

**PENGARUH *PROBLEM BASED LEARNING* - *PREDICT, OBSERVE,*  
*AND EXPLAIN (PBLPOE)* TERHADAP PERUBAHAN MODEL  
MENTAL SISWA PADA TOPIK SUHU DAN KALOR**

**SKRIPSI**

Diajukan untuk memenuhi sebagian syarat memperoleh gelar Sarjana pada Program Studi  
Pendidikan Fisika



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**PENGARUH *PROBLEM BASED LEARNING - PREDICT, OBSERVE, AND EXPLAIN (PBLPOE)* TERHADAP PERUBAHAN MODEL MENTAL SISWA PADA TOPIK SUHU DAN KALOR**

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Tri Utomo Budi, 2023

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## HALAMAN PENGESAHAN SKRIPSI

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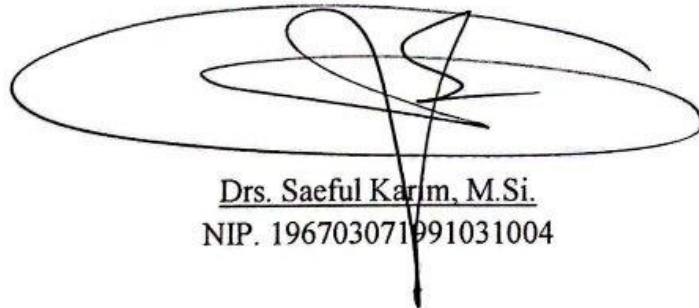
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**ABSTRAK**

Model mental masih belum banyak diteliti dalam pembelajaran. Padahal model mental sangat penting dibangun untuk memahami fenomena fisika yang dinamis termasuk bagaimana memahami fenomena fisis pada skala mikroskopis. Melalui gambaran model mental dapat diketahui penyebab tingginya miskonsepsi yang terjadi selama ini. Penelitian ini mencoba mengatasi permasalahan tersebut dengan melakukan pembelajaran yang dapat berpengaruh terhadap perubahan model mental yaitu dengan menerapkan *Problem Based Learning - Predict, Observe, and Explain* (PBLPOE). Metode yang digunakan adalah metode campuran dengan tipe *Explanatory Sequential*. Partisipan penelitian berjumlah 64 siswa kelas XI MIPA di salah satu SMA Negeri di kota Bandung. Desain implementasi PBLPOE yaitu *control group pretest posttest design*. Penggalan data kualitatif model mental dilakukan dengan wawancara terhadap siswa yang memiliki model mental belum ilmiah. Berdasarkan hasil analisis, didapatkan PBLPOE berpengaruh terhadap perubahan model mental siswa ke arah yang lebih ilmiah. Dari hasil tes dan wawancara didapatkan siswa yang memiliki model mental belum ilmiah disebabkan jawaban siswa atas tes yang diajukan keluar dari batas pengukuran topik suhu dan kalor.

**Kata Kunci:** Model Mental, PBLPOE, PBL, Suhu dan Kalor

**THE EFFECT OF PROBLEM BASED LEARNING - PREDICT,  
OBSERVE, AND EXPLAIN (PBLPOE) TO CHANGES IN STUDENTS'  
MENTAL MODELS IN THE TOPICS OF TEMPERATURE AND HEAT**

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**ABSTRACT**

*Mental models are still not much researched in learning. Even though mental models are very important to build to understand dynamic physical phenomena, including how to understand physical phenomena on a microscopic scale. Through the description of the mental model, it can be seen the cause of the high number of misconceptions that have occurred so far. This study tries to overcome these problems by conducting learning that can affect changes in mental models, namely by applying Problem Based Learning - Predict, Observe, and Explain (PBLPOE). The method used is a mixed method with the Explanatory Sequential type. The number of research participants was 64 students of class XI MIPA at one of Bandung City Senior High Schools. The design of the PBLPOE implementation is the control group pretest posttest design. Qualitative data mining of mental models was carried out by interviewing students who had unscientific mental models. Based on the results of the analysis, it was found that PBLPOE had an effect on changing students' mental models in a more scientific direction. From the results of the tests and interviews, it was found that students had unscientific mental models because the students' answers to the tests submitted were outside the limits of measuring the topic of temperature and heat.*

**Keywords:** *Mental Model, PBLPOE, PBL, Temperature and Heat*

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## DAFTAR PUSTAKA

- Akçay, B. (2009). *Problem-based learning in science education*. Journal of Turkish Science Education, 6(1), 26–36.
- Aldila, S., dan Mukhaiyar, R. (2020). *Efektivitas model pembelajaran problem based learning pada mata pelajaran dasar listrik dan elektronika di kelas X SMK Negeri 1 Bukittinnggi*. Ranah Research: Journal of Multidisciplinary Research and Development, 2(2), 51-57.
- Alfiani. (2015). Analisis Profil Miskonsepsi dan Konsistensi Konsepsi Siswa SMA pada Topik Suhu dan Kalor. Seminar Nasional Fisika 2015 Jurusan Fisika, Fakultas MIPA, Universitas Negeri Jakarta.
- Amalia, R., Sari, I.M. dan Sinaga, P. (2017). *Students' Mental Model on Heat Convection Concept and Its' Relations with Students' Conception on Heat and Temperature*. Journal of Physics: Conference Series, 812, 012092
- Amrizaldi, Diantoro, M., dan Wartono. (2014). *Pengembangan Tes Diagnostis Untuk Memetakan Model Mental Siswa Kelas X SMA/MA Materi Suhu dan Kalor*. In Prosiding Seminar Nasional Fisika (pp. 27-31). Jakarta: Universitas Negeri Jakarta.
- Applin, H., Williams, B., Day, R., dan Buro, K. (2011). *A Comparison of Competencies between Problem-Based Learning and Non-Problem-Based Graduate Nurses*. Nurse Education Today, 31(2), 129-134. <https://doi.org/10.1016/j.nedt.2010.05.003>
- Arends, R. I. (2012). *Learning to teach*. New York. McGraw-Hill
- Askill-Williams, H., Murray-Harvey, R., dan Lawson, M. J. (2007). *Teacher education students' reflections on how problem-based learning has changed their mental models about teaching and learning*. Teacher Educator, 42(4), 237–263. <https://doi.org/10.1080/08878730709555406>.
- Baptiste, Sue. (2003). *Problem-Based Learning: A self-directed journey*. Thorofare: Slack Inc.
- Batlolona, J. R. dan Souisa, H. F. (2020). *Problem based learning: Students' mental models on water conductivity concept*. Int. J. Eval. & Res. Educ. Vol. 9, No. 2, June 2020: 269 - 277.
- Batlolona, J. R., Singerin, S., dan Diantoro, M. (2020). *Influence of Problem Based Learning Model on Student Mental Models*. Jurnal Pendidikan Fisika, 16 (1): 14-23

- Batlolona, J. R., Diantoro, M., Wartono, dan Leasa, M. (2020). *Students' Mental Models of Solid Elasticity: Mixed Method Study*. Journal of Turkish Science Education. 17(2), 200-210.
- Bilen, K., Özel, M., dan Köse, S. (2016). *Using action research based on the predict-observe-explain strategy for teaching enzymes*. Turkish Journal of Education, 5(2), 72-81. doi:10.19128/turje.70576.
- Carriger, M. S. (2015). *Problem-Based Learning and Management Development – Empirical and Theoretical Considerations*. The International Journal of Management Education, 13(3), 249-259.
- Chiou, G.L dan Anderson, O.R. (2010). *A Study of Undergraduate Physics Students' Understanding of Heat Conduction Based on Mental Model Theory and An Ontology-Process Analysis*. Science Education Journal Volume, 94, 825-854
- Chiou, G.L. (2013). *Reappraising The Relationships Between Physics Student's Mental Models and Predictions: An Example of Heat Convection*. Physical Review Special Topics-Physics Education Research, 9
- Corpuz, E. D., Rebello, N. S. (2011). *Investigating students' mental models and knowledge construction of microscopic friction*. Phys. Rev. Spec. Topics-Phys. Edu. Res. 7 020102
- Creswell, J. W. dan Guetterman, T.C. (2019). *Educational Research Planning, Conducting and Evaluating Quantitative and Qualitative Research Si Edition*. Library of Congress Cataloging-in-Publication Data. Saddle River, New Jersey: Pearson
- Didis, N., Eryilmas, A., dan Erkoc, S. (2014). *Investigating Students' Mental Models about the Quantization of Light, Energy, and Angular Momentum*. Physical Rev. Spec. Topics- Physics Education Research, 10(02127)
- Dinata, P. A. C. dan Suparwoto. (2018). *Problem-based learning with jukung and balogo to improve students' mental model in south borneo*. IOP Conf. Series: Journal of Physics: Conf. Series 1097 (2018) 012026.
- Edward-Leis, C. (2012). *Challenging Learning Journeys in The Classroom: Using Mental Model Theory to Inform How Pupils Think When They Are Generating Solutions*. Conference article PATT 26 Conference; Technology Education in 21st Century; Stockholm; Sweden.
- Esema, D., Susari, E., dan Kurniawan, D. (2012). *Problem-Based Learning*. Satya Widya, Vol. 28, No. 2. Desember 2012: 167-173.

- Fahrinnisak. (2018). *Penerapan Model Pembelajaran POE (Predict, Observe, Explain) Terhadap Hasil Belajar Siswa Kelas V di SDN Pangarangan III Sumenep*. Jurnal Pendidikan Dasar, 2(1), 10-25
- Fitriani, A., Zubaidah, S., Susilo, H., dan Al Muhdhar, M. H. I. (2020). *PBLPOE: A Learning Model to Enhance Students' Critical Thinking Skills and Scientific Attitudes*. International Journal of Instruction, 13(2), 89-106. <https://doi.org/10.29333/iji.2020.1327a>
- Fitriani, A., Zubaidah, S., Susilo, H., dan Al Muhdhar, M. H. I. (2020). *The Effects of Integrated Problem-Based Learning, Predict, Observe, Explain on Problem-Solving Skills and Self-Efficacy*. Eurasian Journal of Educational Research, 85, 45-64, DOI: 10.14689/ejer.2020.85.3
- Fraenkel, J. R., Wallen, N. E., dan Hyun, H. H. (2012). *How to design and evaluate research in education* (8th ed.). New York: Mc Graw Hill.
- Giancoli, D. C. (2013). *Physics: Principles with Application*, Seventh Edition, Pearson Education Inc. Diterjemahkan kedalam Bahasa Indonesia oleh Hardiansyah, I. Fisika: Prinsip dan Aplikasi, Edisi ketujuh, Jakarta: Erlangga
- Gilbert, J.K., Boulter, C. J., dan Elmer, R. (2000). *Positioning Models in Science Education and in Design and Technology Education*. Dalam J. K. Gilbert and C. J. Boulter (Penyunting), *Developing Models in Science Education* (hlm. 3017). The Netherlands: Kluwer Academic Publishers.
- Glick, M.B., Chermack, T.J., Luckel, H., dan Gauck, B.Q. (2012). *Effects of Scenario Planning on Participant Mental Models*. European Journal of Training and Development, 36(5) 488-507
- Haili, H., Maknun, J., dan Siahaan, P. (2017). *Problem Solving Based Learning Model with Multiple Representations to Improve Student's Mental Modelling Ability on Physics*. The 4th International Conference on Research, Implementation, and Education of Mathematics and Science (4th ICRIEMS), AIP Conf. Proc. 1868, 070004-1–070004-7; doi: 10.1063/1.4995180
- Hake, R. R. (1999). *Analyzing Change/Gain Scores*. AREA-D American Education Research Association's Division.D., Measurement and Research Methodology.
- Hamzah, K., Liliawati, W., dan Samsudin, A. (2019). *Identification of Misconception On Global Warming Material: Impact and Solution At Middle School*. Journal Of Physics: Conference Series 1280

- Indrawati dan Setiawan W. (2009). *Pembelajaran Aktif, Kreatif, Efektif, dan Menyenangkan untuk Guru SD*. Bandung: PPPPTK IPA
- Intisavira, T. (2022). *Pengembangan Instrumen Identifikasi Model Mental Siswa Sekolah Menengah Atas pada Materi Suhu dan Kalor dengan Menggunakan Analisis Rasch*. (Skripsi). Universitas Pendidikan Indonesia, Bandung
- Jasdilla, L., Fitria, Y., dan Sopandi, W. (2019). *Predict Observe Explain (POE) strategy toward mental model of primary students*. Journal of Physics: Conference Series 1157
- Johnson-Laird, P. N. (2013). *Mental Models and Cognitive Change*. Journal of Cognitive Psychology, 25(2), 131-138
- Kanginan, M. (2013). *Fisika 2 untuk SMA/MA Kelas XI*. Jakarta : Erlangga.
- Kantarianata, D., Lia, Y., dan Nandang, M., (2017). *Identifikasi Model Mental Siswa Pada Materi Suhu Dan Kalor*. Pros. Seminar Pendidikan IPA Pascasarjana UM.
- Karim, S., Saepuzaman, D. (2018). *Termodinamika* (Diktat), Jurusan Pendidikan Fisika FPMIPA UPI.
- Karo-Karo, E. (2021). *Investigasi Model Mental Siswa SMA dan Pengajar Fisika pada Materi Kalor dan Perambatan Kalor*. (Skripsi). Universitas Pendidikan Indonesia, Bandung
- Liew W. C. (2004). *The Effectiveness of Predict-Observe-Explain Technique in Diagnosing Student's Understanding of Science and Identifying Their Level of Achivement*.
- Moseley, C., Desjean-Perrotta, B., dan Utley, J. (2010). *The draw-an-environment test rubric (DAET-R): Exploring pre-service teachers' mental models of the environment*. Environmental Education Research, 16(2), 189-208.
- Norman, D. A., (1983). *Some observations on mental models ed D A Gentner and A L Stevens Mental Models*. Hillsdale, NJ: Lawrence Erlbaum Associates. Pp 6-14
- Priyadi, R., Diantoro, M., Parno, P., & Taqwa, M. (2020). *Using argument-driven inquiry learning to improve students' mental models*. In AIP Conference Proceedings (Vol. 2215, No. 1). AIP Publishing
- Pendrill, A. (2020). *Forces in circular motion : discerning student strategies*. Physics Education, 55(4), 1-10.



- Razali, N. M., dan Wah, Y. B. (2011). *Power comparisons of shapiro-wilk, kolmogorov-smirnov, lilliefors and anderson-darling tests*. Journal of statistical modeling and analytics, 2(1), 21-33.
- Rhem, James. (1998). *Problem Based Learning: An Introduction*. The National Teaching & Learning Forum: Vol. 8: No. 1.
- Sahyar, Ridwan A., Sani, dan Malau, T. (2017). *The effect of PBL model and SRL toward physics problem solving ability of students at senior high school*. American Journal of Educational Research, 5(3), 279-283. doi: 10.12691/education-5-3-8.
- Sari, I. M. (2021). *Pengembangan Pembelajaran Berbasis Model Berbantuan E-Book untuk Mengontruksi Model Mental pada Materi Suhu, Kalor, dan Perambatan Kalor*. (Disertasi). Sekolah Pascasarjana, Universitas Pendidikan Indonesia, Bandung.
- Sari, I. M. dan Saepuzaman, D. (2016). *Physics Students' Mental Model and Prediction in Heat Convection Concept*. Conference Proceeding of International Conference on Innovation in Engineering and Vocational Education (ICIEVE). Atlantis Press. Doi: 10.2991/icieve-15.2016.48
- Sari, I.M. (2017). *What Do They Know About Heat and Heat Conduction? A Case Study to Excavate Pre-service Physics Teachers' Mental Model in Heat and Heat Conduction*. J. Physics: Conference Series, 812, 012090
- Sari, I.M., Malik, A., Saepuzaman, D., Rusdiana, D., dan Ramalis, T.R. (2019a). *Pre-service Physics Teachers' Mental Models of Heat Conduction: a Case Study of The Process-Analogy of Heat Conduction*. J. Physics: Conference Series, 1157, 032073
- Sari, I.M., Fauzi, D., Malik, A., Saepuzaman, D., Ramalis, T.R., dan Rusdiana, D. (2019b). *Excavating The Quality of Vocational Students' Mental Models and Prediction on Heat Conduction*. J. Physics: Conference Series, 1204, 012042
- Sari, L., dan Aulia, P. (2021). *Pengaruh Metode Bercerita dengan Gambar dalam Meningkatkan Kemampuan Komunikasi Anak Usia Dini*. GENIUS: Indonesian Journal of Early Childhood Education, 2(2), 127-140.
- Savery, J. R. (2006). *Overview of Problem-based Learning: Deûnitions and Distinctions*. Interdisciplinary Journal of Problem-based Learning: Vol. 1: Iss. 1, Article 3.

- Seel, N. (2017). *Model-based Learning: a Synthesis of Theory and Research*. Educational Technology Research and Development. doi: 10.1007/s11423-016-9507-9
- Senge, P. M., (1990) *The fifth discipline: the art and practice of the learning organization*. New York: Currency Doubleday
- Stains, M., dan Sevian, H. (2015). *Uncovering Implicit Assumptions: a Large-Scale Study on Students' Mental Models of Diffusion*. Research in Science Education, 45(6), 807–840. <https://doi.org/10.1007/s11165-014-9450-x>.
- Sugiyono. (2013). *Metode Penelitian Kombinasi (Mixed Method)*. Bandung: ALFABETA, cv.
- Supasorn, S. (2015). *Grade 12 students' conceptual understanding and mental models of galvanic cells before and after learning by using small-scale experiments in conjunction with a model kit*. Chemistry Education Research and Practice, 16(2), 393–407. <https://doi.org/10.1039/c4rp00247d>.
- Tipler, P. A. (1991). *Physics for Scientists and Engineers*, Third Edition, Worth Publisher, Inc. Diterjemahkan kedalam Bahasa Indonesia oleh Prasetio, L. dan Adi, R. W. (1998). *Fisika untuk Sains dan Teknik*. Edisi Ketiga, Jilid 1. Jakarta: Erlangga
- Utari, G. P., dan Liliawati, W. (2019). *Identifikasi miskonsepsi siswa pada materi suhu dan kalor menggunakan four tier diagnostic test di SMA*. Prosiding Seminar Nasional Fisika 5.0, 86-98.
- Vieira, R. M., dan Tenreiro-Vieira, C. (2016). *Fostering Scientific Literacy and Critical Thinking in Elementary Science Education*. International Journal of Science and Mathematics Education, 14(4), 659-680.
- Vosniadou, S. dan Brewer, W. F. (1992). *Mental Models of the Earth: A Study of Conceptual Change in Childhood*. Cognitive Psychology, 24, 535-585.
- Vosniadou, S. dan Brewer, W. F. (1994). *Mental Models of the Day/Night Cycle*. Cognitive Science, 18, 123-183.
- Vosniadou, S. (2002). *Mental models in conceptual development*. Springer, Boston, MA
- Wahyuni, D. (2014). *Efektivitas Implementasi Pembelajaran Model Problem Based Learning (PBL) Diintegrasikan dengan Predict-Observe-Explain (POE) terhadap Prestasi Belajar Siswa ditinjau dari Kreativitas dan Kemampuan Inferensi Siswa*. (Tesis). Universitas Sebelas Maret, Surakarta.

White R. T. dan Gunstone R. F. (1992). *Probing Understanding*. Great Britain:  
Falmer Press