BAB V
SIMPULAN, IMPLIKASI DAN REKOMENDASI

1.1. Simpulan

Berdasarkan hasil penelitian dan pembahasan, maka dapat ditarik beberapa rincian simpulan sebagai berikut:

1. Perkuliahan fisika dasar berbasis masalah didukung multimedia interaktif dengan platform android dengan karakteristik memiliki sintaks yang terdiri dari lima fase yang setiap fasenya disertai aktivitas belajar mandiri dengan multimedia interaktif berplatform android. Adapun kelima fasenya adalah: (1) Orientasi mahasiswa pada masalah; (2) Mengorganisasi mahasiswa untuk belajar; (3) Investigasi mandiri dan kelompok; (4) mengembangkan dan menampilkan artifek dan presentasi, (5) Analisis dan evaluasi proses pemecahan masalah pada 5 materi/topik perkuliahan terkait fisika dasar yaitu: gerak dua dimensi, dinamika, fluida statis, fluida dinamis dan kalor. Dukungan multiemdia interaktif berplatform android yang memiliki komponen teori, animasi, video, serta latihan soal dapat meningkatkan keterampilan berpikir kritis, kemampuan pemecahan masalah dan kemampuan ICT mahasiswa.
2. Perkuliahan fisika dasar berbasis masalah didukung multimedia interaktif dengan platform android dapat meningkatkan keterampilan berpikir kritis mahasiswa.
3. Perkuliahan fisika dasar berbasis masalah didukung multimedia interaktif dengan platform android dapat meningkatkan kemampuan pemecahan masalah mahasiswa.
4. Perkuliahan fisika dasar berbasis masalah didukung multimedia interaktif dengan platform android dapat meningkatkan kemampuan ICT mahasiswa calon guru fisika yaitu berada pada kategori sedang dengan level memerlukan bimbingan.
5. Terdapat peningkatan yang signifikan keterampilan berpikir kritis, kemampuan pemecahan masalah dan kemampuan ICT mahasiswa yang mendapatkan perkuliahan menggunakan model PBL-MMIa dibandingkan dengan

mahasiswa yang mendapatkan perkuliahan menggunakan model PBL tanpa MMIa.

6. Hasil skala sikap mahasiswa dan dosen berada pada kategori setuju dan sangat setuju terhadap implementasi perkuliahan fisika dasar berbasis masalah didukung multimedia interaktif dengan platform android.

1.2. Implikasi

Implikasi hasil penelitian ini terhadap permasalahan keterampilan berpikir kritis, kemampuan pemecahan masalah dan kemampuan ICT adalah perkuliahan fisika dasar berbasis masalah didukung multimedia interaktif dengan platform android dapat membekalkan keterampilan berpikir kritis, kemampuan pemecahan masalah dan kemampuan ICT. Selain itu model PBL-MMIa juga dapat memberikan dampak positif penggunaan aplikasi android melalui aplikasi Phydia sebagai multimedia interaktif dengan platform android khususnya untuk pembelajaran fisika dasar, yang mampu memfasilitasi aktivitas belajar mandiri secara online. PBL-MMIa juga dapat memberikan kontribusi pada peningkatan kualifikasi akademik dan kompetensi mahasiswa calon guru fisika sebagai agen pembelajaran, serta memiliki keterampilan-keterampilan yang diperlukan pada abad 21.

1.3. Rekomendasi

Berdasarkan temuan dan hasil penelitian, Peneliti memberikan rekomendasi untuk penelitian dan pengembangan lebih lanjut terkait perkuliahan fisika dasar berbasis masalah didukung multimedia interaktif dengan platform android untuk meningkatkan keterampilan berpikir kritis, kemampuan pemecahan masalah dan kemampuan ICT sebagai berikut:

1. Masalah harus dapat memfasilitasi mahasiswa untuk mempelajari banyak konsep fisika selama proses pembeajaran.
2. Masalah harus relevan dengan kehidupan mahasiswa agar pembelajaran lebih bermakna.
3. Multimedia interaktif dengan platform android membutuhkan spesifikasi handphone yang baik untuk mendapatkan hasil yang baik pula.

DAFTAR PUSTAKA

Abdimannobovna, M. L., & Sharifovna, Y. D. (2019). Implementation Bases Of Using Multimedia Technologies In The Organization Of Educational Process. *THINK INDIA (Quarterly Journal)*, *22*(4), 6258–6269.

Adams, W. K., & Wieman, C. E. (2015). Analyzing the many skills involved in solving complex physics problems. *American Journal of Physics*, *83*(5), 459–467. https://doi.org/10.1119/1.4913923

Adri, M., Rusdinal, Zainul, R., Darni, Sriadhi, Wahyuningtyas, N., Khaerudin, Nasrun, Rahmulyani, Nuranjani, Nurmaniah, Wedi, A., Surahman, E., Aisyah, E. N., Oktaviani, H. I., Sri Martini Meilanie, R., Purnamawati, S. N., Hapidin, Listyasari, W. D., … Adnan, E. (2020). Development of Content Learning System in Professional Education Subjects for Educational Institutions in Indonesia. *Journal of Physics: Conference Series*, *1594*(1). https://doi.org/10.1088/1742-6596/1594/1/012022

Ali, M., Talib, C.-A., Hasniza Ibrahim, N., Surif, J., & Halim Abdullah, A. (2016). The Importance of Monitoring Skills in Physics Problem Solving. *European Journal of Education Studies*, *1*(3), 1–10.

Amin, A. M., Corebima, A. D., Zubaidah, S., & Mahanal, S. (2020). The correlation between metacognitive skills and critical thinking skills at the implementation of four different learning strategies in animal physiology lectures. *European Journal of Educational Research*, *9*(1), 143–163. https://doi.org/10.12973/eu-jer.9.1.143

Anaelka, A. H. (2018). Education 4.0 Made Simple: Ideas For Teaching. *International Journal of Education and Literacy Studies*, *6*(3), 92. https://journals.aiac.org.au/index.php/IJELS/article/view/4616

Anagün, Ş. S. (2018). Teachers' perceptions about the relationship between 21st century skills and managing constructivist learning environments. *International Journal of Instruction*, *11*(4), 825–840.

https://doi.org/10.12973/iji.2018.11452a

Andari, S., Windasari, W., Chandra Setiawan, A., & Rifqi, A. (2021). Student Exchange Program of Merdeka Belajar-Kampus Merdeka (MBKM) in Covid-19 Pandemic. *JPP (Jurnal Pendidikan Dan Pembelajaran)*, *28*(1), 30–37. https://doi.org/10.17977/um047v28i12021p030

Anindyarini, A., Rokhman, F., Mulyani, M., & . A. (2018). Behavioristic Theory and Its Application in the Learning of Speech. *KnE Social Sciences*, *3*(9), 522. https://doi.org/10.18502/kss.v3i9.2714

Argaw, A. S., Haile, B. B., Ayalew, B. T., & Kuma, S. G. (2017). The effect of problem based learning (PBL) instruction on students' motivation and problem solving skills of physics. *Eurasia Journal of Mathematics, Science and Technology Education*, *13*(3), 857–871. https://doi.org/10.12973/eurasia.2017.00647a

Arista, F. S., & Kuswanto, H. (2018). Virtual physics laboratory application based on the android smartphone to improve learning independence and conceptual understanding. *International Journal of Instruction*, *11*(1), 1–16. https://doi.org/10.12973/iji.2018.1111a

Asysyifa, D. S., . J., Wilujeng, I., & Kuswanto, H. (2019). Analysis of Students Critical Thinking Skills Using Partial Credit Models (PCM) in Physics Learning. *International Journal of Educational Research Review*, 245–253. https://doi.org/10.24331/ijere.518068

Ayyildiz, Y., & Tarhan, L. (2018). Problem-based learning in teaching chemistry: enthalpy changes in systems. *Research in Science and Technological Education*, *36*(1), 35–54. https://doi.org/10.1080/02635143.2017.1366898

Baharuddin, M. R. (2021). Adaptasi Kurikulum Merdeka Belajar Kampus Merdeka (Fokus: Model MBKM Program Studi). *Jurnal Studi Guru Dan Pembelajaran*, *4*(1), 195–205. https://www.e-journal.my.id/jsgp/article/view/591

Bahri, A., Jamaluddin, A. B., Muharni, A., Fikri, M. J. N., & Arifuddin, M. (2021). The Need of Science Learning to Empower High Order Thinking Skills in 21st Century. *Journal of Physics: Conference Series*, *1899*(1). https://doi.org/10.1088/1742-6596/1899/1/012144

Balta, N., & Asikainen, M. A. (2019). Introductory students' attitudes and approaches to physics problem solving: Major, achievement level and gender differences. *Journal of Technology and Science Education*, *9*(3), 378–387. https://doi.org/10.3926/JOTSE.666

Bao, L., & Koenig, K. (2019). Physics education research for 21st century learning. *Disciplinary and Interdisciplinary Science Education Research*, *1*(1), 1–12. https://doi.org/10.1186/s43031-019-0007-8

Baquier Orozco, R., Barraza Castillo, R. I., & Husted Ramos, S. (2020). Neoaltar: An interactive multimedia day of the dead experience. *Heliyon*, *6*(2). https://doi.org/10.1016/j.heliyon.2020.e03339

Barak, M. (2020). Problem-, Project- and Design-Based Learning: Their Relationship to Teaching Science, Technology and Engineering in School. *Journal of Problem-Based Learning*, *7*(2), 94–97. https://doi.org/10.24313/jpbl.2020.00227

Batlolona, J. R., Baskar, C., Kurnaz, M. A., & Leasa, M. (2018). The improvement of problem-solving skills and physics concept mastery on temperature and heat topic. *Jurnal Pendidikan IPA Indonesia*, *7*(3), 273–279. https://doi.org/10.15294/jpii.v7i3.12432

Boud, D., & Dawson, P. (2021). What feedback literate teachers do: an empirically-derived competency framework. *Assessment and Evaluation in Higher Education*, *0*(0), 1–14. https://doi.org/10.1080/02602938.2021.1910928

Brodsky, B. E., & Darkhovsky, B. S. (2000). Non-Parametric Statistical Diagnosis. In *Springer-Science+Business Media, B.V.* https://doi.org/10.1007/978-94-015-9530-8

Budi, A. S., Muliyati, D., Ambarwulan, D., & Bakri, F. (2019). The development of ICT-based learning curriculum for pre-service physics teacher. *Journal of Physics: Conference Series*, *1318*(1). https://doi.org/10.1088/1742-6596/1318/1/012137

Cevik, M., & Senturk, C. (2019). Multidimensional 21st century skills scale : Validity and reliability study. *Cypriot Journal of Educational*, *14*(1), 11–28.

Daniel, E. (2016). The Usefulness of Qualitative and Quantitative Approaches and Methods in Researching Problem-Solving Ability in Science Education Curriculum. *Journal of Education and Practice*, *7*(15), 91–100. https://doi.org/2222-288X

Darmaji, Astalini, Kurniawan, D. A., Parasdila, H., Iridianti, Susbiyanto, Kuswanto, & Ikhlas, M. (2019). E-Module based problem solving in basic physics practicum for science process skills. *International Journal of Online and Biomedical Engineering*, *15*(15), 4–17. https://doi.org/10.3991/ijoe.v15i15.10942

Darmaji, Kurniawan, D. A., Astalini, Lumbantoruan, A., & Samosir, S. C. (2019). Mobile learning in higher education for the industrial revolution 4.0: Perception and response of physics practicum. *International Journal of Interactive Mobile Technologies*, *13*(9), 4–20. https://doi.org/10.3991/ijim.v13i09.10948

Dasilva, B. E., Ardiyati, T. K., Suparno, Sukardiyono, Eveline, E., Utami, T., & Ferty, Z. N. (2019). Development of Android-based Interactive Physics Mobile Learning Media (IPMLM) with scaffolding learning approach to improve HOTS of high school students. *Journal for the Education of Gifted Young Scientists*, *7*(3), 659–681. https://doi.org/10.17478/jegys.610377

de Bie, H., Wilhelm, P., & van der Meij, H. (2015). The Halpern Critical Thinking Assessment: Toward a Dutch appraisal of critical thinking. *Thinking Skills and Creativity*, *17*, 33–44. https://doi.org/10.1016/j.tsc.2015.04.001

Defrizal, Redaputri, A. P., Narundana, V. T., Nurdiawansyah, & Dharmawan, Y.

Y. (2022). Institutional Model Design for the Implementation of the Program Merdeka Belajar Kampus Merdeka (Merdeka Learning Program-Merdeka Campus or MBKM). *Studies in Learning and Teaching*, *3*(1), 28–35. https://doi.org/10.46627/silet.v3i1.93

Devy Alvionita, Prabowo, & Z.A. Imam Supardi. (2020). Problem Based Learning With The SETS Method To Improve The Student's Critical Thinking Skill of Senior High School. *IJORER : International Journal of Recent Educational Research*, *1*(3), 246–260. https://doi.org/10.46245/ijorer.v1i3.46

Dewi, N. R., Magfiroh, L., Nurkhalisa, S., & Dwijayanti, I. (2019). The development of contextual-based science digital storytelling teaching materials to improve students' critical thinking on classification theme. *Journal of Turkish Science Education*, *16*(3), 364–378. https://doi.org/10.12973/tused.10288a

Din, M. (2020). Evaluating university students' critical thinking ability as reflected in their critical reading skill: A study at bachelor level in Pakistan. *Thinking Skills and Creativity*, *35*(January), 100627. https://doi.org/10.1016/j.tsc.2020.100627

Djamas, D., Tinedi, V., & Yohandri. (2018). Development of interactive multimedia learning materials for improving critical thinking skills. *International Journal of Information and Communication Technology Education*, *14*(4), 66–84. https://doi.org/10.4018/IJICTE.2018100105

Dowd, J. E., Thompson, R. J., Schiff, L. A., & Reynolds, J. A. (2018). Understanding the complex relationship between critical thinking and science reasoning among undergraduate thesis writers. *CBE Life Sciences Education*, *17*(1). https://doi.org/10.1187/cbe.17-03-0052

Drigas, A., & Kontopoulou, M.-T. L. (2016). ICTs based Physics Learning. *International Journal of Engineering Pedagogy (IJEP)*, *6*(3), 53. https://doi.org/10.3991/ijep.v6i3.5899

Dunleavy, S., Kestin, G., Callaghan, K., McCarty, L., & Deslauriers, L. (2022).

Increased learning in a college physics course with timely use of short multimedia summaries. *Physical Review Physics Education Research*, *18*(1), 10110. https://doi.org/10.1103/PhysRevPhysEducRes.18.010110

Ennis, P. J. (2015). The Palgrave Handbook of Critical Thinking in Higher Education. In *Syria Studies* (Vol. 7, Issue 1). https://www.researchgate.net/publication/269107473_What_is_governance/link/548173090cf22525dcb61443/download%0Ahttp://www.econ.upf.edu/~reynal/Civil wars_12December2010.pdf%0Ahttps://think-asia.org/handle/11540/8282%0Ahttps://www.jstor.org/stable/41857625

Erdogan, F. (2019). Effect of cooperative learning supported by reflective thinking activities on students' critical thinking skills. *Eurasian Journal of Educational Research*, *2019*(80), 89–112. https://doi.org/10.14689/ejer.2019.80.5

Fathurrochman, I., Danim, S., Syaiful Anwar, A., & Kurniah, N. (2021). The School Principals' Role in Education Management at the Regional Level: An Analysis of Educational Policy in the Industrial Revolution 4.0. *Advances in Social Science, Education and Humanities Research*, *532*(532), 237–242. https://doi.org/10.2991/assehr.k.210227.042

Fayanto, S., Misrawati, M., Sulisworo, D., Istiqomah, H. F. N., & Sukariasih, L. (2019). The Implementation of Multimedia on Physics Learning Based on Direct Instruction Model in The Topic of Light. *Indonesian Journal of Learning Education and Counseling*, *1*(2), 124–132. https://doi.org/10.31960/ijolec.v1i2.94

Fidan, M., & Tuncel, M. (2019). Integrating augmented reality into problem based learning: The effects on learning achievement and attitude in physics education. *Computers and Education*, *142*(July), 103635. https://doi.org/10.1016/j.compedu.2019.103635

Firmansyah, J., & Suhandi, A. (2021). Critical thinking skills and science process skills in physics practicum. *Journal of Physics: Conference Series*, *1806*(1). https://doi.org/10.1088/1742-6596/1806/1/012047

Foley, G. (2020). Introduction: The state of adult education and learning. *Dimensions of Adult Learning: Adult Education and Training in a Global Era*, 3–18. https://doi.org/10.4324/9781003115366-2

Fuente, J. A. D., & Binas, L. C. (2020). Teachers' competence in information and communications technology (ICT) as an educational tool in teaching: An empirical analysis for program intervention. *Journal of Research in Education, Science, and Technology*, *5*(2), 61–76. https://www.researchgate.net/profile/Jayson-Dela-Fuente/publication/350466721_Teachers'_Competence_in_Information_and_Communications_Technology_ICT_as_an_Educational_Tool_in_Teaching_An_Empirical_Analysis_for_Program_Intervention/links/6061d2c4299bf173677

G B Neerusha, & A Anila. (2019). " I can ' t tell you what the learning difficulty is ": Barriers experienced by college science instructors in teach ... Related papers. *Teaching and Teacher Education*, *79*, 17–27.

Georgakis, T., & Ennis, P. J. (2015). Heidegger in the Twenty- First Century. In *Library of Congress*.

Giacomazzi, M., Fontana, M., & Camilli Trujillo, C. (2022). Contextualization of critical thinking in sub-Saharan Africa: A systematic integrative review. *Thinking Skills and Creativity*, *43*(November 2021). https://doi.org/10.1016/j.tsc.2021.100978

González-salamanca, J. C., Agudelo, O. L., & Salinas, J. (2020). Key competences, education for sustainable development and strategies for the development of 21st century skills. A systematic literature review. *Sustainability (Switzerland)*, *12*(24), 1–17. https://doi.org/10.3390/su122410366

Good, M., Maries, A., & Singh, C. (2019). Impact of traditional or evidence-based active-engagement instruction on introductory female and male students' attitudes and approaches to physics problem solving. *Physical Review Physics Education Research*, *15*(2), 20129.

https://doi.org/10.1103/PhysRevPhysEducRes.15.020129

Goodsett, M. (2020). Best practices for teaching and assessing critical thinking in information literacy online learning objects. *Journal of Academic Librarianship*, *October 2019*, 102163. https://doi.org/10.1016/j.acalib.2020.102163

Griffin, P., McGaw, B., & Care, E. (2014). Assessment and Teaching of 21st Century Skills. In *Assessment and teaching of 21st century skills*. https://doi.org/10.1007/978-94-007-2324-5_2

Gunawan, G., Harjono, A., Herayanti, L., & Husein, S. (2019). Problem-based learning approach with supported interactive multimedia in physics course: Its effects on critical thinking disposition. *Journal for the Education of Gifted Young Scientists*, *7*(4), 1075–1089. https://doi.org/10.17478/jegys.627162

Gunawan, G., Harjono, A., Nisyah, M., Kusdiastuti, M., & Herayanti, L. (2020). Improving students' problem-solving skills using inquiry learning model combined with advance organizer. *International Journal of Instruction*, *13*(4), 427–442. https://doi.org/10.29333/iji.2020.13427a

Gurcay, D., & Ferah, H. O. (2018). High School Students' Critical Thinking Related to Their Metacognitive Self-Regulation and Physics Self-Efficacy Beliefs. *Journal of Education and Training Studies*, *6*(4), 125. https://doi.org/10.11114/jets.v6i4.2980

Gustafsson, P., Jonsson, G., & Enghag, M. (2015). The problem-solving process in physics as observed when engineering students at university level work in groups. *European Journal of Engineering Education*, *40*(4), 380–399. https://doi.org/10.1080/03043797.2014.988687

Gyimah, N. (2020). Assessing Technological Innovation on Education in the World of Coronavirus (COVID-19). *SSRN Electronic Journal*, *March*. https://doi.org/10.2139/ssrn.3670389

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. https://scholar.google.com/citations?view_op=view_citation&hl=en&user=10EI2q8AAAAJ&citation_for_view=10EI2q8AAAAJ:IjCSPb-OGe4C

Hakim, A. L., Fajri, M. B., & Faizah, E. N. (2022). Evaluation Of Implementation Of MBKM: Does Academic Stress Affect On Student Learning Outcomes? *International Journal of Educational …*, *3*(1), 1–16. https://www.ijersc.org/index.php/go/article/download/246/239

Halim, A., Soewarno, Yani, E., Elisa, Mahzum, E., Farhan, A., & Irwandi, I. (2021). Relationship between the use of the internet as a learning resource and physics learning outcomes. *Journal of Physics: Conference Series*, *1882*(1). https://doi.org/10.1088/1742-6596/1882/1/012029

Hamimi, L., & Sari, R. (2020). The Development Of Proof Teaching Materials For High School Students. *Advances in Social Science, Education and Humanities Research*, *488*(Aisteel), 113–119. https://doi.org/10.4108/eai.17-10-2018.2294081

Haruta, J., Yoshida, K., Goto, M., Yoshimoto, H., Ichikawa, S., Mori, Y., Yoshimi, K., & Otsuka, M. (2018). Development of an interprofessional competency framework for collaborative practice in Japan. *Journal of Interprofessional Care*, *32*(4), 436–443. https://doi.org/10.1080/13561820.2018.1426559

Haryadi, R., & Pujiastuti, H. (2020). PhET simulation software-based learning to improve science process skills. *Journal of Physics: Conference Series*, *1521*(2). https://doi.org/10.1088/1742-6596/1521/2/022017

Hu, L., Chen, G., Li, P., & Huang, J. (2021). Multimedia Effect in Problem Solving: A Meta-Analysis. In *Educational Psychology Review* (Vol. 33, Issue 4). Educational Psychology Review. https://doi.org/10.1007/s10648-021-09610-z

Hua, S. J. (2010). The Application of the Multimedia Technology in Teaching

Introduction to Tourism. *Advanced Materials Research*, *994*, 124–126. https://doi.org/10.1109/MVHI.2010.109

Huda, C., Aji, S., Hudha, M., Wartono, M., & Gamat, F. (2018). Inquiry / Discovery-Based Instruction to Improve Critical Thinking Skills and Mastery of Physics Concepts. *Advances in Social Science, Education and Humanities Research*, *173*(Icei 2017), 66–68. https://doi.org/10.2991/icei-17.2018.18

Hung, C. S., & Wu, H. K. (2018). Tenth graders' problem-solving performance, self-efficacy, and perceptions of physics problems with different representational formats. *Physical Review Physics Education Research*, *14*(2), 20114. https://doi.org/10.1103/PhysRevPhysEducRes.14.020114

Husein, S., Gunawan, Harjono, A., & Wahyuni, S. (2019). Problem-Based Learning with Interactive Multimedia to Improve Students' Understanding of Thermodynamic Concepts. *Journal of Physics: Conference Series*, *1233*(1). https://doi.org/10.1088/1742-6596/1233/1/012028

Ince, E. (2018). An Overview of Problem Solving Studies in Physics Education. *Journal of Education and Learning*, *7*(4), 191–200. https://doi.org/10.5539/jel.v7n4p191

Irwandi, I., Sari, I. M., Oktavia, R., & Syukri, M. (2020). MEMS and IoT Applications in ISLE-based STEM Physics Learning Media for Mechanics Topic with LabVIEW Integration. *Journal of Physics: Conference Series*, *1462*(1). https://doi.org/10.1088/1742-6596/1462/1/012066

Ismail, N. S., Harun, J., Zakaria, M. A. Z. M., & Salleh, S. M. (2018). The effect of Mobile problem-based learning application DicScience PBL on students' critical thinking. *Thinking Skills and Creativity*, *28*, 177–195. https://doi.org/10.1016/j.tsc.2018.04.002

Israel, O., & Nsibirwa, D. Z. (2018). Information Literacy Skills in using Electronic Information Resources. *Library Philosophy & Practice*, 1–17.

Istiyono, E., Mustakim, S. S., Widihastuti, Suranto, & Mukti, T. S. (2019).

Measurement of physics problem-solving skills in female and male students by physteprоss. *Jurnal Pendidikan IPA Indonesia*, *8*(2), 170–176. https://doi.org/10.15294/jpii.v8i2.17640

Istiyono, Edi. (2018). IT-based HOTS assessment on physics learning as the 21st century demand at senior high schools: Expectation and reality. *AIP Conference Proceedings*, *2014*(September). https://doi.org/10.1063/1.5054418

Jafar, D. S. A., Saud, M. S., Hamid, M. Z. A., Suhairom, N., Hisham, M. H. M., & Zaid, Y. H. (2020). TVET teacher professional competency framework in industry 4.0 era. *Universal Journal of Educational Research*, *8*(5), 1969–1979. https://doi.org/10.13189/ujer.2020.080534

Jalinus, N., Verawardina, U., Azis Nabawi, R., Darma, Y., Padang, N., Hamka, J., & Tawar Barat, A. (2021). Developing Blended Learning Model in Vocational Education Based On 21st Century Integrated Learning and Industrial Revolution 4.0. *Turkish Journal of Computer and Mathematics Education*, *12*(9), 1276–1291.

Jamaludin, J., Kakaly, S., & Batlolona, J. R. (2022). Critical thinking skills and concepts mastery on the topic of temperature and heat. *Journal of Education and Learning (EduLearn)*, *16*(1), 51–57. https://doi.org/10.11591/edulearn.v16i1.20344

Jolley, D., Davis, M., Lavender, A. P., & Roberts, L. (2020). An online critical thinking course reduces misconceptions in the knowledge of personal trainers. *Studies in Continuing Education*, *0*(0), 1–16. https://doi.org/10.1080/0158037X.2020.1738373

Kaplan, D. E. (2018). Behaviorism in Online Teacher Training. *Psychology*, *09*(04), 570–577. https://doi.org/10.4236/psych.2018.94035

Khamparia, A., & Pandey, B. (2017). Impact of interactive multimedia in E-learning technologies: Role of multimedia in E-learning. *Enhancing Academic Research With Knowledge Management Principles*, *March*, 199–227.

https://doi.org/10.4018/978-1-5225-2489-2.ch007

Kim, N. J., Belland, B. R., & Walker, A. E. (2018). Effectiveness of Computer-Based Scaffolding in the Context of Problem-Based Learning for Stem Education: Bayesian Meta-analysis. *Educational Psychology Review*, *30*(2), 397–429. https://doi.org/10.1007/s10648-017-9419-1

Kim, T., Kang, B., Rho, M., Sezer, S., & Im, E. G. (2019). A multimodal deep learning method for android malware detection using various features. *IEEE Transactions on Information Forensics and Security*, *14*(3), 773–788. https://doi.org/10.1109/TIFS.2018.2866319

Knaus, T. (2020). Technology criticism and data literacy: The case for an augmented understanding of media literacy. *Journal of Media Literacy Education*, *12*(3), 6–16. https://doi.org/10.23860/JMLE-2020-12-3-2

Koryuhina, C., & Shamshina, T. (2018). Challenges of ICT in education. *The 16th INTERNATIONAL SCIENTIFIC CONFERENCE OF INFORMATION TECHNOLOGIES AND MANAGEMENT*, 26–27. https://www.ismaitm.lv/images/files/theses/2018/03_MDM/15_IT&M2018_Korjuhina_Shamshina.pdf

Kozikoğlu, İ. (2019). Investigating critical thinking in prospective teachers: Metacognitive skills, problem solving skills and academic self-efficacy. *Journal of Social Studies Education Research*, *10*(2), 111–130.

Kratt, D. (2020). Teachers' perspectives on educator mental health competencies: A qualitative case study. *American Journal of Qualitative Research*, *2*(1), 22–40. https://doi.org/10.29333/ajqr/5792

Kustijono, R., & Zuhri, F. (2018). The use of Facebook and WhatsApp application in learning process of physics to train students' critical thinking skills. *IOP Conference Series: Materials Science and Engineering*, *296*(1). https://doi.org/10.1088/1757-899X/296/1/012025

Laksana, D. N. L., Dhiu, K. D., Jau, M. Y., & Ngonu, M. R. (2020). Developing

Early Childhood Cognitive Aspects Based on Anderson And Krathwohl's Taxonomy. *JPI (Jurnal Pendidikan Indonesia)*, *8*(2), 219. https://doi.org/10.23887/jpi-undiksha.v8i2.19481

Lameras, P., & Moumoutzis, N. (2021). Towards the development of a digital competency framework for digital teaching and learning. *IEEE Global Engineering Education Conference, EDUCON*, *2021-April*, 1226–1232. https://doi.org/10.1109/EDUCON46332.2021.9454027

Li, J., Zhang, X., & Hu, Z. (2018). The design and application of flip classroom teaching based on computer technology. *International Journal of Emerging Technologies in Learning*, *13*(10), 95–107. https://doi.org/10.3991/ijet.v13i10.9453

Liliarti, N., & Kuswanto, H. (2018). Improving the competence of diagrammatic and argumentative representation in physics through android-based mobile learning application. *International Journal of Instruction*, *11*(3), 106–122. https://doi.org/10.12973/iji.2018.1138a

Liu, C. H. (2019). A compatibility testing platform for android multimedia applications. *Multimedia Tools and Applications*, *78*(4), 4885–4904. https://doi.org/10.1007/s11042-018-6268-y

Liu, Y., & Pásztor, A. (2022). Effects of problem-based learning instructional intervention on critical thinking in higher education: A meta-analysis. *Thinking Skills and Creativity*, *45*(June), 101069. https://doi.org/10.1016/j.tsc.2022.101069

Lusiyana, A., Festiyed, & Yulkifli. (2019). The problems of integrating multiple representation skills in physics learning. *Journal of Physics: Conference Series*, *1185*(1). https://doi.org/10.1088/1742-6596/1185/1/012035

Ma'Ruf, M., Handayani, Y., Marisda, D. H., & Riskawati, R. (2020). The needs analysis of basic physics learning devices based on hybrid learning. *Journal of Physics: Conference Series*, *1422*(1). https://doi.org/10.1088/1742-6596/1422/1/012029

Ma'ruf, M., Marisda, D. H., & Handayani, Y. (2019). The basic physical program based on education model online assisted by alfa media to increase creative thinking skills. *Journal of Physics: Conference Series*, *1157*, 032068. https://doi.org/10.1088/1742-6596/1157/3/032068

Ma'Ruf, M., Marisda, D. H., & Handayani, Y. (2019). The basic physical program based on education model online assisted by alfa media to increase creative thinking skills. *Journal of Physics: Conference Series*, *1157*(3). https://doi.org/10.1088/1742-6596/1157/3/032068

Ma'ruf, M., Setiawan, A., & Suhandi, A. (2019a). Identification of Android-based interactive multimedia needs for basic physics content. *AIP Conference Proceedings*, *2194*(December). https://doi.org/10.1063/1.5139792

Ma'ruf, M., Setiawan, A., & Suhandi, A. (2019b). Identification of Android-based interactive multimedia needs for basic physics content. *AIP Conference Proceedings*, *2194*. https://doi.org/10.1063/1.5139792

Ma'ruf, M., Setiawan, A., Suhandi, A., & Siahaan, P. (2020a). Identification of the ability to solve the problem of contextual physics possessed by prospective physics teachers related to basic physics content. *Journal of Physics: Conference Series*, *1521*(2). https://doi.org/10.1088/1742-6596/1521/2/022011

Ma'ruf, M., Setiawan, A., Suhandi, A., & Siahaan, P. (2020b). Identification of the ability to solve the problem of contextual physics possessed by prospective physics teachers related to basic physics content. *Journal of Physics: Conference Series*, *1521*(2). https://doi.org/10.1088/1742-6596/1521/2/022011

Made, I., Citra, A., & Hadi Nasbey, W. (2015). Improvement of Learning Process and Learning Outcomes in Physics Learning by using Collaborative Learning Model of Group Investigation at High School (grade X, SMAN 14 Jakarta). *Journal of Education and Practice*, *6 No 11*(11), 75–80. www.iiste.org

Made Rajendra, I., & Made Sudana, I. (2018). The Influence of Interactive

Multimedia Technology to Enhance Achievement Students on Practice Skills in Mechanical Technology. *Journal of Physics: Conference Series*, *953*(1). https://doi.org/10.1088/1742-6596/953/1/012104

Mahbubah, K., Habibulloh, M., Hermita, N., & Samsudin, A. (2020). Measuring Critical Thinking based Multimedia on Buoyant Force Concept: A Preliminary Design. *Journal of Physics: Conference Series*, *1655*(1). https://doi.org/10.1088/1742-6596/1655/1/012112

Major, T., & Mulvihill, T. M. (2018). Problem-based learning pedagogies in teacher education: The case of Botswana. *Interdisciplinary Journal of Problem-Based Learning*, *12*(1). https://doi.org/10.7771/1541-5015.1543

Maknun, J. (2020). Implementation of Guided Inquiry Learning Model to Improve Understanding Physics Concepts and Critical Thinking Skill of Vocational High School Students. *International Education Studies*, *13*(6), 117. https://doi.org/10.5539/ies.v13n6p117

Malhotra, R., & Verma, N. (2020). An impact of using multimedia presentations on engineering education. *Procedia Computer Science*, *172*, 71–76. https://doi.org/10.1016/j.procs.2020.05.011

Malik, A., Setiawan, A., Suhandi, A., Permanasari, A., Dirgantara, Y., Yuniarti, H., Sapriadil, S., & Hermita, N. (2018). Enhancing Communication Skills of Pre-service Physics Teacher through HOT Lab Related to Electric Circuit. *Journal of Physics: Conference Series*, *953*(1). https://doi.org/10.1088/1742-6596/953/1/012017

Malmia, W., Makatita, S. H., Lisaholit, S., Azwan, A., Magfirah, I., Tinggapi, H., & Umanailo, M. C. B. (2019). Problem-based learning as an effort to improve student learning outcomes. *International Journal of Scientific and Technology Research*, *8*(9), 1140–1143.

Mann, L., Chang, R., Chandrasekaran, S., Coddington, A., Daniel, S., Cook, E., Crossin, E., Cosson, B., Turner, J., Mazzurco, A., Dohaney, J., O'Hanlon, T., Pickering, J., Walker, S., Maclean, F., & Smith, T. D. (2021). From problem-

based learning to practice-based education: a framework for shaping future engineers. *European Journal of Engineering Education*, *46*(1), 27–47. https://doi.org/10.1080/03043797.2019.1708867

Marisda, D. H., & Handayani, Y. (2020). The combination of interactive conceptual learning models and multimedia interactive to minimize misconceptions on the science content. *Journal of Physics: Conference Series*, *1572*, 012069. https://doi.org/10.1088/1742-6596/1572/1/012069

Marquès Puig, J. M., Daradoumis, T., Arguedas, M., & Calvet Liñan, L. (2022). Using a distributed systems laboratory to facilitate students' cognitive, metacognitive and critical thinking strategy use. *Journal of Computer Assisted Learning*, *38*(1), 209–222. https://doi.org/10.1111/jcal.12605

Martínez-Bravo, M. C., Chalezquer, C. S., & Serrano-Puche, J. (2022). Dimensions of Digital Literacy in the 21st Century Competency Frameworks. *Sustainability (Switzerland)*, *14*(3). https://doi.org/10.3390/su14031867

Martinez, A. A., Woodley, X. M., Lucero, L., & Parra, J. (2019). Technology, Literacy, and Self-Regulated Learning: The Impact eReaders have on the Reading Engagement Behaviors of a Group of Intermediate Grade Boys. *Journal of Literacy and Technology*, *20*(3).

Massolt, J., & Borowski, A. (2020). Perceived relevance of university physics problems by pre-service physics teachers: personal constructs. *International Journal of Science Education*, *42*(2), 167–189. https://doi.org/10.1080/09500693.2019.1705424

Matthee, M., & Turpin, M. (2019). Teaching critical thinking, problem solving, and design thinking: Preparing IS students for the future. *Journal of Information Systems Education*, *30*(4), 242–252.

Mourtos, N. J. (2010). Challenges students face in solving open-ended problems. *International Journal of Engineering Education*, *26*(4), 846–859.

Mugobi, T., & Mlozi, S. (2021). The impact of external factors on ICT usage

practices at UNESCO World Heritage Sites. *Journal of Tourism, Heritage and Services Marketing*, *7*(1), 3–12. https://doi.org/10.5281/zenodo.4514800

Muktiarni, M., Widiaty, I., Abdullah, A. G., Ana, A., & Yulia, C. (2019). Digitalisation trend in education during industry 4.0. *Journal of Physics: Conference Series*, *1402*(7), 0–6. https://doi.org/10.1088/1742-6596/1402/7/077070

Muliandi, A., Susilowati, N. E., Rahmah, S., Wahyuni, S., & Rusdiana, D. (2021). MRIM (Multiple Representation-Based Interactive Multimedia): Is it Good to Improve Students' Scientific Literacy? *U-Teach: Journal Education of Young Physics Teacher*, *2*(1), 9–21. https://doi.org/10.30599/uteach.v2i1.37

Mutakinati, L., Anwari, I., & Yoshisuke, K. (2018). Analysis of students' critical thinking skill of middle school through stem education project-based learning. *Jurnal Pendidikan IPA Indonesia*, *7*(1), 54–65. https://doi.org/10.15294/jpii.v7i1.10495

Nakpong, N., & Chanchalor, S. (2019). Interactive multimedia games to enhance the emotional intelligence of deaf and hard of hearing adolescents. *International Journal of Instruction*, *12*(2), 305–320. https://doi.org/10.29333/iji.2019.12220a

Ngajie, B. N., Li, Y., Tiruneh, D. T., & Cheng, M. (2020). Investigating the effects of a systematic and model-based design of computer-supported argument visualization on critical thinking. *Thinking Skills and Creativity*, *38*(August), 100742. https://doi.org/10.1016/j.tsc.2020.100742

Nggadas, D. E. P., & Ariswan, A. (2019). The mastery of physics concepts between students are learning by ICT and laboratory experiments based-teaching. *Momentum: Physics Education Journal*, *2*(1), 21–31. https://doi.org/10.21067/mpej.v3i1.3343

Nijdam, S., Teunissen, J., & Ebert, U. (2020). The physics of streamer discharge phenomena. *Plasma Sources Science and Technology*, *29*(10). https://doi.org/10.1088/1361-6595/abaa05

Nurdyani, F., Slamet, I., & Sujadi, I. (2018). Creative thinking level of students with high capability in relations and functions by problem-based learning. *Journal of Physics: Conference Series*, *983*(1), 2–7. https://doi.org/10.1088/1742-6596/983/1/012102

Nursuhud, P. I., Oktavia, D. A., Kurniawan, M. A., Wilujeng, I., Jumadi, & Kuswanto, H. (2019). Multimedia Learning Modules Development based on Android Assisted in Light Diffraction Concept. *Journal of Physics: Conference Series*, *1233*(1). https://doi.org/10.1088/1742-6596/1233/1/012056

Nurtanto, M., Fawaid, M., & Sofyan, H. (2020). Problem Based Learning (PBL) in Industry 4.0: Improving Learning Quality through Character-Based Literacy Learning and Life Career Skill (LL-LCS). *Journal of Physics: Conference Series*, *1573*(1), 0–10. https://doi.org/10.1088/1742-6596/1573/1/012006

Nygren, T., Haglund, J., Samuelsson, C. R., Af Geijerstam, Å., & Prytz, J. (2019). Critical thinking in national tests across four subjects in Swedish compulsory school. *Education Inquiry*, *10*(1), 56–75. https://doi.org/10.1080/20004508.2018.1475200

Ogunwolu, L., Ajibola, E. O., & Sosimi, A. (2018). An approach for critical evaluation of examination questions in an engineering faculty using the classical bloom taxonomy. *Nigerian Journal of Technology*, *37*(4), 1065. https://doi.org/10.4314/njt.v37i4.28

Oke, A., & Fernandes, F. A. P. (2020). Innovations in teaching and learning: Exploring the perceptions of the education sector on the 4th industrial revolution (4IR). *Journal of Open Innovation: Technology, Market, and Complexity*, *6*(2). https://doi.org/10.3390/JOITMC6020031

Omiles, M. E., Dumlao, J. B., Rubio, Q. K. C., & Ramirez, E. J. D. R. (2020). Development of the 21st Century Skills through Educational Video Clips. *International Journal on Studies in Education*, *1*(1), 11–20. https://doi.org/10.46328/ijonse.5

Omiunu, O. G. (2019). E-literacy-adoption model and performance of women-owned SMEs in Southwestern Nigeria. *Journal of Global Entrepreneurship Research*, *9*(1). https://doi.org/10.1186/s40497-019-0149-3

Permatasari, B. D., Gunarhadi, & Riyadi. (2019). The influence of problem based learning towards social science learning outcomes viewed from learning interest. *International Journal of Evaluation and Research in Education*, *8*(1), 39–46. https://doi.org/10.11591/ijere.v8i1.15594

Puig, B., Blanco-Anaya, P., Bargiela, I. M., & Crujeiras-Pérez, B. (2019). A systematic review on critical thinking intervention studies in higher education across professional fields. *Studies in Higher Education*, *44*(5), 860–869. https://doi.org/10.1080/03075079.2019.1586333

Purwaningsih, E., Sari, S. P., Sari, A. M., & Suryadi, A. (2020). The effect of stem-pjbl and discovery learning on improving students' problem-solving skills of the impulse and momentum topic. *Jurnal Pendidikan IPA Indonesia*, *9*(4), 465–476. https://doi.org/10.15294/jpii.v9i4.26432

Putra, P. D. A., Sulaeman, N. F., Supeno, & Wahyuni, S. (2021). Exploring Students' Critical Thinking Skills Using the Engineering Design Process in a Physics Classroom. *Asia-Pacific Education Researcher*, *2017*. https://doi.org/10.1007/s40299-021-00640-3

Rachmadtullah, R., Zulela, M. S., & Sumantri, M. S. (2018). Development of computer-based interactive multimedia: Study on learning in elementary education. *International Journal of Engineering and Technology(UAE)*, *7*(4), 2035–2038. https://doi.org/10.14419/ijet.v7i4.16384

Rahman, R., Sakti, A. W., Widya, R. N., & Yugafiati, R. (2019). Elementary Education Literacy in the Era of Industrial Revolution 4.0. *Advances in Social Science, Education and Humanities Research*, *257*(Icollite 2018), 190–193. https://dosen.ikipsiliwangi.ac.id/wp-content/uploads/sites/6/2021/02/ICOLLITE041.pdf

Ramadhan, S., Mardapi, D., Prasetyo, Z. K., & Utomo, H. B. (2019). The

development of an instrument to measure the higher order thinking skill in physics. *European Journal of Educational Research*, *8*(3), 743–751. https://doi.org/10.12973/eu-jer.8.3.743

Ramkisan A More. (2021). Digital Information Literacy among Undergraduate Students in Dodamarg. *Journal of Emerging Technologies and Innovative Research (JETIR)*, *8*(3), 973–977.

Ratnaningtyas, L., Jumadi, Wilujeng, I., & Kuswanto, H. (2019). Android-based Physics Comic Media Development on Thermodynamic Experiment for Mapping Cooperate Attitude for Senior High School. *Journal of Physics: Conference Series*, *1233*(1). https://doi.org/10.1088/1742-6596/1233/1/012054

Risdianto, E., Dinissjah, M. J., Nirwana, & Kristiawan, M. (2020). The effect of Ethno science-based direct instruction learning model in physics learning on students' critical thinking skill. *Universal Journal of Educational Research*, *8*(2), 611–615. https://doi.org/10.13189/ujer.2020.080233

Rizal, R., Rusdiana, D., Setiawan, W., & Siahaan, P. (2020). Creative thinking skills of prospective physics teacher. *Journal of Physics: Conference Series*, *1521*(2). https://doi.org/10.1088/1742-6596/1521/2/022012

Romero Ariza, M., Quesada Armenteros, A., & Estepa Castro, A. (2021). Promoting critical thinking through mathematics and science teacher education: the case of argumentation and graphs interpretation about climate change. *European Journal of Teacher Education*, *00*(00), 1–19. https://doi.org/10.1080/02619768.2021.1961736

Ropika, D., Suhandi, A., & Muslim, M. (2019). Enhancing vocation students physics problem-solving skills through modeling instruction applying on the direct current circuit. *Journal of Physics: Conference Series*, *1157*(3). https://doi.org/10.1088/1742-6596/1157/3/032048

Ruhiawati, I. Y., Candra, A. P., & Sari, S. N. (2021). Design and Build a Multimedia System for Indonesian Religious Activities Based on Android.

International Journal of Cyber and IT Service Management, *1*(2), 233–239. https://doi.org/10.34306/ijcitsm.v1i2.64

Sa'diyah, L. H., Siahaan, P., Suhendi, E., Samsudin, A., Hadiana Aminudin, A., Rais, A., Sari, I., & Rachmadtullah, R. (2020). Critical Thinking Instrument Test (CTIT): Developing and Analyzing Sundanese Students' Critical Thinking Skills on Physics Concepts Using Rasch Analysis. *International Journal of Psychosocial Rehabilitation*, *24*(June), 2020. https://doi.org/10.37200/IJPR/V24I8/PR281423

Sabran, & Sabara, E. (2019). Keefektifan Google Classroom sebagai media pembelajaran. *PROSIDING SEMINAR NASIONAL LEMBAGA PENELITIAN UNIVERSITAS NEGERI Makasar*, 122–125. https://webcache.googleusercontent.com/search?q=cache:SS_jKM_r2TAJ:https://ojs.unm.ac.id/semnaslemlit/article/download/8256/4767+&cd=2&hl=id&ct=clnk&gl=id

Safitri, H., Hamidah, I., & Setiawan, W. (2019). The preliminary study of learning interaction in physics concepts for developing e-learning to promote students' critical thinking. *Journal of Physics: Conference Series*, *1157*(3). https://doi.org/10.1088/1742-6596/1157/3/032054

Safitri, I., Pasaribu, R., Simamora, S. S., & Lubis, K. (2019). The effectiveness of android application as a student aid tool in understanding physics project assignments. *Jurnal Pendidikan IPA Indonesia*, *8*(4), 512–520. https://doi.org/10.15294/jpii.v8i4.19433

Sagala, R., Umam, R., Thahir, A., Saregar, A., & Wardani, I. (2019). The effectiveness of stem-based on gender differences: The impact of physics concept understanding. *European Journal of Educational Research*, *8*(3), 753–761. https://doi.org/10.12973/eu-jer.8.3.753

Sahida, D., & Zarvianti, E. (2019). Development of Problem Based Learning (PBL) practicum guide to improve student Creative Thinking Skills (CTS) in basic physics subject. *Journal of Educational and Learning Studies*, *2*(1), 39.

https://doi.org/10.32698/0492

Saldo, I. J. P., & Walag, A. M. P. (2020). Utilizing Problem-Based and Project-Based Learning in Developing Students ' Communication and Collaboration Skills in Physics. *American Journal of Educational Research*, *8*(5), 232–237. https://doi.org/10.12691/education-8-5-1

Santyasa, I. W., Rapi, N. K., & Sara, I. W. W. (2020). Project based learning and academic procrastination of students in learning physics. *International Journal of Instruction*, *13*(1), 489–508. https://doi.org/10.29333/iji.2020.13132a

Santyasa, I. W., Santyadiputra, G. S., & Juniantari, M. (2019). *Problem-based learning model versus direct instruction in achieving critical thinking ability viewed from students' social attitude in learning physics*. *335*(ICESSHum), 633–644. https://doi.org/10.2991/icesshum-19.2019.101

Santyasa, I. W., Warpala, I. W. S., & Sudarma, I. K. (2018). The Power of Group Investigation Model on Student Critical Thinking, Attitude, and Character in Learning Physics. *Advances in Social Science, Education and Humanities Research*, *274*, 101–106. https://doi.org/10.2991/iccite-18.2018.23

Sapriadil, S., Setiawan, A., Suhandi, A., Malik, A., Safitri, D., Lisdiani, S. A. S., & Hermita, N. (2018). Optimizing students' scientific communication skills through higher order thinking virtual laboratory (HOTVL). *Journal of Physics: Conference Series*, *1013*(1). https://doi.org/10.1088/1742-6596/1013/1/012050

Saputra, M. D., Joyoatmojo, S., Wardani, D. K., & Sangka, K. B. (2019). Developing critical-thinking skills through the collaboration of Jigsaw model with problem-based learning model. *International Journal of Instruction*, *12*(1), 1077–1094. https://doi.org/10.29333/iji.2019.12169a

SAPUTRI, D. Y., RUKAYAH, R., & INDRIAYU, M. (2018). Need Assessment of Interactive Multimedia Based on Game in Elementary School: A Challenge into Learning in 21st Century. *International Journal of Educational Research*

Review, *3*(3), 1–8. https://doi.org/10.24331/ijere.411329

Sartono, E. K. E., & T. S., & Herwin Herwin. (2022). Interactive multimedia based on cultural diversity to improve the understanding of civic concepts and learning motivation. *World Journal on Educational Technology: Current Issues*, *14*(2), 356–368.

Sarwi, S., Ellianawati, E., & Suliyanah. (2019). Grounding physics and its learning for building global wisdom in the 21st century. *Journal of Physics: Conference Series*, *1171*(1). https://doi.org/10.1088/1742-6596/1171/1/012001

Sasson, I., Yehuda, I., & Malkinson, N. (2018). Fostering the skills of critical thinking and question-posing in a project-based learning environment. *Thinking Skills and Creativity*, *29*, 203–212. https://doi.org/10.1016/j.tsc.2018.08.001

Serevina, V., Sunaryo, Raihanati, Astra, I. M., & Sari, I. J. (2018). Development of E-Module Based on Problem Based Learning (PBL) on Heat and Temperature to Improve Student's Science Process Skill. *TOJET: The Turkish Online Journal of Educational Technology –*, *17*(3), 26–36.

Setyawati, Y., Afandi, A., & Titin, T. (2020). Mourtos's Problem Solving Skills: A View Based on Gender. *International Journal of Science and Applied Science: Conference Series*, *4*(1), 91. https://doi.org/10.20961/ijsascs.v4i1.49461

Sheeba, & Begum, H. (2018). Comparative Study of Developing Interactive Multimedia Applications using Adobe Flash and HTML / CSS. *International Journal of Advanced Research in Computer Science and Electronics Engineering*, *7*(5), 5–9.

Silva, J. B. da. (2020). A Teoria da Aprendizagem Significativa de David Ausubel: uma análise das condições necessárias. *Research, Society and Development*, *4*(1), 1–9. https://pesquisa.bvsalud.org/portal/resource/en/mdl-20203177951%0Ahttp://dx.doi.org/10.1038/s41562-020-0887-9%0Ahttp://dx.doi.org/10.1038/s41562-020-0884-z%0Ahttps://doi.org/10.1080/13669877.2020.1758193%0Ahttp://sersc.org/jo

urnals/index.php/IJAST/article

Silviariza, W. Y., Sumarmi, & Handoyo, B. (2021). Improving critical thinking skills of geography students with spatial-problem based learning (SPBL). *International Journal of Instruction*, *14*(3), 133–152. https://doi.org/10.29333/iji.2021.1438a

Smith, B., Kirby, N., Skinner, B., Wightman, L., Lucas, R., & Foster, C. (2019). Infographic. Physical activity for disabled adults. *British Journal of Sports Medicine*, *53*(6), 335–336. https://doi.org/10.1136/bjsports-2018-100158

Smolcic, E., & Arends, J. (2017). Building Teacher Interculturality. *Teacher Education Quarterly*, 51–73. http://dx.doi.org/10.1016/j.buildenv.2017.06.016

Song, X., & McCarthy, G. (2018). Governing Asian international students: the policy and practice of essentialising 'critical thinking.' *Globalisation, Societies and Education*, *16*(3), 353–365. https://doi.org/10.1080/14767724.2017.1413978

Styers, M. L., Van Zandt, P. A., & Hayden, K. L. (2018). Active learning in flipped life science courses promotes development of critical thinking skills. *CBE Life Sciences Education*, *17*(3), 1–13. https://doi.org/10.1187/cbe.16-11-0332

Suastra, I. W., Ristiati, N. P., Adnyana, P. P. B., & Kanca, N. (2019). The effectiveness of Problem Based Learning - Physics module with authentic assessment for enhancing senior high school students' physics problem solving ability and critical thinking ability. *Journal of Physics: Conference Series*, *1171*(1). https://doi.org/10.1088/1742-6596/1171/1/012027

Sugiyanto, Setiawan, A., Hamidah, I., & Ana, A. (2020). Integration of mobile learning and project-based learning in improving vocational school competence. *Journal of Technical Education and Training*, *12*(2), 55–68. https://doi.org/10.30880/jtet.2020.12.02.006

Suhirman, S., Prayogi, S., & Asy'ari, M. (2021). Problem-Based Learning with

Character-Emphasis and Naturalist Intelligence: Examining Students Critical Thinking and Curiosity. *International Journal of Instruction*, *14*(2), 217–232. https://doi.org/10.29333/iji.2021.14213a

Sulistyo, W. D., & Kurniawan, M. N. L. K. B. (2020). The development of "Jeger" application using android platform as history learning media and model. *International Journal of Emerging Technologies in Learning*, *15*(7), 110–122. https://doi.org/10.3991/IJET.V15I07.11649

Suliyanah, Deta, U. A., Kurniawan, F. K., Lestari, N. A., Yantidewi, M., Jauhariyah, M. N. R., & Prahani, B. K. (2021). Literature Review on the Use of Educational Physics Games in Improving Learning Outcomes. *Journal of Physics: Conference Series*, *1805*(1). https://doi.org/10.1088/1742-6596/1805/1/012038

Suliyanah, Putri, H. N. P. A., & Rohmawati, L. (2018). Identification student's misconception of heat and temperature using three-tier diagnostic test. *Journal of Physics: Conference Series*, *997*(1). https://doi.org/10.1088/1742-6596/997/1/012035

Sumbawati, M. S., Wibawa, R. C., Munoto, & Wibawa, S. C. (2018). Development of Vocational Interactive Multimedia based on Mobile Learning. *IOP Conference Series: Materials Science and Engineering*, *288*(1). https://doi.org/10.1088/1757-899X/288/1/012101

Susanti, A., Diani, R., Satiarti, R. B., Munawaroh, R., & Fujiani, D. (2021). Blended learning model: The effect on physics problem-solving skills viewed from self-efficacy. *IOP Conference Series: Earth and Environmental Science*, *1796*(1). https://doi.org/10.1088/1742-6596/1796/1/012014

Sustekova, E., Kubiatko, M., & Usak, M. (2019). Validation of critical thinking test on Slovak conditions. *Eurasia Journal of Mathematics, Science and Technology Education*, *15*(12). https://doi.org/10.29333/ejmste/112295

Syamsuddin, A., Tahir, R., Munir, A., Ali, M. Y., & Mado, I. (2022). Deskripsi Pembekalan Program Pembelajaran Kolaboratif Partisipatif pada Kegiatan

Implementasi Kurikulum Kerjasama MBKM. *Jurnal Studi Guru Dan Pembelajaran*, *5*(1), 16–24. https://doi.org/10.30605/jsgp.5.1.2022.1660

Tania, R., Jumadi, & Astuti, D. P. (2020). The application of physics e-handout assisted by PBL model use Edmodo to improve critical thinking skills and ICT literacy of high school students. *Journal of Physics: Conference Series*, *1440*(1). https://doi.org/10.1088/1742-6596/1440/1/012037

Tania, Reni, & Jumadi. (2021). The Application of Physics Learning Media Based on Android with Learning Problem Based Learning (PBL) to Improve Critical Thinking Skills. *Proceedings of the 7th International Conference on Research, Implementation, and Education of Mathematics and Sciences (ICRIEMS 2020)*, *528*(Icriems 2020), 583–590. https://doi.org/10.2991/assehr.k.210305.085

Theasy, Y., Wiyanto, & Sujarwata. (2018). Multi-representation ability of students on the problem solving physics. *Journal of Physics: Conference Series*, *983*(1). https://doi.org/10.1088/1742-6596/983/1/012005

Thees, M., Kapp, S., Strzys, M. P., Beil, F., Lukowicz, P., & Kuhn, J. (2020). Effects of augmented reality on learning and cognitive load in university physics laboratory courses. *Computers in Human Behavior*, *108*, 106316. https://doi.org/10.1016/j.chb.2020.106316

Tiruneh, D. T., De Cock, M., & Elen, J. (2018). Designing Learning Environments for Critical Thinking: Examining Effective Instructional Approaches. *International Journal of Science and Mathematics Education*, *16*(6), 1065–1089. https://doi.org/10.1007/s10763-017-9829-z

Tsalapatas, H., De Carvalho, C. V., Heidmann, O., & Houstis, E. (2019). Active problem-based learning for engineering higher education. *CSEDU 2019 - Proceedings of the 11th International Conference on Computer Supported Education*, *2*(Csedu), 347–351. https://doi.org/10.5220/0007720403470351

Tumanngor, A. M. R., Jumadi, J., Wilujeng, I., & Ringo, E. S. (2019). The Profile of Students' Physics Problem Solving Ability in Optical Instruments. *Jurnal*

Penelitian & Pengembangan Pendidikan Fisika, *5*(1), 29–40. https://doi.org/10.21009/1.05104

Tyagi, R., Vishwakarma, S., Alexandrovich, Z. S., & Mohammmed, S. (2020). ICT Skills for Sustainable Development Goal 4. *Quality Education*, *October*, 435–442. https://doi.org/10.1007/978-3-319-95870-5_39

Ulger, K. (2018). The effect of problem-based learning on the creative thinking and critical thinking disposition of students in visual arts education. *Interdisciplinary Journal of Problem-Based Learning*, *12*(1), 3–6. https://doi.org/10.7771/1541-5015.1649

Utami, S. N., Siahaan, P., & Setiawan, A. (2018). Development of instrument critical and creative thinking skills on fluids motion. *Universitas Pendidikan Indonesia*, *3*, 209. http://science.conference.upi.edu/proceeding/index.php/ICMScE/issue/view/

Utami, V. B., & Wilujeng, I. (2020). STEM application through simple technology to improve technology literacy. *Journal of Physics: Conference Series*, *1440*(1). https://doi.org/10.1088/1742-6596/1440/1/012050

Velly, D. (2021). Increasing the Motivation and Learning Outcomes of Students through the Application of the Problem Based Learning Model in Learning Physics. *Journal of Science and Science Education*, *2*(1), 52–57. https://doi.org/10.29303/jossed.v2i1.719

Vhalery, R., Setyastanto, A. M., & Leksono, A. W. (2022). Kurikulum Merdeka Belajar Kampus Merdeka: Sebuah Kajian Literatur. *Research and Development Journal of Education*, *8*(1), 185. https://doi.org/10.30998/rdje.v8i1.11718

Vignal, M., & Wilcox, B. R. (2022). Investigating unprompted and prompted diagrams generated by physics majors during problem solving. *Physical Review Physics Education Research*, *18*(1), 10104. https://doi.org/10.1103/PhysRevPhysEducRes.18.010104

Vyalikova, G., Plekhanova, M., Pluzhnikova, J., & Savelyeva, S. (2019). General Pedagogical ICT Competency as a Content-forming Factor in the Training of a New Teacher. *V International Forum on Teacher Education*, *1*, 989–1001. https://doi.org/10.3897/ap.1.e0736

Walsh, C., Quinn, K. N., Wieman, C., & Holmes, N. G. (2019). Quantifying critical thinking: Development and validation of the physics lab inventory of critical thinking. *Physical Review Physics Education Research*, *15*(1), 10135. https://doi.org/10.1103/physrevphyseducres.15.010135

Wang, Q., & Lu, P. (2019). Research on Application of Artificial Intelligence in Computer Network Technology. *International Journal of Pattern Recognition and Artificial Intelligence*, *33*(5). https://doi.org/10.1142/S0218001419590158

Wechsler, S. M., Saiz, C., Rivas, S. F., Vendramini, C. M. M., Almeida, L. S., Mundim, M. C., & Franco, A. (2018). Creative and critical thinking: Independent or overlapping components? *Thinking Skills and Creativity*, *27*(November 2017), 114–122. https://doi.org/10.1016/j.tsc.2017.12.003

Wheeler, M. F., Wick, T., & Lee, S. (2020). IPACS: Integrated Phase-Field Advanced Crack Propagation Simulator. An adaptive, parallel, physics-based-discretization phase-field framework for fracture propagation in porous media. *Computer Methods in Applied Mechanics and Engineering*, *367*. https://doi.org/10.1016/j.cma.2020.113124

Whitcomb, K. M., Guthrie, M. W., Singh, C., & Chen, Z. (2021). Improving accuracy in measuring the impact of online instruction on students ' ability to transfer physics problem-solving skills. *Physical Review Physics Education Research*, *17*(1), 10112. https://doi.org/10.1103/PhysRevPhysEducRes.17.010112

Widiawati, L., Joyoatmojo, S., & Sudiyanto, S. (2018). Higher order thinking skills as effect of problem based learning in the 21st century learning. *International Journal of Multicultural and Multireligious Understanding*, *5*(3), 96–105.

http://ijmmu.com

Widyastuti, E., & Susiana. (2019). Using the ADDIE model to develop learning material for actuarial mathematics. *Journal of Physics: Conference Series*, *1188*(1). https://doi.org/10.1088/1742-6596/1188/1/012052

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

Wiranata, D., Widiana, I. W., & Bayu, G. W. (2021). The Effectiveness of Learning Activities Based on Revised Bloom Taxonomy on Problem-Solving Ability. *Indonesian Journal Of Educational Research and Review*, *4*(2), 289. https://doi.org/10.23887/ijerr.v4i2.37370

Wrahatnolo, T., & Munoto. (2018). 21St Centuries Skill Implication on Educational System. *IOP Conference Series: Materials Science and Engineering*, *296*(1). https://doi.org/10.1088/1757-899X/296/1/012036

Yanti, H., Setiawan, A., Nurhabibah, & Yannuar. (2018). Teacher's Perception about the Use of E-Learning/Edmodo in Educational Activities. *IOP Conference Series: Materials Science and Engineering*, *306*(1). https://doi.org/10.1088/1757-899X/306/1/012055

Yanto, F. (2019). Development of problem-based student worksheet with authentic assessment to improve student's physics problem solving ability. *Journal of Physics: Conference Series*, *1185*(1). https://doi.org/10.1088/1742-6596/1185/1/012075

Yasin, M., Fakhri, J., Siswadi, Faelasofi, R., Safi'i, A., Supriadi, N., Syazali, M., & Wekke, I. S. (2020). The effect of SSCS learning model on reflective thinking skills and problem solving ability. *European Journal of Educational Research*, *9*(2), 743–752. https://doi.org/10.12973/eu-jer.9.2.743

Yildiz Durak, H. (2021). Modeling of relations between K-12 teachers' TPACK levels and their technology integration self-efficacy, technology literacy

levels, attitudes toward technology and usage objectives of social networks. *Interactive Learning Environments*, *29*(7), 1136–1162. https://doi.org/10.1080/10494820.2019.1619591

Yuliarni, I., Marzal, J., & Kuntarto, E. (2019). Analysis of Multimedia Learning Mathematics Storyboard Design. *International Journal of Trends in Mathematics Education Research*, *2*(3), 149. https://doi.org/10.33122/ijtmer.v2i3.119

Yunus, M., Setyosari, P., Utaya, S., & Kuswandi, D. (2021). The influence of online project collaborative learning and achievement motivation on problem-solving ability. *European Journal of Educational Research*, *10*(2), 813–823. https://doi.org/10.12973/EU-JER.10.2.813

Yusuf, I., & Widyaningsih, S. W. (2019). HOTS profile of physics education students in STEM-based classes using PhET media. *Journal of Physics: Conference Series*, *1157*(3). https://doi.org/10.1088/1742-6596/1157/3/032021

Zainuddin, Hasanah, A. R., Salam, M. A., Misbah, & Mahtari, S. (2019). Developing the interactive multimedia in physics learning. *Journal of Physics: Conference Series*, *1171*(1). https://doi.org/10.1088/1742-6596/1171/1/012019

Zorluoğlu, S. L., & Güven, Ç. (2020). Analysis of 5th Grade Science Learning Outcomes and Exam Questions According to Revised Bloom Taxonomy. *Journal of Educational Issues*, *6*(1), 58. https://doi.org/10.5296/jei.v6i1.16197

Zulazhari, Djamas, D., Yulkifli, & Festiyed. (2019). Preliminary study of the use of games interactive multimedia module to increase critical thinking of students in senior high school. *Journal of Physics: Conference Series*, *1185*(1). https://doi.org/10.1088/1742-6596/1185/1/012137