Ramdiah, S., Mayasari, R., Husamah, H. & Fauzi, A. (2018b). The effect of TPS and PBL learning models to the analytical ability of students in biology classroom. *Asia-Pacific Forum on Science Learning and Teaching*, *19*(2), 1-15. Retrieved from https://www.proquest.com/docview/2335664764?pq-origsite=gscholar&fromopenview=true

Ren, X., Tong, Y., Peng, P., & Wang, T. (2020). Critical thinking predicts academic performance beyond general cognitive ability: Evidence from adults and children. *Intelligence*, *82*, 1-10. DOI: https://doi.org/10.1016/j.intell.2020.101487

Saiful, A. M. İ. N., Utaya, S., Bachri, S., Sumarmi, S., & Susilo, S. (2020). Effect of problem based learning on critical thinking skill and enviromental attitude. *Journal for the Education of Gifted Young Scientists, 8*(2), 743-755. DOI: https://doi.org/10.17478/jegys.650344

Salybekova, N., Issayev, G., Abdrassulova, Z., Bostanova, A., Dairabaev, R., & Erdenov, M. (2021). Pupils' research skills development through project-based learning in biology. *Cypriot Journal of Educational Science*, *16*(3), 1106-1121. DOI: https://doi.org/10.18844/cjes.v16i3.5829

Saraya, D.A.D. & Mayasari, R. (2017). Pengaruh model pembelajaran problem based learning (PBL) terhadap keterampilan berpikir kritis siswa kelas XI IPA SMA Negeri 13 Banjarmasin. *Jurnal Pendidikan Hayati, 3*(1), 20-25. DOI: https://doi.org/10.33654/jph.v3i1.453

Sari, L. N. I. (2018). Perbedaan kemampuan pemecahan masalah matematika siswa dengan menggunakan model pembelajaran probing prompting dan problem based learning di MTSN 2 Padangsidimpuan. *Logaritma: Jurnal Ilmu-ilmu Pendidikan dan Sains*, *6*(02), 85-101. DOI: https://doi.org/10.24952/logaritma.v6i02.1276

Suatini, N. K. A. (2019). Langkah-langkah mengembangkan kemampuan berpikir kritis pada siswa. *Kamaya: Jurnal Ilmu Agama, 2*(1), 41-50. Retrieved from https://jayapanguspress.penerbit.org/index.php/kamaya/article/view/108

Susanti, D., Zaini, M., & Putra, A. P. (2022). The natural science practical guide developed based on critical thinking skills: Implementation test results. *Jurnal Biologi-Inovasi Pendidikan*, *4*(2), 119-125. DOI: http://dx.doi.org/10.20527/bino.v4i2.12412

Trianto, I.B. (2014). Mendesain Model Pembelajaran Inovatif, Progresif, dan Kontekstual Jakarta: Penerbit Prenada media Group

Von Colln-Appling, C., & Giuliano, D. (2017). A concept analysis of critical thinking: a guide for nurse educators. *Nurse education today*, *49*, 106-109. DOI: https://doi.org/10.1016/j.nedt.2016.11.007

Widana, I. W., & Diartiani, P. A. (2021). Model pembelajaran problem based learning berbasis etnomatematika untuk meningkatkan aktivitas dan hasil belajar matematika. *Emasains: Jurnal Edukasi Matematika Dan Sains*, *10*(1), 88-98. DOI: https://doi.org/10.5281/zenodo.4657740

Wulandari, B., & Surjono, H. D. (2013). Pengaruh problem-based learning terhadap hasil belajar ditinjau dari motivasi belajar PLC di SMK. *Jurnal Pendidikan Vokasi, 3*(2), 178-191. DOI: http://dx.doi.org/10.21831/jpv.v3i2.1600

Yew, E. H., & Goh, K. (2016). Problem-based learning: An overview of its process and impact on learning. *Health professions education, 2*(2), 75-79. DOI: http://dx.doi.org/10.1016/j.hpe.2016.01.004