BAB V

KESIMPULAN, IMPLIKASI DAN REKOMENDASI

Bab ini terdiri dari tiga bagian. Bagian pertama memaparkan kesimpulan berdasarkan hasil analisis data, temuan dan pembahasan. Bagian kedua memaparkan tentang implikasi berdasarkan hasil temuan penelitian. Bagian ketiga memparkan rekomendasi atau saran-saran berdasarkan hasil penelitian untuk pemecahan masalah atau penelitian yang akan datang.

5.1 Kesimpulan

Berdasarkan uraian hasil analisis data, temuan dan pembahasan pada bab sebelumnya, secara umum dapat disimpulkan bahwa program perkuliahan Termodinamika berbasis PMK berbantuan simulasi interaktif dan *derivative games* dapat meningkatkan kemampuan pemecahan masalah dan berpikir reflektif. Secara khusus, penelitian menghasilkan simpulan-simpulan sebagai berikut.

Program perkuliahan termodinamika berbasis PMK memiliki karakteristik dalam membangun kesiapan belajar, mengembangkan kemampuan dalam mengeksplorasi masalah, melakukan pemecahan masalah bersama secara interaktif melalui kegiatan berbagi pengetahuan dan ide untuk menemukan solusi dalam penyelesaian masalah, melatihkan peserta didik dalam berpikir refleksi dan mengases hasil dan proses pembelajaran yang telah mereka lakukan. Program ini memiliki spesifikasi media simulasi interaktif dan *derivative games* yang digunakan untuk penjelasan konsep termodinamika. Melalui program ini dapat meningkatkan produktivitas mahasiswa dalam menyelesaikan masalah dan berpikir reflektif. Pemecahan masalah dilakukan dengan mengases kemampuan mahasiswa dalam memahami skema masalah (*Problem Schema*), berpikir analogi (*analogy*), menghubungkan sebab akibat (*causal*), memberikan argumen terhadap sebuah kasus atau masalah (*argumentation*). Sedangkan berpikir reflektif menekankan pada peningkatan level kemampuan berpikir reflektif yaitu aspek *habitual action*,

Undertanding, Refelction dan Critical Reflection. Program perkuliahan memiliki fasilitas pendukung utama dalam pembelajaran.

Termodinamika yaitu menghasilkan Lembar Kegiatan Mahasiswa dan Rencana Pembelajaran Semester, instrumen tes pemecahan masalah termodinamika dan instrumen skala berpikir reflektif.

Program perkuliahan termodinamika berbasis PMK berbantuan simulasi interaktif dan *derivative games* efektif dan signifikan dalam meningkatkan kemampuan pemecahan masalah baik untuk data keseluruhan maupun untuk tiap aspek (*Problem Schema, Analogy, Causal* dan *Argumentation*). Program ini juga memiliki dampak yang tinggi dalam meningkatkan kemampuan pemecahan masalah untuk data keseluruhan dan aspek *problem schema* dan berdampak sedang pada aspek *analogy*, *causal* dan *argumentation*.

Program perkuliahan termodinamika berbasis PMK berbantuan simulasi interaktif dan *derivative games* efektif dan signifikan dalam meningkatkan kemampuan berpikir reflektif untuk data keseluruhan maupun untuk tiap aspek (*Understanding, reflection dan Critical reflection*) kecuali pada aspek *habitual action.* Program ini juga memiliki dampak yang tinggi dalam meningkatkan kemampuan pemecahan masalah untuk data keseluruhan dan aspek *reflection*, berdampak sedang pada aspek *analogy*, *causal* dan *argumentation* dan rendah pada *habitual action*.

Program PMK efektif dalam meningkatkan kemampuan pemecahan masalah dan berpikir reflektif. Mahasiswa memberikan respon positif terhadap program perkuliahan termodinamika berbasis PMK berbantuan *derivative games* dalam meningkatkan kemampuan pemecahan masalah dan berpikir reflektif. Sebagian besar mahasiswa termotivasi dalam belajar termodinamika melalui program perkuliahan berbasis PMK berbantuan simulasi interaktif dan *derivative games*. Simulasi interaktif, *derivative games* dan Lembar kerja Mahasiswa yang digunakan telah membantu mahasiswa dalam pemahaman konsep dan mencari solusi dalam pemecahan masalah termodinamika. Sebagian besar mahasiswa setuju melalui program perkuliahan PMK berbantuan simulasi interaktif dan *derivative games* membantu mahasiswa untuk aktif berkontribusi dalam kelompoknya, memberikan sanggahan argumen untuk memperkuat temuan dan menemukan

solusi untuk pemecahan masalah, memberi kemudahan dalam pemecahan permasalahan termodinamika dan meningkatkan berpikir reflektif.

5.2 Implikasi

Penelitian ini menghasilkan program perkuliahan termodinamika berbasis pemecahan masalah kolaboratif berbantuan simulasi interaktif dan *derivative games* yang efektif terhadap peningkatan kemampuan pemecahan masalah dan berpikir reflektif. Berdasarkan hasil kesimpulan maka ada beberapa implikasi yang harus diterapkan jika ingin perkuliahan termodinamika berbasis PMK berbantuan simulasi interaktif dan *derivative games* pada bidang yang lain.

Implikasi teoretis penelitian ini adalah pengembangan program perkuliahan pemecahan masalah kolaboratif berdasarkan rekonstruksi dari pembelajaran kolaboratif dan berbasis masalah dalam Pendidikan fisika. Pengembangan program pembelajaran ini harus memperhatikan pemetaan konten materi, karakter materi yang akan dipelajari, pemilihan media yang membantu dalam penjelasan konsep. Jika komponen-komponen tersebut dilibatkan dalam pembelajaran dan dibuat struktur program yang utuh, maka pembelajaran berbasis PMK ini akan dapat digunakan dengan baik dan efektif. Spesifikasi media simulasi interaktif dan *derivative games* diimplementasikan untuk membantu dalam penjelasan konsep. Kedua media tersebut disesuaikan dengan karakteristik materi pembelajaran. Kegiatan mengamati, menganalisis, menginterprestasi pada simulasi interaktif dan *derivative games* berdampak pada tingginya interkasi kolaboratif mahasiswa. Dengan demikian, pemilihan media yang tepat juga mempengaruhi keefektifan program perkuliahan yang dikembangkan.

Intergrasi Program PMK dengan bantuan simulasi interaktif dan *derivative games* dalam pembelajaran termodinamika berdampak signifikan terhadap peningkatan kemampuan pemecahan masalah dan berpikir reflektif. Keterlibatan mahasiswa dalam berkolaborasi, bertukar ide, memberikan memberikan argumen dan bantahan dalam tahapan program PMK dimunculkan untuk mengembangkan kemampuan pemecahan masalah. Sedangkan karakter refleksi pemecahan masalah

pada program dilatihkan agar terjadi evaluasi terhadap proses dan hasil pembelajaran. Dengan demikian, kedua kemampuan tersebut dapat meningkat secara signifikan.

Program perkuliahan berbasis pemecahan masalah kolaboratif yang memiliki spesifikasi media simulasi interaktif dan *derivative games* dapat menambah literatur keilmuan pengetahuan khususnya dalam bidang penelitian Pendidikan sains. Hal ini dapat memudahkan peneliti atau praktisi lainnya dalam mengembangkan secara teoritis model pembelajaran berdasarkan hasil penelitian.

Implikasi Praktis penelitian ini adalah Program perkuliahan berbasis pemecahan masalah kolaboratif berbantuan simulasi interaktif dan *derivative games* memberikan kemudahan bagi guru, dosen atau praktisi lainnya dalam meningkatkan keaktifan peserta didik untuk mencapai tujuan pembelajaran. Program ini sangat fleksibel digunakan untuk setiap materi jika *scaffolding* untuk tiap materi dapat dianalisis dengan tepat. Program perkuliahan ini menjadi pilihan yang tepat atau rujukan oleh teman sejawat pengampu mata kuliah termodinamika untuk diaplikasikan dalam pembelajarannya jika ingin meningkatkan kemampuan pemecahan masalah dan berpikir reflektif.

5.3 Rekomendasi

Penelitian ini merupakan bagian dari pengembangan inovasi pembelajaran fisika yang berusaha untuk merekonstruksi pembelajaran pemecahan masalah kolaboratif menjadi pembelajaran yang dinamis dan memiliki dampak positif dalam meningkatkan kemampuan pemecahan masalah dan berpikir reflektif. Diperlukan banyak riset lanjutan agar pembelajaran ini menjadi lebih baik diantaranya adalah perkuliahan PMK berbasis simulasi interaktif dan *derivative games* dapat digunakan untuk konteks perkuliahan yang memiliki karakteristik sama dengan termodinamika. Misalnya materi atau matakuliah Termokimia.

Peneliti selanjutnya dapat menggunakan indikator kemampuan Kemampuan pemecahan masalah yang berbeda dan dikembangkan sesuai dengan tahapan atau proses pada sintak perkuliahan termodinamika berbasis PMK,

sehingga memiliki peluang penelitian yang lebih kompleks. Kemampuan berpikir reflektif juga dapat diukur dengan indikator yang lain. Jika tetap menggunakan level berpikir reflektif Kember maka peneliti harus mengembangkan aspek pernyataan level lebih banyak dari pernyataan level penelitian ini dan sampel uji coba lebih besar.

DAFTAR PUSTAKA

Abdullah, M. (2007). *Pengantar Fisika Statistik untuk Mahasiswa*. Bandung: Institut Teknologi Bandung.

Adolphus, T., Alamina, J., & Aderonmu, T. (2013). The Effects of Collaborative Learning on Problem Solving Abilities among Senior Secondary School Physics Students in Simple Harmonic Motion. *Journal of Education and Practice*, *4*(25), 95–101.

Akpınar, E. (2014). The use of interactive computer animations based on POE as a presentation tool in primary science teaching. *Journal of Science Education and Technology*, *23*(4), 527–537. https://doi.org/10.1007/s10956-013-9482-4

Aljaberi, N. M., & Gheith, E. (2016). Pre-Service Class Teacher' Ability in Solving Mathematical Problems and Skills in Solving Daily Problems. *Higher Education Studies*, *6*(3), 32. https://doi.org/10.5539/hes.v6n3p32

Alvarado, M. V, & Neira, M. A. (2019). Collaborative Reflective Practice : Its Influence on Pre- service EFL Teachers ' Emerging Professional Identities. *IJLTR*, *7*(3), 53–70.

Álvarez-Rúa, C., & Borge, J. (2016). From Discrete to Continuous Process Simulation in Classical Thermodynamics: Irreversible Expansions of Ideal Monatomic Gases. *Journal of Chemical Education*, *93*(12), 2110–2116. https://doi.org/10.1021/acs.jchemed.6b00226

Alvarez, C., Salavati, S., Nussbaum, M., & Milrad, M. (2013). Collboard: Fostering new media literacies in the classroom through collaborative problem solving supported by digital pens and interactive whiteboards. *Computers and*

Education, *63*, 368–379. https://doi.org/10.1016/j.compedu.2012.12.019

Antonenko, P., Jahanzad, F., & Greenwood, C. (2015). Research and Teaching: Fostering Collaborative Problem Solving and 21st Century Skills Using the DEEPER Scaffolding Framework. *Journal of College Science Teaching*, *043*(09). https://doi.org/10.2505/4/jcst14_043_06_79

Apriyani, R., Ramalis, T. R., & Suwarma, I. R. (2019). Analyzing Student's Problem Solving Abilities of Direct Current Electricity in STEM-based Learning. *Journal of Science Learning*, *2*(3), 85–91. https://doi.org/10.17509/jsl.v2i3.17559

Ayvacı, H. Ş., & Özbek, D. (2019). The Effect of Documentary Films on Preservice Science Teachers' Views of Nature of Science. *Journal of Science Learning*, *2*(3), 97–107. https://doi.org/10.17509/jsl.v2i3.17998

Badan Standar Nasional Pendidikan. (2010). Paradigma Pendidikan Nasional Abad XXI. In *Paradigma Pendidikan Nasional Abad XXI*.

Bajracharya, R. R., Emigh, P. J., & Manogue, C. A. (2019). Students' strategies for solving a multirepresentational partial derivative problem in thermodynamics. *Physical Review Physics Education Research*, *15*(2), 20124. https://doi.org/10.1103/PhysRevPhysEducRes.15.020124

Bajracharya, R. R., & Thompson, J. R. (2016). Analytical derivation: An epistemic game for solving mathematically based physics problems. *Physical Review Physics Education Research*, *12*(1). https://doi.org/10.1103/ PhysRevPhys EducRes.12.010124

Balta, E. E. (2018). Reflective Thinking Tendencies and Epistemological Beliefs in Terms of Learning Styles. *International Journal of Higher Education*, *7*(6), 106. https://doi.org/10.5430/ijhe.v7n6p106

Balta, N. (2017). The Effect of Student Collaboration in Solving Physics Problems Using an Online Interactive Response System. *European Journal of Educational Research*, *6*(3), 385–394. https://doi.org/10.12973/eu-jer.6.3.385

Baran, Medine, Maskan, A., & Yasar, S. (2018). Learning physics through project-based learning game techniques. *International Journal of Instruction*, *11*(2), 221–234. https://doi.org/10.12973/iji.2018.11215a

Baran, Mukadder, & Sozbilir, M. (2018). An Application of Context- and Problem-Based Learning (C-PBL) into Teaching Thermodynamics. *Research in Science Education*, *48*(4), 663–689. https://doi.org/10.1007/s11165-016-9583-1

Barron, B. (2000). Achieving Coordination in Collaborative Problem-Solving

Groups. *The Journal of The Learning Sciences*, *9*(4), 403–436.

Beerenwinkel, A., & von Arx, M. (2017). Constructivism in Practice: an Exploratory Study of Teaching Patterns and Student Motivation in Physics Classrooms in Finland, Germany and Switzerland. *Research in Science Education*, *47*(2), 237–255. https://doi.org/10.1007/s11165-015-9497-3

Bell, R. L. (2014). Teaching the Nature of Science: Three critical questions. *National Geographic*, *98*(6), 1111–1113. https://doi.org/10.1002/sce.21131

Bloom, B. S., Engelhart, M. D., Furst, E. J., Hill, W. H., & Krathwohl, D. R. (1979). *Taxonomy of Educational Objectives: Handbook I Cognitive Domain*. https://doi.org/10.1300/J104v03n01_03

Boğar, Y. (2019). Synthesis Study on Argumentation in Science Education. *International Education Studies*, *12*(9), 1–14. https://doi.org /10.5539/ies.v 12n9p1

Boyd, E. M., & Fales, A. W. (1983). Reflective learning: Key to Learning from Experience. *Journal of Humanistic Psychology*, *23*(2), 99–117. https://doi.org /10.1177/0022167883232011

Brodbeck, F., & Greitemeyer, T. (2000). A Dynamic Model of Group Performance: Considering the Group Members' Capacity to Learn. *Group Processes & Intergroup Relations*, *3*(2), 159–182. https://doi.org/10.1177/1368 4302000 03002004

Çalik, M., Ebenezer, J., Özsevgeç, T., Küçük, Z., & Artun, H. (2015). Improving Science Student Teachers' Self-perceptions of Fluency with Innovative Technologies and Scientific Inquiry Abilities. *Journal of Science Education and Technology*, *24*(4), 448–460. https://doi.org/10.1007/s10956-014-9529-1

Carin, A.A. & Sund, R. . (1989). *Teaching Science Through Discovery*. Columbus: Merrill Publishing Company.

Ceberio, M., Almudí, J. M., & Franco, Á. (2016). Design and Application of Interactive Simulations in Problem-Solving in University-Level Physics Education. *Journal of Science Education and Technology*, *25*(4), 590–609. https://doi.org/10.1007/s10956-016-9615-7

Cho, K. L., & Jonassen, D. H. (2002). The effects of argumentation scaffolds on argumentation and problem solving. *Educational Technology Research and Development*, *50*(3), 5–22. https://doi.org/10.1007/BF02505022

Coca, D. M. (2012). Motivational Change Realized by Cooperative Learning Applied In Thermodynamics. *European Journal of Physics Education*, *3*(4), 13–26.

Cohen, J. (1988). *Statistical Power Analysis for the Behavioral Sciences* (Second Edi). New York: Lawrence Earlbaum Associates, Inc Pub, Mahwah.

Coleman, E. B. (1998). Using Explanatory Knowledge during Collaborative Problem Solving in Science. *Journal of the Learning Sciences*, *7*(3–4), 387–427. https://doi.org/10.1207/s15327809jls0703&4_5

Collins, A., & Ferguson, W. (1993). Epistemic Forms and Epistemic Games: Structures and Strategies to Guide Inquiry. *Educational Psychologist*, *28*(1), 25–42. https://doi.org/10.1207/s15326985ep2801_3

Comrey, A. L., & Lee, H. B. (1992). A first course in factor analysis, 2nd ed. In *A first course in factor analysis, 2nd ed.* Lawrence Erlbaum Associates, Inc.

Cordry, S. M. (2010). Thermodynamics and Human Population. *The Physics Teacher*, *48*(6), 403–407. https://doi.org/10.1119/1.3479722

Cox, A. J., Belloni, M., Dancy, M., & Christian, W. (2003). Teaching thermodynamics with physlets® in introductory physics. *Physics Education*, *38*(5), 433–440. https://doi.org/10.1088/0031-9120/38/5/309

Demir, S. (2015). Evaluation of Critical Thinking and Reflective Thinking Skills among Science Teacher Candidates. *Journal of Education and Practice*, *6*(18), 17–21. Retrieved from https://acces.bibl.ulaval.ca/login?url= https://search.ebscohost.com/login.aspx?direct=true&db=eric&AN=EJ1079684&lang=fr&site=ehost-live

Dewey, J. (1933). *How We Think: A restatement ofthe relation of reflective thinking to the educative process.* Lexington, Massachusetts: Heath and Company.

Didiş Körhasan, N., & Hldlr, M. (2019). How should textbook analogies be used in teaching physics? *Physical Review Physics Education Research*, *15*(1), 1–8. https://doi.org/10.1103/PhysRevPhysEducRes.15.010109

Elliott, A. C., & Woodward, W. A. (2007). *Statistical analysis quick reference guidebook: With SPSS examples*. Thousand Oaks, CA: Sage Publications.

Egoyan, A. (2011). *The Role of Physics in Science Integration*. Tbilisi, Georgia: lia Chavchavadze State University.

Ellianawati, Rusdiana, D., Sabandar, J., & Rusli, A. (2014). Capaian Level Berpikir Reflektif Mahasiswa Program Remidial Perkuliahan Fisika Matematika 1 Berbasis Cognitive Apprenticeship Instruction. *Jurnal Pendidikan Fisika Indonesia*, *10*(2), 150–157. https://doi.org/10.15294/jpfi.v10i2.3450

Ergül, N. R. (2018). Pre-service science teachers' construction and interpretation of graphs. *Universal Journal of Educational Research*, *6*(1), 139–144. https://doi.org/10.13189/ujer.2018.060113

Falconer, J. L. (2016). Combining interactive thermodynamics simulations with screencasts and conceptests. *Chemical Engineering Education*, *50*(1), 63–69.

Fatchurrohman, R. (2017). Pengaruh Motivasi Berprestasi Terhadap Kesiapan Belajar, Pelaksanaan Prakerin Dan Pencapaian Kompetensi Mata Pelajaran Produktif. *Innovation of Vocational Technology Education*, *7*(2), 164–174. https://doi.org/10.17509/invotec.v7i2.6292

Fraenkel, J. R., Wallen, N. E., & Hyun, H. H. (2012). *How to design and evaluate research in education* (Eight Edit). New York: Mc-Graw Hill.

Franco, A. (2008). Didactic Resources for Teaching English. *International Journal of Computers*, *2*(3).

Frodeman, R. (1995). Geological reasoning: geology as an interpretive and historical science. *Geological Society of America Bulletin*, *107*(8), 960–968. https://doi.org/10.1130/0016-7606(1995)107<0960:GRGAAI>2.3.CO

Geelan, D. (2013). Teacher Explanation of Physics Concepts: A Video Study. *Research in Science Education*, *43*(5), 1751–1762. https://doi.org/ 10.1007/ s11165-012-9336-8

Ghanizadeh, A. (2017). The interplay between reflective thinking, critical thinking, self-monitoring, and academic achievement in higher education. *Higher Education*, *74*(1), 101–114. https://doi.org/10.1007/s10734-016-0031-y

Ghanizadeh, A., & Jahedizadeh, S. (2017). Validating the Persian Version of Reflective Thinking Questionnaire and Probing Iranian University Students' Reflective Thinking and Academic Achievement. *International Journal of Instruction*, *10*(3), 209–226. https://doi.org/10.12973/iji.2017.10314a

Giancoli, C. D. (2005). *Physics :Priciples with Applications* (Sixth Edit). https://doi.org/10.1017/CBO9781107415324.004

Gök, T., & Sýlay, I. (2010). The Effects of Problem Solving Strategies on Students' Achievement, Attitude and Motivation. *Latin-American Journal of Physics Education*, *4*, 7–21. Retrieved from http://dialnet.unirioja .es/servlet/articulo? codigo=3694877

Graesser, A. C., Fiore, S. M., Greiff, S., Andrews-Todd, J., Foltz, P. W., & Hesse, F. W. (2018). Advancing the Science of Collaborative Problem Solving. *Psychological Science in the Public Interest*, *19*(2), 59–92. https://doi.org/ 10.1177/1529100618808244

Gunawan, M. A. (2015). *Statistik Penelitian Bidang Pendidikan, Psikologi dan Sosial*. Yogyakarta: Parama.

Hafizah, E., Misbah, M., & Annur, S. (2018). Kemampuan pemecahan masalah

mahasiswa pada materi mekanika. *Momentum: Physics Education Journal*, *2*(2), 72–78. https://doi.org/10.21067/mpej.v2i2.2729

Hake, R. R. (2002). Relationship of individual student normalized learning gains in mechanics with gender, high-school physics, and pretest scores on Mathematics and Spatial Visualization. *Physics Education Research Conference*, *8*(August 2002), 1–14. Retrieved from https://scholar.google.com/citations?view_op=view_citation&hl=en&user=10EI2q8AAAAJ&citation_for_view=10EI2q8AAAAJ:IjCSPb-OGe4C

Häkkinen, P., Järvelä, S., Mäkitalo-Siegl, K., Ahonen, A., Näykki, P., & Valtonen, T. (2017). Preparing teacher-students for twenty-first-century learning practices (PREP 21): a framework for enhancing collaborative problem-solving and strategic learning skills. *Teachers and Teaching: Theory and Practice*, *23*(1), 25–41. https://doi.org/10.1080/13540602.2016.1203772

Hansson, L., & Leden, L. (2016). Working with the nature of science in physics class: Turning "ordinary" classroom situations into nature of science learning situations. *Physics Education*, *51*(5).https://doi.org/10.1088/0031-9120/51/5/055001

Hecklau, F., Galeitzke, M., Flachs, S., & Kohl, H. (2016). Holistic Approach for Human Resource Management in Industry 4.0. *Procedia CIRP*, *54*(June 2017), 1–6. https://doi.org/10.1016/j.procir.2016.05.102

Helaluddin, H., & Fransori, A. (2019). Integrasi the Four Cs Dalam Pembelajaran Bahasa Di Era Revolusi Industri 4.0. *EduHumaniora | Jurnal Pendidikan Dasar Kampus Cibiru*, *11*(2), 95–106. https://doi.org/10.17509/eh.v11i2.16977

Heller, K., & Heller, P. (2010). Cooperative Problem Solving in Physics A User ' s Manual Can this be True? *University of Minnesota*, 310.

Henriksen, E. K., Angell, C., Vistnes, A. I., & Bungum, B. (2018). What Is Light ? Nature of Physics. In *Science & Education* (Vol. 27). Science & Education.

Hesse, F., Care, E., Buder, J., Sassenberg, K., & Griffin, P. (2015). Assessment and Teaching of 21st Century Skills. *Assessment and Teaching of 21st Century Skills*, 37–57. https://doi.org/10.1007/978-94-017-9395-7

Hidayat, S. R., Setyadin, A. H., Hermawan, H., Kaniawati, I., Suhendi, E., Siahaan, P., & Samsudin, A. (2017). Pengembangan Instrumen Tes Keterampilan Pemecahan Masalah pada Materi Getaran, Gelombang, dan Bunyi. *Jurnal Penelitian & Pengembangan Pendidikan Fisika*, *3*(2), 157–166. https://doi.org/10.21009/1.03206

Hodnik Čadež, T., & Manfreda Kolar, V. (2015). Comparison of types of

generalizations and problem-solving schemas used to solve a mathematical problem. *Educational Studies in Mathematics*, *89*(2), 283–306. https://doi.org/10.1007/s10649-015-9598-y

Hsieh, P. H., & Chen, N. S. (2012). Effects of reflective thinking in the process of designing software on students' learning performances. *Turkish Online Journal of Educational Technology*, *11*(2), 88–99.

Hu, D., Chen, K., Leak, A. E., Young, N. T., Santangelo, B., Zwickl, B. M., & Martin, K. N. (2019). Characterizing mathematical problem solving in physics-related workplaces using epistemic games. *Physical Review Physics Education Research*, *15*(2), 20131. https://doi.org/10.1103 /PhysRevPhys EducRes.15.020131

Hung, W., & Jonassen, D. H. (2006). Conceptual understanding of causal reasoning in physics. *International Journal of Science Education*, *28*(13), 1601–1621. https://doi.org/10.1080/09500690600560902

Ibrahim, B., & Rebello, N. S. (2013). Role of mental representations in problem solving: Students' approaches to nondirected tasks. *Physical Review Special Topics - Physics Education Research*, *9*(2), 1–17. https://doi.org/10.1103 /PhysRevSTPER.9.020106

Ince, E. (2018). An Overview of Problem Solving Studies in Physics Education. *Journal of Education and Learning*, *7*(4), 191. https://doi.org/10.5539 /jel.v7n4p191

J. Ellis, T., & Levy, Y. (2010). A Guide for Novice Researchers: Design and Development Research Methods. *Proceedings of the 2010 InSITE Conference*, 107–118. https://doi.org/10.28945/1237

Jackson, C., Taylor, C., & Buchheister, K. (2013). Incorporating math games into the classroom will help your students become motivated problem solvers. *JSTOR*, *18*(7), 424–429.

Jensen, J. H., Niss, M., & Jankvist, U. T. (2017). Problem solving in the borderland between mathematics and physics. *International Journal of Mathematical Education in Science and Technology*, *48*(1), 1–15. https://doi.org/10.1080 /0020739X.2016.1206979

Jewett, J. W. (2015). Bringing (Century-Old) Technology into the Classroom, Part I: Teaching Mechanics and Thermodynamics with Antiques. *The Physics Teacher*, *53*(7), 428–431. https://doi.org/10.1119/1.4931013

Johnson, N. (2012). Teacher's And Student s Perceptions Of Problem Solving Difficulties In Physics. *International Multidisciplinary E-Journal*, *1*(5), 97–101.

Jonane, L. (2015). Using analogies in teaching physics: A study on latvian teachers' views and experience. *Journal of Teacher Education for Sustainability*, *17*(2), 53–73. https://doi.org/10.1515/jtes-2015-0011

Jonassen, D. H. (2011). *Learning to solve the problems*. Taylor & Francis: Routledge.

Ke, F. (2019). Mathematical problem solving and learning in an architecture-themed epistemic game. *Educational Technology Research and Development*, *67*(5), 1085–1104. https://doi.org/10.1007/s11423-018-09643-2

Kember, D., Jones, A., Loke, A., McKay, J., Sinclair, K., Tse, H., … Yeung, E. (1999). Determining the level of reflective thinking from students' written journals using a coding scheme based on the work of Mezirow. *International Journal of Lifelong Education*, *18*(1), 18–30. https://doi.org/10.1080/026013799293928

Kember, D., Leung, D. Y. P., Jones, A., Loke, A. Y., McKay, J., Sinclair, K., … Yeung, E. (2000). Development of a questionnaire to measure the level of reflective thinking. *Assessment and Evaluation in Higher Education*, *25*(4), 381–395. https://doi.org/10.1080/713611442

Kember, D., Mckay, J., Sinclair, K., & Kam Yuet Wong, F. (2008). A four-category scheme for coding and assessing the level of reflection in written work. *Assessment and Evaluation in Higher Education*, *33*(4), 369–379. https://doi.org/10.1080/02602930701293355

Khalid, F., Ahmad, M., Karim, A. A., Daud, M. Y., & Din, R. (2015). Reflective Thinking: An Analysis of Students' Reflections in Their Learning about Computers in Education. *Creative Education*, *06*(20), 2160–2168. https://doi.org/10.4236/ce.2015.620220

Khan, S. (2011). New Pedagogies on Teaching Science with Computer Simulations. *Journal of Science Education and Technology*, *20*(3), 215–232. https://doi.org/10.1007/s10956-010-9247-2

Kim, M., & Pegg, J. (2019). Case analysis of children's reasoning in problem-solving process. *International Journal of Science Education*, *41*(6), 739–758. https://doi.org/10.1080/09500693.2019.1579391

Körhasan, N. D., & Gürel, D. K. (2014). *Student Teachers' Physics Knowledge and Sources of Knowledge to Explain Everyday Phenomena*. *30*(4), 298–309.

Kulkarni, V., & Tambade, P. (2013). Assessing the Conceptual Understanding about Heat and Thermodynamics at Undergraduate Level. *European Journal Of Physics Education*, *4*(2), 9–16. Retrieved from http://ejpe.erciyes.edu.tr/index.php/EJPE/article/view/101

Kumar, D. . (2004). Analysis of laptop computers in science. *Sci Educa Int*, *15*(3), 201–208.

Kurikulum. (2018). *Dokumen Kurikulum Program Studi Fisika*. OKU Timur: STKIP NURUL HUDA.

Kustusch, M. B., Roundy, D., Dray, T., & Manogue, C. A. (2014). Partial derivative games in thermodynamics: A cognitive task analysis. *Physical Review Special Topics - Physics Education Research*, *10*(1), 1–16. https://doi.org/10.1103/PhysRevSTPER.10.010101

Larkin, J. H., & Reif, F. (2007). Education Understanding and Teaching Problem - Solving in Physics Understanding and Teaching Problem- Solving in Physics. *European Journal of Science*, *1*(2), 191–203.

Leak, A. E., Rothwell, S. L., Olivera, J., Zwickl, B., Vosburg, J., & Martin, K. N. (2017). Examining problem solving in physics-intensive Ph.D. research. *Physical Review Physics Education Research*, *13*(2), 1–13. https://doi.org/10.1103/PhysRevPhysEducRes.13.020101

Lee, H. J. (2005). Understanding and assessing preservice teachers' reflective thinking. *Teaching and Teacher Education*, *21*(6), 699–715. https://doi.org/10.1016/j.tate.2005.05.007

Leman, M. A. (2018). *Cara Praktis Melakukan Uji Validitas Alat Ukur Penelitian*. Yogyakarta: Gosyen.

Lin, L., Mills, L. A., & Ifenthaler, D. (2016). Collaboration, multi-tasking and problem solving performance in shared virtual spaces. *Journal of Computing in Higher Education*, *28*(3), 344–357. https://doi.org/10.1007/s12528-016-9117-x

Linn, M. C. (2003). Technology and science education: Starting points, research programs, and trends. *International Journal of Science Education*, *25*(6), 727–758. https://doi.org/10.1080/09500690305017

Liu, Q. T., Liu, B. W., & Lin, Y. R. (2019). The influence of prior knowledge and collaborative online learning environment on students' argumentation in descriptive and theoretical scientific concept. *International Journal of Science Education*, *41*(2), 165–187. https://doi.org/10.1080/09500693.2018.1545100

Llin, T.-J., Duh, H. B.-L., Li, N., Wang, H.-Y., & Tsai, C.-C. (2013). An investigation of learners' collaborative knowledge construction performances and behavior patterns in an augmented reality simulation system. In *Computers and Education* (Vol. 68). https://doi.org/10. 1016/j.compedu. 2013.05.011

Lorenzo, M. (2005). The Development, Implementation, And Evaluation Of A Problem Solving Heuristic. *International Journal of Science and Mathematics Education*, 33–58.

Lukitasari, M., Handika, J., & Murtafiah, W. (2017). 21st Century Skills Mahasiswa Calon Guru Dalam Pembelajaran Matematika. *Prosiding Seminar Hasil Penelitian Dan Pengabdian Kepada Masyarakat UNIPMA*, (4), 372–378.

Mahmudi, A. (2006). Pembelajaran Kolaboratif. *Seminar Nasional MIPA 2006*, 60–70.

Markant, D. B., Ruggeri, A., Gureckis, T. M., & Xu, F. (2016). Enhanced Memory as a Common Effect of Active Learning. *Mind, Brain, and Education*, *10*(3), 142–152. https://doi.org/10.1111/mbe.12117

Marzabal, A., Merino, C., Moreira, P., & Delgado, V. (2019). Assessing Science Teaching Explanations in Initial Teacher Education: How Is This Teaching Practice Transferred Across Different Chemistry Topics? *Research in Science Education*, *49*(4), 1107–1123. https://doi.org/10.1007/s11165-019-9855-7

Mayer, R. E. (1992). *Thinking problem-solving, cognition*. New York: W.H. Freeman; 2nd edition.

Mazorodze, R., & Reiss, M. (2018). Raising Attainment in Post-Compulsory Physics through Collaborative Problem Solving. *School Science Review*, *99*(369), 96–104.

McComas, W. F., & Almazroa, H. (1998). The NOS in Science Education; An Introduction.pdf. *Science & Education*, Vol. 7, pp. 511–532.

Mezirow, J. (1991). *Transformative Dimensions of Adult Learning*. San Fransisco: Jossey-Bass.

Michael, J. (2006). Where's the evidence that active learning works? *American Journal of Physiology - Advances in Physiology Education*, *30*(4), 159–167. https://doi.org/10.1152/advan.00053.2006

Mirzaei, F., Phang, F. A., & Kashefi, H. (2014). Measuring Teachers Reflective Thinking Skills. *Procedia - Social and Behavioral Sciences*, *141*, 640–647. https://doi.org/10.1016/j.sbspro.2014.05.112

Moon, J. (2007). Critical thinking: An exploration of theory and practice. In *Critical Thinking: An Exploration of Theory and Practice*. https://doi.org/10.4324/9780203944882

Moran, M. J., & Shapiro, H. N. (2006). Fundamentals of engineering thermodynamics. *John Wiley & Sons*.

Mulop, N., Yusof, K. M., & Tasir, Z. (2012). A Review on Enhancing the Teaching and Learning of Thermodynamics. *Procedia - Social and Behavioral Sciences*, *56*(Ictlhe), 703–712. https://doi.org/10.1016/j.sbspro.2012.09.706

Musyafak, A., Linuwih, S., & Sulhadi. (2013). *Konsepsi Alternatif Mahasiswa Fisika Pada Materi Termodinamika*. *2*(3), 54–60.

Naghdipour, B., & Emeagwali, O. L. (2013). Assessing the Level of Reflective Thinking in ELT Students. *Procedia - Social and Behavioral Sciences*, *83*, 266–271. https://doi.org/10.1016/j.sbspro.2013.06.052

Nainggolan, S. W. (1978). *Termodinamika Teori-Soal-Penyelasaian*. Armico, Bandung.

National Research Council. (2000). How People Learn: Brain, Mind, Experience, and School: Expanded Edition. In *How People Learn: Brain, Mind, Experience, and School* (pp. 31–50). https://doi.org/10.17226/9853

Nelson, L. M. (2013). Collaborative problem solving. In *Instructional-Design Theories and Models: A New Paradigm of Instructional Theory* (Vol. 2). https://doi.org/10.4324/9781410603784-17

Niss, M. (2018). What Is Physics Problem-Solving Competency? The Views of Arnold Sommerfeld and Enrico Fermi. *Science and Education*, *27*(3–4), 357–369. https://doi.org/10.1007/s11191-018-9973-z

Nordin, N. M., & Osman, K. (2018). Students' Generated Animation: An Innovative Approach to Inculcate Collaborative Problem Solving (CPS) Skills in Learning Physics. *Journal of Education in Science, Environment and Health*, 205. https://doi.org/10.21891/jeseh.436758

OECD. (2014). *PISA 2012 Results : Creative Problem Solving*. OECD 2017.

Oliveri, M. E., Lawless, R., & Molloy, H. (2017). A Literature Review on Collaborative Problem Solving for College and Workforce Readiness. *ETS Research Report Series*, *2017*(1), 1–27. https://doi.org/10.1002/ets2.12133

Olur, B. (2020). Development Of Reflective Thinking Scale. *European Journal of Alternative Education Studies*, 1–15. https://doi.org/10.5281/zenodo.3588469

Olusegun, S. (2015). Constructivism Learning Theory: A Paradigm for Teaching and Learning. *IOSR Journal of Research & Method in Education Ver. I*, *5*(6), 2320–7388. https://doi.org/10.9790/7388-05616670

Panggabean, D. ., Irfandi, & Sinuraya, J. (2017). Improving Of The Student Learning In Lectures Of General Physics I By Collaborative Learning Model Based On Saintific Approach. *Jurnal Pendidikan Fisika Indonesia*, *13*(2), 79–87. https://doi.org/10.15294/jpfi.v13i2.10152

Partanen, L. (2016). Student oriented approaches in the teaching of thermodynamics at universities-developing an effective course structure. *Chemistry Education Research and Practice*, *17*(4), 766–787. https://doi.org/10.1039/c6rp00049e

Patnani, M. (2013). Upaya Meningkatkan Kemampuan Problem Solving pada mahasiswa. *Jurnal Psikogenesis*, *1*(2), 185–198.

Pike, G. R., Smart, J. C., & Ethington, C. A. (2012). The Mediating Effects of Student Engagement on the Relationships Between Academic Disciplines and Learning Outcomes: An Extension of Holland's Theory. *Research in Higher Education*, *53*(5), 550–575. https://doi.org/10.1007/s11162-011-9239-y

Podolak, K., & Plattsburgh, S. (2013). Interactive Modern Physics Worksheets Methodology and Assessment by Students. *European Journal of Physics Education*, *4*(2), 27–31. https://doi.org/10.20308/ejpe.03366

Politsinsky, E., Demenkova, L., & Medvedeva, O. (2015). Ways of Students Training Aimed at Analytical Skills Development while Solving Learning Tasks. *Procedia - Social and Behavioral Sciences*, *206*(November), 383–387. https://doi.org/10.1016/j.sbspro.2015.10.070

Powell, S. R., & Fuchs, L. S. (2018). Effective Word-Problem Instruction: Using Schemas to Facilitate Mathematical Reasoning. *Teaching Exceptional Children*, *51*(1), 31–42. https://doi.org/10.1177/0040059918777250

Prince, M. J., & Felder, R. M. (2006). Inductive teaching and learning methods: Definitions, comparisons, and research bases. *Journal of Engineering Education*, *95*(2), 123–138. https://doi.org/10.1002/j.2168-9830.2006.tb00884.x

PSI. (2016). Rincian capaian pembelajaran program sarjana pendidikan fisika. Retrieved from http://www.fisika.or.id/

Puntambekar, S., Erkens, G., & Hmelo-Silver, C. (2011). *Analyzing interactions in CSCL. Methods, approaches and issues*. New York: Springer New York.

Rahimi, N. H. Z., Mat Rashid, A., & Hamzah, R. (2015). Hubungan Antara Penglibatan Dalam Teknikal Dan Vokasional. *Journal of Human Capital Development*, *8*(1), 105–120.

Redish, E. F., & Burciaga, J. R. (2004). Teaching Physics with the Physics Suite. *American Journal of Physics*, *72*(3), 414–414. https://doi.org/10.1119/1.1691552

Ritz, H., & Schneider-Bentley, L. (2018). Collaborative problem solving at Chalkboard vs. on paper for first-year calculus. *Advances in Engineering*

Education, *6*(3), 1–22.

Rizzi, A. (2012). Nature of Physics, Modern and Ancient. In *Institute for Avanced Physics*. LA.

Rotherham, A J. and Willingham, D. T. (2010). 21st-Century" Skills Not New, but a Worthy Challenge. *American Educator*, 17–20. https:// doi.org/10.1145 /1719292.1730970

Rusydi, R. (2017). Pembelajaran Berbasis Masalah (Pbm) Pada Materi Termodinamika Untuk Meningkatkan Kemampuan Kognitif Dan Kemampuan Kreatif (Kreativitas) Mahasiswa Ftk Uin Ar-Raniry Banda Aceh. *Jurnal IPA & Pembelajaran IPA*, *1*(2), 192–202. https://doi.org/10.24815/jipi.v1i2.9694

Sağır, U., Şafak, Aslan, Oktay, Bertiz, Harun, … Fulya. (2016). Investigation of the relationship between pre-service science teachers ' perceived self-efficacy in science teaching and disposition toward reflective thinking. *European Journal of Science and Mathematics Education*, *4*(3), 331–345.

Saleh, S. (2014). Malaysian students' motivation towards Physics learning. *European Journal of Science and Mathematics Education*, *2*(4), 223–232.

Saputri, A. A. I. (2017). Developing Physics E-Scaffolding Teaching Media to Increase the Eleventh-Grade Students' Problem Solving Ability and Scientific Attitude. *International Journal of Environmental and Science Education*, *12*(4), 729–745.

Saricayir, H., Ay, S., Comek, A., Cansiz, G., & Uce, M. (2016). Determining Students' Conceptual Understanding Level of Thermodynamics. *Journal of Education and Training Studies*, *4*(6), 69–79. https://doi.org/10.11114 /jets.v4i6.1421

Satjatam, P., Sarintip, R., & Teerachai, N. (2016). Developing reflective thinking instructional model for enhancing students desirable learning outcomes. *Educational Research and Reviews*, *11*(6), 238–251. https://doi.org/1 0.5897/err2015.2380

Schoenfeld, A. H. (2007). What is mathematical proficiency and how can it be assessed? *Assessing Mathematical Proficiency*, *53*, 59–74. https://doi.org/10 .1017/CBO9780511755378.008

Schon, D. A. (1987). *Educating the Reflective Practitioner. Towards a New Design for Teaching and Learning in the Professions*. https://doi.org/10.1136/ qshc.1.1.81

Sen, H. S. (2013). Reflective thinking skills of primary school students based on problem solving ability. *International Journal of Academic Research*, *5*(5),

41–48. https://doi.org/10.7813/2075-4124.2013/5-5/b.6

Sinensis, A. R., Firman, H., Hamidah, I., & Muslim, M. (2019). Reconstruction of collaborative problem solving based learning in thermodynamics with the aid of interactive simulation and derivative games. *Journal of Physics: Conference Series*, *1157*(3). https://doi.org/ 10.1088/1742-6596/1157 /3/032 042

Sivaci, S. Y. (2017). The Relationship between Reflective Thinking Tendencies and Social Problem Solving Abilities of Pre-Service Teachers. *Journal of Education and Training Studies*, *5*(11), 21.https://doi.org/10.11114/jets.v 5i11.2273

Slameto. (2018). Penerapam Cooperative Learning Untuk Meningkatkan HOTS. *Jurnal Pendidikan Dasar*, *4*(1), 124–140.

Smith, T. I., Christensen, W. M., Mountcastle, D. B., & Thompson, J. R. (2015). Identifying student difficulties with entropy, heat engines, and the Carnot cycle. *Physical Review Special Topics - Physics Education Research*, *11*(2), 1–14. https://doi.org/10.1103/PhysRevSTPER.11.020116

Soni, M. K., & Bhattacharya, T. (2019). Design and development of Game based Evaluation and Learning (GABEL) for applied thermodynamics course for active learning. *Proceedings of the International Conference on Industrial Engineering and Operations Management*, *2019*(MAR), 3673–3678.

Soodmand Afshar, H., & Rahimi, M. (2016). Reflective thinking, emotional intelligence, and speaking ability of EFL learners: Is there a relation? In *Thinking Skills and Creativity* (Vol. 19). https://doi.org/10.1016 /j.tsc.2015.10.005

Sorensen, P., Newton, L., & McCarthy, S. (2012). Developing a science teacher education course that supports student teachers' thinking and teaching about the nature of science. *Research in Science and Technological Education*, *30*(1), 29–47. https://doi.org/10.1080/02635143.2012.671767

Stahl, G. (2005). Group cognition in computer-assisted collaborative learning. *Journal of Computer Assisted Learning*, *21*(2), 79–90. https: //doi.org /10.111 / j.1365-2729.2005.00115.x

Styer, D. F. (2008). Entropy and evolution. *American Journal of Physics*, *76*(11), 1031–1033. https://doi.org/10.1119/1.2973046

Taylor, K., & Baek, Y. (2018). Collaborative Robotics, More Than Just Working in Groups. *Journal of Educational Computing Research*, *56*(7), 979–1004. https://doi.org/10.1177/0735633117731382

Tejeda, S., & Dominguez, A. (2018). Influence of Interactions in the Collaborative Solving of a Velocity Problem. *International Electronic Journal of Mathematics Education*, *14*(1), 91–108. https://doi.org/10.12973/iejme/3979

Theobald, J., Gardner, F., & Long, N. (2017). Teaching Critical Reflection in Social Work Field Education. *Journal of Social Work Education*, *53*(2), 300–311. https://doi.org/10.1080/10437797.2016.1266978

Tim Pengembang Kurikulum Pendidikan Tinggi. (2017). *KKNI dan SN-DIKTI*. Jakarta: KEMENRISTEKDIKTI.

Tim Pengembang SPMI. (2014). *Standar Nasional Pendidikan Tinggi*. Jakarta: KEMENRISTEKDIKTI.

Töman, U., Sabiha O Ç, A., & Atilla Ç, A. (2014). Analysis of Pre-Service Science Teachers' Views About the Methods Which Develop Reflective Thinking. *International Journal on New Trends in Education and Their Implications October*, (October), 16–1309. Retrieved from www.ijonte.org

Tuminaro, J., & Redish, E. F. (2007). Elements of a cognitive model of physics problem solving: Epistemic games. *Physical Review Special Topics - Physics Education Research*, *3*(2), 1–22. https://doi.org/10.1103/ PhysRevSTPER. 3.020101

Ünver, G. (2007). *Reflective thinking In new trends in education*. Ankara: Pegema Yaıncılık.

UU Pendidikan Tinggi. (2012). *Undang-Undang Republik Indonesia Nomor 12 Tahun 2012 Tentang Pendidikan Tinggi*.

Vieira, C., Magana, A. J., García, R. E., Jana, A., & Krafcik, M. (2018). Integrating Computational Science Tools into a Thermodynamics Course. *Journal of Science Education and Technology*, *27*(4), 322–333. https://doi.org/10.1007/s10956-017-9726-9

Wang, Y., & Chiew, V. (2010). On the cognitive process of human problem solving. *Cognitive Systems Research*, *11*(1), 81–92. https://doi.org/10.1016/ j.cogsys.2008.08.003

Wijaya, E. Y., Sudjimat, D. A., & Nyoto, A. (2016). Transformasi pendidikan Sebagai tuntutab. *Seminar Nasional Pendidikan Matematika 2016 ~ Universitas Kanjuruhan Malang*, *1*, 263–278. https://doi.org/2528-259X

Williams, M. (2018). The Missing Curriculum in Physics Problem-Solving Education. *Science and Education*, *27*(3–4), 299–319. https://doi.org/10.1007/ s11191-018-9970-2

Winarso, W. (2016). Assessing the Readiness of Student Learning Activity and

Learning Outcome. *Assessing the Readiness of Student Learning Activity and Learning Outcome*, *10*(2). https://doi.org/10.13170/jp.10.2.5246

Wu, G., & Wu, A. Y. (2019). A new perspective of how to understand entropy in thermodynamics. *Physics Education*, *55*(1), 015005. https://doi.org/10.1088/1361-6552/ab4de6

Xie, C. (2012). Interactive Heat Transfer Simulations for Everyone. *The Physics Teacher*, *50*(4), 237–240. https://doi.org/10.1119/1.3694080

Yang, D., Streveler, R. A., Miller, R. L., Slotta, J. D., Matusovich, H. M., & Magana, A. J. (2012). Using computer-based online learning modules to promote conceptual change: Helping students understand difficult concepts in thermal and transport science. *International Journal of Engineering Education*, *28*(3), 686–700.

Yao-Ping Peng, M., & Chen, C. C. (2019). The effect of instructor's learning modes on deep approach to student learning and learning outcomes. *Educational Sciences: Theory and Practice*, *19*(3), 65–85. https://doi.org/10 .12738 /estp.2019.3.005

Zemansky, W. M., & Dittman, H. R. (1997). *Heat and thermodynamics* (Seven edit). Mc-Graw Hill.

Zhang, L. (2014). A Meta-analysis Method to Advance Design of Technology-Based Learning Tool: Combining Qualitative and Quantitative Research to Understand Learning in Relation to Different Technology Features. *Journal of Science Education and Technology*, *23*(1), 145–159. https ://doi.or g/10.1007 /s10956-013-9460-x

Zwickl, B. M., Hu, D., Finkelstein, N., & Lewandowski, H. J. (2015). Model-based reasoning in the physics laboratory: Framework and initial results. *Physical Review Special Topics - Physics Education Research*, *11*(2). https://doi.org/10.1103/PhysRevSTPER.11.020113