The Effectiveness of the Problem Based Flipped Classroom Model with E-Modules in Improving Critical Thinking Skills of Pre-Service Physics Teachers

Sutrio, Ahmad Busyairi*, Aris Doyan, Kosim, & Hikmawati
Physics Education Study Program, University of Mataram , Indonesia
*Corresponding Author: ahmad.busyairi@unram.ac.id

Received: 11 October 2023; **Accepted**: 11 December 2023; **Published**: 13 December 2023
DOI: https://dx.doi.org/10.29303/jpft.v9i2.5826

Abstract - *Critical thinking skills are one of four skills that students must have in the 21st century. However, several research results show that students' critical thinking skills in Indonesia are still very low. This research aims to test the effectiveness of the Problem-Based Flipped Classroom (PBFC) model assisted by e-Modules in improving the critical thinking skills of prospective physics teachers. This type of research is quasi-experimental with a non-equivalent control group design. The research was conducted at the Physics Education Study Program at the University of Mataram. The research subjects consisted of 52 prospective physics teachers who were studying Basic Physics I. Data was collected using a critical thinking skills test given before and after treatment. The results of data analysis show that the average score of critical thinking skills of prospective physics teachers in the experimental class and control class both increased to the moderate category with N-Gain scores of 0.63 and 0.48 respectively. Based on the results of the t-test at the 95% confidence level (α = 0.05) with the degree of freedom (dk= $n_1 + n_2 - 2 = 52$) it shows that there is a significant difference in the increase in Critical Thinking Skills between the experimental class and the control class with a value of $t_{hitung} = 2.21$ with a value of $t_{tabel} = t_{0.95\,(52)} = 2.01$ ($t_{hitung} > t_{tabel}$). Apart from that, based on the results of the effect size calculation, it shows that the effectiveness of the E-Module assisted PBFC model in improving students' critical thinking skills relative to the conventional model is different in the large category. In other words, the PBFC model assisted by e-modules can be used as an alternative learning in the classroom to improve the critical thinking skills of prospective physics teachers or students in general.*

Keywords: *Problem Based Flipped Classroom; E-Module; Critical Thinking Skills; Pre-Service Physics Teachers*

INTRODUCTION

Critical thinking skills are one of the skills that students must have in the 21st century. Critical thinking skills have now become a trend that is the main focus of learning in several developed countries in the world. Several developed countries such as the United States, Canada, Europe, Australia and New Zealand place critical thinking skills into their educational curriculum (Prayogi et al, 2018a; Howard, 2018). Likewise in Indonesia, since 2013 critical thinking skills have become one of the competencies that all students in Indonesia must have (Regulation of the Minister of Education and Culture of the Republic of Indonesia Number 73 of 2013).

Considering the importance of critical thinking skills, several assessment programs at the international level include critical thinking skills as one of the domains in their assessment, including the PISA and TIMSS International Student Assessment Programs (Verawati et.al, 2018; Mullis et al, 2015). Based on the data provided by the two studies, it shows that the average score for the critical thinking domain of Indonesian students is always below the international average score (Simbolon, et.al, 2019). Apart from that, several previous research results also show that the critical thinking skills of Indonesian students from junior high school (SMP) to tertiary education (PT) are still low. This is proven by the research results of

Kassiavera et.al, (2019); Farcis, (2019); Makhrus et.al, (2020); Safitri et.al, (2021) show that students' critical thinking skills, especially in solving physics problems, are still very low. The results of this research indicate that the learning activities implemented in schools or universities have so far not been able to improve students' critical thinking skills.

There are two main factors causing students' low critical thinking skills, namely curriculum and learning. A curriculum designed with a broad target material makes teachers or lecturers more focused on completing the delivery of all teaching material in accordance with the specified time. This has an impact on the low level of depth of material that students are able to absorb during class learning. Apart from that, the use of learning models and methods that are not oriented towards critical thinking activities can also cause students' low critical thinking skills (Soden, 1994); Bloomer, 1998; Anderson et. al., 2001). One learning model that can be used to overcome limited face-to-face time in class and is oriented towards students' critical thinking activities is the Problem Based Flipped Classroom (PBFC) Model.

PBFC is a combination of the Problem Based Learning (PBL) model with the Flipped Classroom (FC) learning design. FC is a type of Blended Learning (Hybrid Learning) whose process requires students to first study the material independently at home before the material is discussed in class (Susanti & Pitra, 2019). PBL is a learning model that involves students solving contextual problems through scientific procedures so that students can learn knowledge related to the problem (Ward & Peppard, 2002). Thus, the combination of FC and PBL allows students to spend time studying material independently outside the classroom and inside the classroom to solve more complex problems armed with the material they have studied previously (Chis et. al., 2018). It is hoped that this learning pattern can accelerate the process of assimilation and accommodation in students' cognitive structures so that the learning process in the classroom runs more effectively. Apart from that, the problem-solving process using the PBFC model can be carried out more effectively and optimally.

Empirical evidence of the effectiveness of the PBFC model in improving students' critical thinking skills is the results of research conducted by Inayah, et.al, (2021); Faza, (2022) which shows that the PBFC model is effective in improving students' critical thinking skills. Apart from that, the research results of Srilaphat (2019); Damayanti et. al, (2020); Arnata et. al, (2020), also shows that the PBFC model is effective in improving students' high-level thinking skills.

RESEARCH METHODS

This type of research is a quasi-experiment with a non-equivalent control group design (Frankel, et. al, 2012). The design of this research can be seen in Figure 1 below.

Table 1. Research Design

	Pretest	Treatment	Posttest
Experiment	O_1	X	O_1
Control	O_1	-	O_1

O_1 = Critical thinking skills, X = PBFC Learning Model assisted by E-Module.

This research was conducted at the Physics Education Study Program, Faculty of Teacher Training and Education, University of Mataram. The sample used in this research were all physics education study program students who were taking the Basic Physics I course. The instrument used in this research was a critical thinking skills test instrument. The test was carried out twice, namely before treatment (pretest) and after treatment (posttest). The scoring technique uses a scale of 5 referring to the Ennis-Weir Critical Thinking Essay Test (EWCTET) scoring technique, where the highest score is +3, and the lowest is -1. Because the number of questions in this study consists of 6 questions, the maximum score is +18, and the minimum score is -6. Critical thinking ability criteria adapted from Prayogi et.al, (2018a), are presented in Table 1 below.

Table 2. Categorization of Critical Thinking Skills Using 5 Scales

Intervals	Category
X > 11,00	Very Critical
7,00 < X ≤ 11,00	Critical
3,00 < X ≤ 7,00	Quite critical
-1,00 < X ≤ 3,00	Less Critical
X ≤ -1,00	Not Critical

The pretest and posttest scores were then analyzed by calculating the average normalized gain (N-Gain) with the aim of finding out the criteria for improving the critical thinking skills of prospective physics teachers in both classes. The equation for calculating the average normalized gain is as follows (Hake, 1999).

$$\mathrm{N-Gain} = \frac{(S_{post} - S_{pre})}{(S_{max} - S_{pre})}$$

The results of the N-gain calculation are then interpreted using the criteria created by Hake (1999) with the provisions; N-gain ≥ 0.7 (High), 0.3 < N-gain < 0.7 (Medium), and N-gain ≤ 0.3 (Low).

To determine the difference in the increase in critical thinking skills of teacher candidates who were treated with the E-Module assisted PBFC model and the conventional model, an inferential statistical test was carried out using the t-test (significance test). In addition, to determine the size of the impact (effect size) of implementing the PBFC model assisted by Interactive Video on improving the critical thinking skills of prospective Physics Teachers relative to increasing critical thinking skills with conventional learning models, an effect size calculation was carried out. The effect size in this study was sought by calculating the size of the standardized mean difference (d) with the following equation (Cohen, 1998).

$$d = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{\frac{(n_1 - 1)S_1^2 + (n_2 - 1)S_2^2}{(n_1 - 1) + (n_2 - 1)}}}$$

The calculation results were then consulted with the criteria created by Cohen (1998), namely; 0 < d < 0.2 (small effect); 0.2 ≤ d ≤ 0.8 (medium effect); and d ≥ 0.8 (large effect).

RESULTS AND DISCUSSIONS

The category or level of critical thinking skills of prospective physics teachers before and after being treated in the two class groups can be seen in Table 3 below.

Table 3. Category of Critical Thinking Skills for Prospective Physics teachers

Group	N	Pretest	Category	Posttest	Category
Experiment	28	-2,68	Not Critical	8,43	Critical
Control	26	-2,46	Not Critical	6,06	Quite critical

The data in Table 3 shows that the average critical thinking skills score of prospective physics teachers based on the pretest results in both the experimental class and the control class is in the non-critical category (Score ≤ -1.00). This means that the level of critical thinking skills of prospective physics teachers in both class groups, especially in solving physics problems regarding particle kinematics, is very low. In fact, as many as 46% of prospective physics teachers were unable to answer correctly and provide basic explanations regarding particle kinematics. However, the posttest results showed that there was a change in the category or level of critical thinking skills of prospective physics teachers in both class groups. The average level of critical thinking skills in the experimental class was in the critical category ($7.00 < X \leq 11.00$) while in the control class it was in the moderately critical category (3.00 < These results show that there is an influence of the PBFC model assisted by E-Modules and conventional learning models on improving the critical thinking skills of prospective physics teachers.

Next, to determine the category of improvement in critical thinking skills in the two class groups, N-Gain was calculated. Data on the results of N-Gain Critical Thinking Skills for prospective physics teachers in both class groups can be seen in Table 3 below.

Table 4. Results of N-Gain Calculation for Critical Thinking Skills

Group	N	Pretest	Posttest	N-Gain	Category
Experiment	28	-2,68	8,43	0,63	Medium
Control	26	-2,46	6,06	0,48	Medium

Data from N-Gain calculations in the experimental and control classes shows that there is an increase in the critical thinking skills scores of prospective physics teachers in both classes with a large increase (N-Gain) in both class groups in the medium category. These results indicate that the application of the PBFC Model assisted by E-Modules and the conventional learning model are both able to improve the critical thinking skills of prospective teachers with the magnitude of the increase being in the medium category.

Next, for a more in-depth analysis, an N-gain calculation was carried out for each Critical Thinking Skills indicator. The following are the results of the N-Gain calculation for each Critical Thinking Skills indicator.

Table 5. Data on Critical Thinking Skills for Each Indicator

Critical Thinking Indicators	Group	Pretest	Posttest	N-Gain	Category
Elementary Clarification	Experiment	-0,14	1,93	0,66	Medium
	Control	0,04	1,46	0,48	Medium
Advanced Clarification	Experiment	-0,20	1,96	0,68	Medium
	Control	-0,20	1,35	0,48	Medium
Inference	Experiment	-0,30	1,68	0,60	Medium
	Control	-0,20	1,27	0,46	Medium
Basic Suport	Experiment	-1,00	1,57	0,64	Medium
	Control	-1,00	1,12	0,53	Medium
Strategies and Tactics	Experiment	-1,00	1,29	0,57	Medium
	Control	-1,00	0,88	0,47	Medium

The data above shows that the average Critical Thinking Skills of prospective teachers has increased in all indicators of Critical Thinking Skills in both the experimental and control classes. The magnitude of the increase for all indicators of critical thinking skills in both classes was in the medium category.

To find out whether the increase was significantly different or not, a comparative statistical test was carried out using the t-test (significance test). Based on the results of the t-test at the 95% confidence level (a = 0.05) with the degree of freedom (dk= $n_1 + n_2 - 2 = 52$) it shows that there is a significant difference in the increase in Critical Thinking Skills between the experimental class and the control class with a value of $thitung$ = 2.21 with a value of $t_{tabel} = t_{0.95\,(52)}$ = 2.01 ($t_{hitung} > t_{tabel}$).

Next, to find out how big the impact (Effect) or effectiveness of implementing the PBFC model assisted by E-Modules is on improving the Critical Thinking Skills of prospective teachers relative to conventional learning models, an effect size calculation is carried out. The results of the effect size calculation are shown in Table 6.

Table 6. Effect Size Calculation Results

Group	N	N-Gain	Std	Cohen's d	Efektivias
Experiment	28	0,63	0,019	1,07	Large
Control	26	0,48	0,018		

Based on the results of the effect size calculation, it shows that the implementation of the PBFC model assisted by the E-module has an impact on increasing the critical thinking skills of prospective teachers in the large category (d = 1.07).

In this research, the experimental class was treated with the PBFC model assisted by E-Module while the control class was treated with the conventional model. PBFC is a combination of the Problem-Based Learning (PBL) model with the Flipped Classroom (FC) learning design. PBL is a learning model that involves students solving contextual problems through scientific procedures so that students can learn knowledge related to the problem (Ward, 2002). FC is a type of Blended Learning whose process requires students to first study the material independently at home before the material is discussed in class (Susanti & Pitra, 2019). The learning stages in the classroom using PBFC are the same as the PBL stages, namely; (1) Directing learners to the problem; (2) Organizing learners to learn, (3) Guiding a team experience; (4) Developing and represent products; and (5) Analyze and evaluate the problem-solving process (Astutia et al., 2021; Habibah et. al., 2022; Fithriyana & Fikri, 2022; Tabroni et al., 2022; Triyanti, 2022; Fitriyyah, & Wulandari, 2022). It's just that in this PBFC model, students are provided with initial knowledge before participating in the PBL process in the classroom. Because of this, the effectiveness of PBFC in improving students' critical thinking skills is almost the same or even the same as the PBL model.

Each stage in PBL always involves critical thinking activities in it. First, at the stage of student orientation towards the problem. At this stage, the teacher gives students a problem, and students are invited to identify information, analyze the problem, provide a simple explanation, analyze the relationship between variables as a first step in formulating the problem, and identify or formulate criteria to determine possible answers to the problem. formulations that have been made and other critical thinking activities. Of course, these activities can support improving students' critical thinking skills. This statement is in line with the statement by Leicester & Taylor, (2010), namely that students learn to think critically gradually through habits that are trained in the form of activities to identify problems, formulate problems, and answer questions that require explanation.

The second step of the PBL model is organizing learning activities. At this stage, the teacher organizes students to make plans regarding the steps that must be taken. At this stage, several critical thinking activities can increase students' critical thinking skills, including; Selecting criteria for making solutions, formulating alternative solutions, determining temporary actions, reviewing the problems given, obtaining a number of solutions, and preparing rubrics to monitor the progress of planned activities. This activity can certainly train students' critical thinking skills, especially in the aspect of the ability to determine strategy and tactics.

The third step of the PBL model is investigating to find a solution to the given problem (guiding a team experience). This process is dominated by critical thinking activities. At this stage, students observe phenomena and analyze and identify data, information, or concepts that are relevant to the given problem. This activity is closely related to the critical thinking process, especially for the Induce indicator and considering the results of induction and deduction. Likewise with the final stage of the PBL model. The final stage of PBL is analyzing and evaluating the problem-solving process. Analyzing and evaluating activities are identical to critical thinking activities.

Apart from that, empirically it also shows that PBL is effective in improving students' critical thinking skills. This can be seen from the research results of Aswan, et., al. (2018); Cahyono, & Dwikoranto, (2021); Ibrahim, et., al. (2019); Laksono, et., al. (2018); Nasihah, et., al. (2019); Nurhayati, et., al. (2021); Parno, et., al. (2019); Prayogi, et., al. (2018a); Putri, et., al. (2022); Putri, et., al. (2016); Ramadani, & , Murtiani, (2019); Safitri, et., al. (2021); Supriyanto, & Mustika, (2019); Verawati, et., al. (2018); Wulandari, et., al. (2020); and Yuliatia, et., al. (2018) which shows that the PBL model can significantly improve students' Critical Thinking Skills. Other research shows that the PBFC model can further improve students' critical thinking skills compared to conventional models (Triyanti, 2022).

CONCLUSION

It can be concluded that the application of the PBFC model assisted by e-modules can further improve the Critical Thinking Skills of prospective teachers when compared to the conventional model. In other words, the PBFC model assisted by e-modules can be used as alternative learning in the classroom to improve the critical thinking skills of prospective physics teachers or students in general. This research tries to compare the extent of the difference in the effectiveness of the PBFC model assisted by e-modules with conventional learning models in terms of improving students' critical thinking skills. Researchers are interested in finding out the extent of the effect or impact of providing e-modules in problem-based learning. Therefore, the researcher suggests that future researchers be able to compare the PBL model with the PBL model assisted by e-modules or between the PBFC model assisted by e-modules and PBFC assisted by media or other learning sources in order to see the magnitude of the influence of each variable combined or mixed and matched.

REFERENCES

Anderson, L.W. & Krathwohl, D.R. (2001). *A Taxonomy For Learning, Teaching, And Assessing: A Revision Of Bloom's Taxonomy Of educational objectives*. London: Longman, Original Text from Pennsylvania State University.

Arends, R.I. (2012). *Learning to Teach Ninth Edition*. New York: The Mc Graw-Hill Companies, inc.

Arnata, I.W., Mardana, I.B.P., & Suwindra, I.N.P. (2020). Pengaruh Model Pembelajaran Problem Based Flipped Classroom Terhadap Keterampilan Pemecahan Masalah Siswa Kelas XI IPA. *Jurnal Pendidikan Fisika Undiksha*, 10 (1), 36-48. Retrieved from: https://ejournal.undiksha.ac.id/index.php/JJPF/article/view/26723/15668

Ary, D. (2002). *Introduction to Research in Education.* USA: Holt, Rinehart and Winston Inc.

Aswan, D.M, Lufri L. & Sumarmin, R. (2018). Influence of Problem Based Learning on Critical Thinking Skills and Competence Class VIII SMPN 1 Gunuang Omeh, 2016/2017, *IOP Conf. Series: Materials Science and Engineering*. Doi: 10.1088/1757-899X/335/1/012128

Bloomer, M. (1998). They tell you what to do and then they let you get on with it': the illusion of progressivism in GNVQ. *Journal of Education and Work*, 11, (2), 37-62. Doi: https://doi.org/10.1080/1363908980110204

Cahyono, B.D.T., & Dwikoranto, (2021). Implementasi Model Pembelajaran Problem Based Learning untuk Meningkatkan Kemampuan Berfikir Kritis pada Siswa, *IPF: Inovasi Pendidikan Fisika*, 10 (1), 1–7. Doi: http://dx.doi.org/10.20527/jurnalsocius.v9i1.7767

Chis, A. E., Moldovan, A.-N., Murphy, L., Pathak, P., & Muntean, C. H. (2018). Investigating Flipped Classroom and Problem-Based Learning In A Programming Module for Computing Conversion Course. *Educational Technology & Society*, 21 (4), 232–247. Retrieved from: https://www.researchgate.net/publication/328929802_Investigating_Flipped_Classroom_and_Problem-based_Learning_in_a_programming_module_for_computing_conversion_course

Cohen, J. (1988). *Statistical Power Analysis for the Behavioral Sciences, Second Edition*. USA: Lawrence Erlbaum Associates.

Cottrell, S. (2005). *Critical Thinktng Skills*. Palgrave Macmillan.

Damayanti, S.A., Santyasa, I. W., dan Sudiatmika, R. (2020). Pengaruh Model Problem Based-Learning Dengan Flipped Classroom Terhadap Kemampuan Berpikir Kreatif. *Jurnal Kependidikan*, 4 (1), 83-98. Doi: https://doi.org/10.21831/jk.v4i1.25460

Ennis, R. H. (2011). The Nature of Critical Thinking: An Outline of Critical Thinking Disposition and Abilities. *University of Illinois.* Retrieved from: http://faculty.education.illinois.edu/rhennis/documents/TheNatureofCriticalThinking_51711_000.pdf.

Ennis, R.H. (1985). A Logical Basic for Measuring Critical Thnking Skills. *Educational Leadership*, 43 (2): 44-48. Retrieved from: https://jgregorymcverry.com/readings/ennis1985assessingcriticalthinking.pdf

Farcis, F. (2019). Profil Keterampilan Berpikir Kritis Mahasiswa Pendidikan Fisika Universitas Palangka Raya Dalam Proses Analisis Artikel Ilmiah, *Jurnal Jejaring Matematika dan Sains*, 1 (1), 52-58. Retrieved from: C:\Users\USER\Downloads\JURNAL+JEJARING+MATEMATIKA+DAN+SAINS_p56-p62.pdf

Faza, A.R., (2022). Penerapan Model Pembelajaran Flipped Classroom Berbasis Problem Based Learning (FC-PBL) Terhadap Peningkatan Kemampuan Berpikir Kritis Siswa Pada Materi Gerak Harmonik Sederhana, Skripsi. Retrieved from: http://repository.upi.edu/75369/

Fisher, A. (2009). *Berpikir Kritis sebuah Pengantar*. Jakarta: Erlangga

Frankel, J. R., Wallen, N. E. Hyun dan Hellen, H. (2012). *How to Design and Evaluate Research in Education*. New York: McGraw-Hill.

Hake, R. R. (1999). analyzing change/gain scores. American Educational Research Association. Retrieved from: http://www.physics.indiana.edu/~sdi/AnalyzingChange-Gain.pdf.

Howard, P. G. (2018). Twenty-First Century Learning as a Radical Re-Thinking of Education in the Service of Life. *Education Sciences. 8* (189), 1-13. Doi: https://doi.org/10.3390/educsci8040189

Ibrahim, Almukarramah, Gunawan, Marwa, & Don, Y. (2019). Implementation of problem-based learning to improve students' critical thinking skills, *Journal of Physics: Conf. Series 1460 (AICMSTE 2019)*. Doi: 10.1088/1742-6596/1460/1/012058.

Inayah, S., Septian, A., Komala, E. (2021). Efektivitas Model Flipped Classroom Berbasis Problem Based Learning dalam Meningkatkan Kemampuan Berpikir Kritis Mahasiswa, Wacana Akademika, *Majalah Ilmiah Kependidikan*, 5 (2), 138–144. Retrieved from: https://jurnal.ustjogja.ac.id/index.php/wacanaakademika/article/view/11323

Kameo, R.M. (2007). Critical Thinking in the Classroom: Some Cultural Constraints. English Edu. *Journal of Language Teaching and Research*, 7 (l), 1-13. Doi: 10.1002/berj.3295

Kassiavera, S., Suparmi, A., Cari, C., & Sukarmin, S. (2019). Survei Keterampilan Berpikir Kritis Mahasiswa pada Materi Usaha dan Energi, Prosiding SNFA (Seminar Nasional Fisika dan Aplikasinya). Retrieved from: file:///C:/Users/USER/Downloads/35928-93377-3-PB.pdf

Laksono, E.W., Suyanta and Rizky, I. (2018). Problem-based learning implementation to develop critical thinking and science process skills of madrasah Aliyah students in yogyakarta, *Journal of Physics: Conf. Series 1097 (ICRIEMS 5)*. Doi: 10.1088/1742-6596/1097/1/012059

Makhrus, M., Syahrial A.,Wahyudi, Verawati, S.N.P.S., & Busyairi, A. (2020). Kema puan Berpikir Kritis Mahasiswa pada Materi Optik Saat Proses Pembelajaran dengan CCM-CCA Berbantuan Eksperimen Virtual. *KAPPA Journal*, 4 (2), 143-148. Doi: *10.29408/kpj.v4i2.2632*

Mullis, I. V. S., Martin, M. O., Foy, P., & Hooper, M. (2015). *TIMSS 2015 International Results*. Boston: TIMSS & PIRLS International Study Center.

Nasihah, E.D., Supeno, & Lesmono,A.D. (2019). Pengaruh Tutor Sebaya Dalam Pembelajaran Problem Based Learning Terhadap Keterampilan Berpikir Kritis Fisika Siswa SMA, *Jurnal Pendidikan Fisika*, 1 (8), 44-57. Doi: http://dx.doi.org/10.24127/jpf.v8i1.1899

Nurhayati, Wahyudi, and Angraeni, (2021).The influence of problem based learning model and critical thinking ability on higher order thinking skills (HOTs) of physics prospective teachers students, *Journal of Physics: Conference Series, (SNPF 2021)*. Doi: 10.1088/1742-6596/2104/1/012007

Parno, Fathurrahman, Asim, Suwasono, P.,& Ali, M. (2019). The Influence of Problem Based Learning on Critical Thinking Ability for Students in Optical Instrument Topic, Jurnal Pendidikan Fisika Indonesia 15 (1), 39-45. Doi: 10.15294/jpfi.v15i1.19309

Paul, R and Elder, L. 2006. *International Critical Thinktng Test*. Foundation for Critical Thinking.

Prayogi, S., Yuanita, L. & Wasis, (2018a). Critical In- quiry Based Learning: A

Model of Learning to Promote Critical Thinking among Prospective Teachers of Physics, Journal of Turkish Science Education, 15 (1), 43-56. Retrieved from: https://www.tused.org/index.php/tused/article/view/148

Prayogi, S., Yuanita, L. & Wasis. (2018a). Critical In-quiry Based Learning: A Model of Learning to Promote Critical Thinking among Prospective Teachers of Physics. *Journal of Turkish Science Education*, 15 (1), 43-56. Retrieved from: https://www.tused.org/index.php/tused/article/view/148

Putri, D.A.H., Fauziah, N., & Wati, W.W., (2022). Analisis Effect Size Pengaruh Model Problem Based Learning Terhadap Keterampilan Berpikir Kritis dan Pemecahan Masalah Dalam Pembelajaran Sains, *ORBITA. Jurnal Hasil Kajian, Inovasi, dan Aplikasi Pendidikan Fisika*, 8 (2), 205-211. Doi: https://doi.org/10.31764/orbita.v8i2.10295

Putri, R., Saminan Ismail, S., & hasan, M. (2016). Pengaruh Model Problem Based Learning Terhadap Berpikir Kritis dan Hasil Belajar Elastisitas Siswa Kelas XI SMA Negeri 7 Banda Aceh, *Jurnal Pendidikan Sains Indonesia*, 4 (1) 117-128. Retrieved from: https://www.neliti.com/id/publications/122494/pengaruh-model-problem-based-learning-terhadap-berpikir-kritis-dan-hasil-belajar

Ramadani, I. & ,Murtiani, (2019). Pengaruh Implementasi Problem Based Learning (PBL) Terhadap Keterampilan Berpikir Kritis Siswa Dalam Pembelajaran Fisika Kelas XI di SMA N 5 Padang, *Pillar of Physics Education*, 4, 49-56. Doi: http://dx.doi.org/10.24036/1890171074

Ratnaningtyas, Y. (2016). Kemampuan Berpikir Kritis Siswa SMP Kelas VIII dalam Menyelesaikan Soal Higher Order Thinking Ditinjau dari Kemampuan Matematika. *Jurnal Ilmiah Pendidikan Matematika*, 1 (5) 86-94. Retrieved from: https://ejournal.unesa.ac.id/index.php/mathedunesa/article/view/16672

Safitri, H., Hamidah, I., Setiawan, W., & Kaniawati, I. (2021). Profil Keterampilan Berpikir Kritis dan Perilaku Mahasiswa Pendidikan Fisika: Sebuah Peluang MenerapkanProblem Based Learningdalam Pembelajaran Online, *JIPFRI (Jurnal Inovasi Pendidikan Fisika dan Riset Ilmiah)*. 5 (2), 87-94. Doi: https://doi.org/10.30599/jipfri.v5i2.1055

Safitri, H., Hamidah, I., Setiawan, W., & Kaniawati, I. (2021). Profil Keterampilan Berpikir Kritis dan Perilaku Mahasiswa Pendidikan Fisika: Sebuah Peluang MenerapkanProblem Based Learningdalam Pembelajaran Online, *JIPFRI (Jurnal Inovasi Pendidikan Fisika dan Riset Ilmiah)*. 5 (2), 87-94. Doi: https://doi.org/10.30599/jipfri.v5i2.1055

Simbolon, H. Simbolon, M. R., & Harahap, F. (2019). An Analysis of Students' Scientific Literacy Skillsin State Senior High Schools throughout Central Tapanuli District. *Advances in Social Science, Education and Humanities Research*, 384, 105-109. Retrieved from: https://www.atlantis-press.com/proceedings/aisteel-19/125928346

Soden, R. (1994). *Teaching Problem Solving in Vocational Education*. London: Routledge.

Srilaphat, E., & Jantakoon, T. (2019). Ubiquitous flipped classroom instructional model with learning process of scientific to enhance problem-solving skills for higher education (UFC-PS Model). *Canadian*

Center of Science and Education, 9(1), 76-85. Retrieved from: https://files.eric.ed.gov/fulltext/EJ1200988.pdf

Supriyanto, E. and Mustika, (2019). The Improvement of Critical Thinking Skills Through Problem Based Learning Models Assisted by Trackers Video on Parabolic Movements, *Journal of Physics: Conference Series* (SNF 2021). Doi: 10.1088/1742-6596/2019/1/012029

Susanti, L., & Pitra, D.A.H., (2019). Flipped Classroom Sebagai Strategi Pembelajaran Pada Era Digital. Health & Medical Journal, 1 (2) 54-58. Retrieved from: file:///C:/Users/USER/Downloads/242-538-2-PB.pdf

Triyanti, M. (2022). Pengaruh Problem Based Learning Berbasis Blended Learning Terhadap Kemampuan Berpikir Kritis Siswa di SMA Negeri 4 Rejang Lebong, *Linggau Journal Science Education*, 2(1), 67 – 76. Retrieved from: https://jurnal.lp3mkil.or.id/index.php/ljse/article/view/237

Verawati, N. N. S. P., Ayub, S., &Prayogi, S. (2018). Development of Inquiry-Creative-Process Learning Model to Promote Critical Thinking Ability of Physics Prospective Teachers. *Journal of Physics: Conference Series* 1108, 1-6. Doi: 10.1088/1742-6596/1108/1/012005

Ward, J., Peppard, J. (2002), *Strategic Planning For Information Systems, 3rd ed.*, New Jersey: John Wiley & Sons, Inc.