JPPIPA 9(5) (2023)

Jurnal Penelitian Pendidikan IPA

Journal of Research in Science Education

http://jppipa.unram.ac.id/index.php/jppipa/index

The Practicality and Effectiveness of the Physics Independent Learning (PIL) Model Toolkit in Online Tutorials to Improve Physics Independent Learning Skills and Physics Problem-Solving Skills

Paken Pandiangan[1*]

[1]Physics Education Study Program, Universitas Terbuka, Jakarta, Indonesia.

Received: March 25, 2023
Revised: May 26, 2023
Accepted: May 29, 2023
Published: May 31, 2023

[*]Corresponding Author:
Paken Pandiangan
pakenp@ecampus.ut.ac.id

DOI: 10.29303/jppipa.v9i5.3711

Abstract: This study aims to analyze the practicality and effectiveness of the PIL model tool in online tutorials to improve self-learning and problem-solving skills in DL physics students in introductory quantum physics courses. This type of research is educational development research with a sample of 75 undergraduate physics education students at Universitas Terbuka in Indonesia. This research was carried out in three stages, namely preliminary and development studies, limited trials, and extensive trials. The results showed that tutors could carry out all stages of online tutorial activities using the PIL model very well with the percentage of implementation of syntax, social systems, and reaction principles. There was an increase in students' problem-solving abilities and independent learning abilities in each class after taking PIL with high N-gain categories. It can be concluded that the PIL model set is valid, practical, and effectively applied to improve problem solving skills and students' independent skills in learning Introduction to Quantum Physics.

Keywords: Distance learning; Independent learning skills; Physics problem solving skills; PIL model; Quantum physics.

Introduction

The development of the industrial revolution today has greatly affected the joints of human life in all fields, one of which is the influence of the industrial revolution on learning innovation in higher education. The presence of the 4.0 industrial revolution requires universities, especially Universitas Terbuka as providers of Distance Learning (DL) to innovate skills-based learning for the 21st century (Shahroom & Hussin, 2018; Yang & Gu, 2021). Permendikbud No.73 of 2013 concerning the Indonesian National Qualification Framework in the field of higher education has also required tertiary institutions to develop a curriculum that is appropriate to the era of the industrial revolution 4.0 so that students have superior competence with various skills that are in line with the demands of the 21st century known as 4c, namely critical thinking and problem solving skills, creativity and self-directed learning skills, collaboration skills, and communication skills (Fajriyah & Septiyanti, 2021; Syaharuddin, et al., 2022).

Universitas Terbuka has a very important role in pursuing the quality of learning processes and outcomes, including processes, and learning outcomes of the fundamentals of quantum physics through practical and effective learning, especially in DL. One of the characteristics of DL is the separation between students and lecturers in the teaching and learning process so that in the learning process, learning media is needed as a substitute for the presence of lecturers in class (Nadya & Sari, 2021). Research has developed a Physics Independent Learning (PIL) learning model and

How to Cite:
Pandiangan, P. (2023). The Practicality and Effectiveness of the Physics Independent Learning (PIL) Model Toolkit in Online Tutorials to Improve Physics Independent Learning Skills and Physics Problem-Solving Skills. *Jurnal Penelitian Pendidikan IPA*, *9*(5), 4008–4014. https://doi.org/10.29303/jppipa.v9i5.3711

stated that this learning model is valid, practical, and effective for improving physics problem solving skills and students' independent learning skills in DL on electricity and magnetism through face-to-face tutorials (Pandiangan, Sanjaya, & Jatmiko, 2017). The PIL learning model was developed based on the latest theoretical and empirical support and has logic among its supporting components.

In online learning or distance learning, the ability to study independently is needed so that students can participate in learning activities well (Sun, et al., 2018; Wong, et al., 2019). The ability to study independently in online learning can be improved through two main factors, namely providing encouragement to students, providing feedback, or integrating the two, as well as several other factors such as students' cognitive abilities, self-efficacy, prior knowledge, and so on (Wong, et al., 2019). The empirical support that underlies the PIL learning model includes that student learning independence can be achieved by providing scaffolding that is able to increase more dominant student activities, including interaction between students in communication and collaboration (Eveline, et al., 2019). Other research states that a tutor can modify student motivation through interactions with students such as two-way communication, providing feedback, and providing positive reinforcement to students (Fandiño & Velandia, 2020).

Physics instructors at all levels agree that integrating conceptual knowledge with problem solving is a desired goal in learning physics, but students must be able to integrate conceptual knowledge and problem solving to develop knowledge of physics concepts and help students overcome problems that occur by designing authentic (Bao & Koenig, 2019). Problem solving skills and independent learning skills are very important in learning physics, especially learning quantum physics at the tertiary level due to the characteristics of quantum physics material which is considered relatively difficult and complex (Laloë, 2019). The importance of physics problem-solving skills and independent learning skills in learning quantum physics at the tertiary level is based on the characteristics of quantum physics material which is considered relatively difficult and complex. Even though students have good skills in problem solving skills, there is evidence that a basic conceptual understanding of quantum physics is still very weak (Bungum, et al., 2018; Keebaugh, et al., 2019). HOTS learning in the 21st century in the industrial era 4.0 requires human resources with reliable competencies in implementing the PIL learning model so that they can improve problem solving skills, decision making, critical thinking, creative thinking, responsibility, and are able to learn independently (Hursen, 2021; Pandiangan, 2022; Pandiangan, 2023). The emphasis of the PIL model is directed at increasing learning outcomes on indicators of problem formulation, identifying variables, compiling hypotheses, conducting analysis, and drawing conclusions on physics problem solving skills and improving learning outcomes on indicators of initiation and persistence, responsibility, discipline, and curiosity. self-confident and a strong desire to learn, able to organize time and speed of learning, enjoy learning and meet the targets set for independent learning skills (Pandiangan, Sanjaya, Jatmiko, 2017) so that it is more practical to use in online tutorials in DL. The PIL model is designed based on authentic problems and is supported by the help of information and communication technology based on java simulation using the Phet program.

The PIL learning model has also been shown to be very effective (normalize gain is in the high category) to improve students' critical thinking skills and independent learning skills for wave and sound material through face-to-face tutorial mode (Pandiangan, 2018). HOTS learning in the 21st century in the industrial era 4.0 requires competent human resources (Caena & Redecker, 2019; Engeness, 2021; Gündüzalp, 2021) so that they are able to implement the PIL learning model which aims to improve problem solving skills, decision making, critical thinking, think creatively, be responsible, and be able to learn independently. Therefore, a PIL model learning tool must be designed in the form of tutorial activity designs, tutorial activity units, student teaching materials, initiation materials, student worksheets, and ILS and PSS evaluation instruments so that they can be used to improve students' independent learning skills and physics problem solving skills. on DL.

The results of research by Pandiangan, Jatmiko, & Sanjaya (2017) which was conducted on 144 DL students showed that the use of the PIL model in improving problem solving skills was in the moderate category in the limited test and in the high category in the broad test and in improving independent learning skills it was also in the moderate category in the limited test and in the high category on the broad test. This only applies to PIL model tools using electricity and magnetism teaching materials, but it is necessary to do further testing whether the PIL model is practical and effective when using other teaching materials/materials. To see the reliability of the PIL model, this study will re-examine the practicality and effectiveness of the PIL model in other physics materials in the same subject.

The material that will be the object of testing the PIL model in this study is the basics of quantum physics contained in the introductory course of quantum physics at Universitas Terbuka Physics Education Study Program. This study aims to test the practicality of the PIL model tool in online tutorials to improve self-learning skills and physics problem solving skills of DL

students in introductory quantum physics courses, and test the effectiveness of the PIL model tool in online tutorials to improve learning skills independent and physics problem solving skills of DL students in the introductory quantum physics course.

Method

This research is educational development research. This research was conducted in three stages. Phase I preliminary study and development to develop valid PIL model learning tools through Focus Group Discussion (FGD) activities with physics education experts, material experts, and media experts. Phase II, limited trials to test the practicality of the PIL model tool qualitatively by using the PIL model set for teaching materials for Introduction to quantum physics. Phase III, an extensive trial to test the effectiveness of the PIL model using the PIL model tools for introductory quantum physics teaching materials to improve self-learning skills and physics problem-solving skills in DL through online tutorial model**.**

The subject in this study is the PIL model tool. Subjects for the limited trial were selected by 15 undergraduate students of Physics Education at Universitas Terbuka who took the Introductory Quantum Physics course using a purposive sampling technique. The broad test subjects were selected by Universitas Terbuka Physics Education undergraduate students who took the Introductory Quantum Physics course as many as 60 students who could represent the population and carried out by Stratified Random Sampling of the student population at 39 UPBJJ-UT throughout Indonesia.

The instruments used in this study were data collection instruments and student learning outcomes evaluation instruments. The data collection instruments consisted of: validation sheets, observation sheets (implementation of PIL model syntax, tutor's ability to manage learning, and student observation sheets), student response questionnaires to learning components and activities. While the instrument for evaluating student learning outcomes is a test of independent learning skills and a test of physics problem solving skills. The validation of the PIL model tool was carried out through FGD activities by experts, namely science education experts, physics education experts, and open distance education practitioners. The PIL model tools are declared valid and reliable which meet the needs aspect, have state of the art, are supported by strong theoretical and empirical foundations, have consistency between components, and is suitable for use as a PIL model tool to improve students' independent learning skills and physics problem-solving skills in distance education. Data from design, development, and evaluation results were analyzed using qualitative, quantitative, and inferential descriptive analysis methods, including paired t-test and independent t-test.

Result and Discussion

The practicality of this PIL model toolkit can be known through observing tutors and students in two classes in cycles for four initiations, through interviews with tutors, and interviews with students. Observations were made during the implementation of online tutorials using the PIL model tool each for one week at each initiation, while tutor and student interviews were conducted outside of the online tutorial implementation. There are 5 main activities observed adapted to the physics problem-solving skills observed in each phase at each meeting as presented in Figure 1.

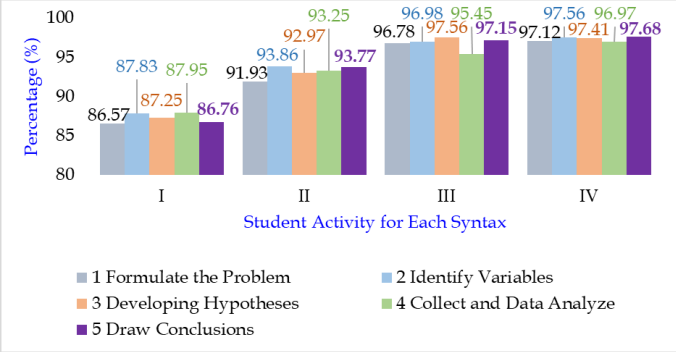


Figure 1. Relevant student activity

All stages of the PIL learning model support students' independent learning abilities. This is evidenced by the results of observing student activity in Figure 1 which shows that student activity for each syntax is very high from the first initiation to the fourth initiation having a percentage of 86.57% to 97.68%. Students with high learning skills can determine their own learning needs and are able to be responsible for planning and carrying out their learning (Geng et al., 2019; Loeng, 2020). Students can determine various approaches and sources to meet their learning needs and can evaluate their own learning progress (Bhandari et al., 2020; Robinson & Persky, 2020).

The independent learning process can only grow and develop through creating opportunities, providing experiences that can encourage the growth of learning motivation, responsibility, self-confidence, self-discipline, and the development of self-concept. Independent learning can grow through providing an understanding of the interests and interests of each student and instilling the values of the importance of learning to prepare for a better future. Instilling self-concept through self-knowledge and future needs of students can be used as a basis for building independent learning (Lee & Choi, 2022; Sedikides, 2021). The PIL learning model toolkit can guide students in carrying

out various relevant student activities during learning, as shown in Figure 6 also that relevant activities seem very high reaching 86.56% to 97.58%, while student activities that are not relevant only range from 2.42% to 13.44% so that the PIL model toolkit is very practical to use.

Interviews with tutors are conducted outside of the implementation of the tutorial to gather information in accordance with the tutor interview guidelines that have been provided. The results of the discussion and evaluation in the form of solutions to each obstacle encountered are summarized in Table 1.

Table 1. Obstacles to Implementing Online Tutorials and Alternative Solutions to Limited Trials Using PIL Model toolkit

Obstacles	Alternative Solutions
Tutors are not yet skilled at using the PIL model, so they have not focused on training ILS and PSS based on the PIL model.	Tutors are retrained to be skilled in using the PIL model tools so that they are more focused on training ILS and PSS based on the PIL model.
Limited tools and materials so that not every student can do their own practical activities	Provide virtual laboratories, such as: Phet simulation and Easy Java Simulation (EJS).
There are students who are less skilled at using practice/simulation tools.	Training how to use practice/simulation tools that students don't know yet.
There are students who do not understand the steps of Physics problem-solving skills and independent learning skills.	Provides examples of steps of Physics problem-solving skills and independent learning skills.

Students generally stated that by using the PIL model, students could have better initiative in learning, be more responsible, more confident and be able to make their own conclusions based on the results of investigations both individually and in groups. The obstacles encountered in the limited trial at the first meeting in group A were corrected at the first meeting in group B. The obstacles encountered at the first meeting in group B were corrected at the second meeting in group A, and so on in cycles until the fourth initiation was completed. The obstacles encountered in group A and group B during the online tutorial process using the PIL model tools were discussed and evaluated at the end of each online tutorial initiation between researchers, PIL model tutors, and observers. Existing obstacles are described, and alternative solutions are determined.

The Effectiveness of the PIL Model Toolkit in Model Testing

The learning impact of the PIL model toolkit on the learning outcomes of ILS and PSS is done by analyzing n gain <g> on the PSS pre-test and post-test scores on the basic material of quantum physics per indicator, namely: formulating problems, identifying variables, making hypotheses, analyze, and draw conclusions. The value of <g> and its categories for all model test classes for all indicators of ILS and PSS ranged from 0.77 to 0.8 (all in the high category). The value of the ILS and PSS N-gain for all model test classes is shown in Figure 2.

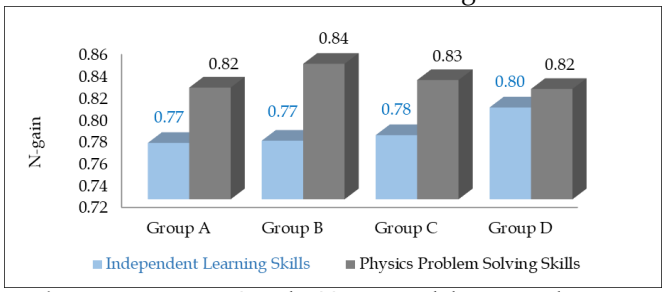


Figure 2. N-gain ILS and PSS PIL models across class test models

In general, there is an increase in students' problem-solving abilities in each class after taking PIL with high N-gain ranging from 0.82 to 0.84. Students by getting satisfactory grades will affect a comprehensive understanding (Budiastara et al., 2022). Practicing problem-solving skills on physics problems allows this strategy to be developed on rational solutions to problems and allows these strategies to be adapted to all kinds of problems that lead to mathematical thinking (Barbieri, Booth, & Chawla, 2023). This is in line with the objectives of teaching physics, which, on the one hand, encourages everyone to be able to solve problems and teach the stages of problem solving, and on the other hand, encourages students to think analytically. In learning physics, individual transitions in the thinking process must be ensured at each stage of problem solving (Heller & Heller, 2010; Ersoy & Güner, 2015).

In addition to increasing problem-solving abilities, there was also an increase in students' independent learning abilities. The type of activity observed corresponds to the indicator of independent learning skills using Knowles' self-directed learning flow adapted from Brockett & Hiemstra (2018) and Schweder (2020) which includes a process in which students: have initiation and persistence in learning; accept responsibility for their own learning; have great discipline and curiosity; have self-confidence and a strong desire to learn; able to organize time and pace their learning well; and enjoy learning and meet the planned targets. It is shown in Figure 4, that the increase in students' independent learning abilities ranges from N-gain 0.77 to 0.80.

Example student's answers:
Identification of problems
How does the flat harmonic wave packet sketch graph if $x_0 = 0, k_0 = 0$ to $L = 1$ and $L = 0{,}5$?
Process carried out
if $x_0 = 0$ and $k_0 = 0$,
then the wave function takes the form:

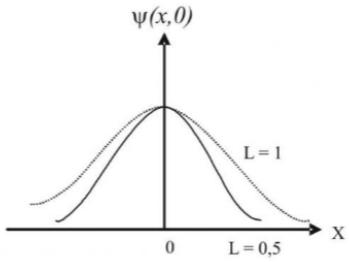
$\psi(x,0) = \left(\frac{1}{2\pi L^2}\right)^{\frac{1}{4}} e^{\frac{x^2}{4L^2}}$, to $L = 1$,

so $\psi(x,0) = \left(\frac{1}{2\pi L^2}\right)^{\frac{1}{4}} e^{\frac{x^2}{4}}$, and to $L = 0{,}5$

so $\psi(x,0) = \left(\frac{2}{\pi}\right)^{\frac{1}{4}} e^{-x}$

Conclusion

If described in graphical form $\psi(x,0)$ versus x, so the sketch is as follows.



The percentage of student teaching and learning for all model test groups after using the PIL model toolkit in learning is shown in Figure 3.

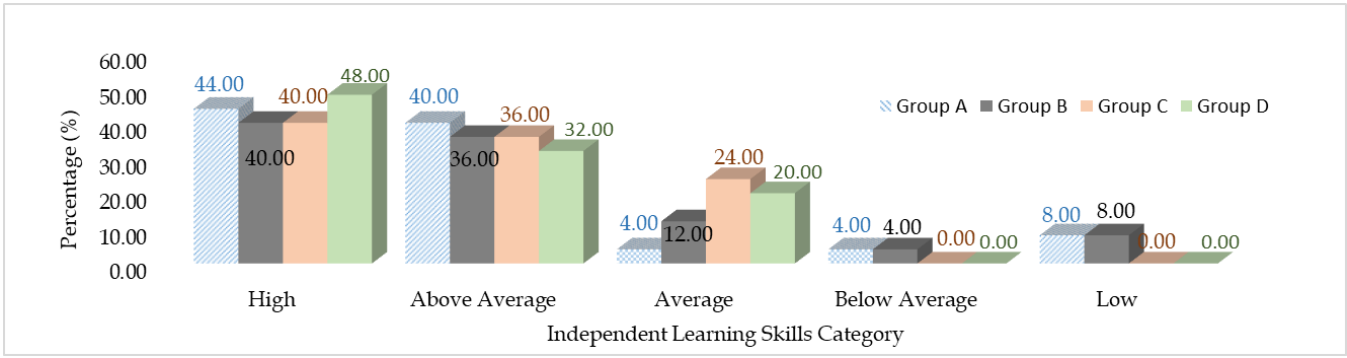


Figure 3. Percentage of student teaching and learning activities in all model test groups

Figure 3 shows that the percentage of student teaching and learning after using the PIL model tools ranges from 40.00% to 48.00% in the high category, 32.00% to 40 above average, 4.00% to 12% on average, 0.00% to 4.00% below average, 0.00 % to 8.00 % is low. This shows that students' self-learning skills after using the PIL model instruments are greater than 90% having good self-learning skills with the average category above. As previously stated, the PIL model has been supported by various theories that are able to facilitate students to carry out independent learning processes through structured learning phases. Teachers have a key role in enabling and supporting independent learning skills (Umaralieva, 2021), if teachers provide opportunities for students to work in their own ways and ideas, then they will be able to develop knowledge, understanding, or skills independently (Viberg, Grönlund, & Andersson, 2023). In addition, self-motivation is also identified as a need for successful independent learning (Umaralieva, 2021).

Conclusion

Based on the results of the development and testing of the PIL model toolkit, it can be concluded that the PIL model toolkit is proven to be valid, practical, and effective so that it is suitable for use to improve physics problem-solving skills and students' independent learning skills in open and distance education. The PIL model set developed in this study is included in the practical and effective category because the implementation of the syntax, social system, principle of reaction is classified as very good; very high student activity; existing obstacles can be sought for alternative solutions; and can have an impact on improving learning outcomes in physics problem-solving skills and students' independent learning skills in open and distance education, with student responses classified as very strong. The PIL model set developed in this study has the same impact on several replication classes in improving learning outcomes of physics problem solving skills and students' independent learning skills in open and distance education so that the PIL model is consistent and stable

Acknowledgment

I would like to thank the Universitas Terbuka for facilitating funding through the Scientific Research program. I also express my gratitude to Dr. Nia Erlina, M.Pd who has given support encouragement so that I can complete this manuscript.

Acknowledgment

I would like to thank the Universitas Terbuka for facilitating funding through the Scientific Research program. I also express my gratitude to Dr. Nia Erlina, M.Pd who has given support encouragement so that I can complete this manuscript.

Funding

This research was funded by Institute for Research and Community Service of Universitas Terbuka, Ministry of Education and Culture, Research And Technology of The

Republic of Indonesia, grant number 14674 /UN31.LPPM/PT.01.03/2020.

Conflicts of Interest

The author declare that there is no conflict of interest directly relevant to the content of this article.

References

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

Barbieri, C. A., Booth, J. L., & Chawla, K. (2023). Let's be rational: worked examples supplemented textbooks improve conceptual and fraction knowledge. Educational Psychology, 43(1), 1-21. https://doi.org/10.1080/01443410.2022.2144142

Bhandari, B., Chopra, D., & Singh, K. (2020). Self-directed learning: assessment of students' abilities and their perspective. *Advances in physiology education, 44(3),* 383-386. https://doi.org/10.1152/advan.00010.2020

Brockett, R. G., & Hiemstra, R. (2018). Self-direction in adult learning: Perspectives on theory, research and practice. Routledge. https://doi.org/10.4324/9780429457319

Budiastra, A. K., Wicaksono, I., & Erlina, N. (2022). The effect of science kit and supervision models on the implementation and implications on the evaluation of science practicum distance learning. *Jurnal Penelitian Pendidikan IPA, 8(5),* 2443-2450. https://doi.org/10.29303/jppipa.v8i5.1610

Bungum, B., Bøe, M. V., & Henriksen, E. K. (2018). Quantum talk: How small-group discussions may enhance students' understanding in quantum physics. *Science Education, 102(4),* 856–877. https://doi.org/10.1002/sce.21447

Caena, F., & Redecker, C. (2019). Aligning teacher competence frameworks to 21st century challenges: The case for the European Digital Competence Framework for Educators (Digcompedu). *European Journal of Education, 54(3),* 356-369. https://doi.org/10.1111/ejed.12345

Engeness, I. (2021). Developing teachers' digital identity: towards the pedagogic design principles of digital environments to enhance students' learning in the 21st century. *European Journal of Teacher Education, 44(1),* 96-114. https://doi.org/10.1080/02619768.2020.1849129

Eveline, E., Wilujeng, I., & Kuswanto, H. (2019, June). The effect of scaffolding approach assisted by PhET simulation on students' conceptual understanding and students' learning independence in Physics. In *Journal of Physics: Conference Series (Vol. 1233, No. 1,* p. 012036). IOP Publishing. https://doi.org/10.1088/1742-6596/1233/1/012036

Fajriah, Y. N., & Septiyanti, S. N. A. (2021). The challenges encountered by EFL teachers in developing students' 4c skills in 21st-Century education. *JEPAL (Journal of English Pedagogy and Applied Linguistics), 1(2),* 106-121. https://doi.org/10.32627/jepal.v1i2.38

Fandiño, F. G. E., & Velandia, A. J. S. (2020). How an online tutor motivates E-learning English. *Heliyon, 6(8),* e04630. https://doi.org/10.1016/j.heliyon.2020.e04630

Geng, S., Law, K. M., & Niu, B. (2019). Investigating self-directed learning and technology readiness in blending learning environment. *International Journal of Educational Technology in Higher Education, 16(1),* 1-22. https://doi.org/10.1186/s41239-019-0147-0

Gündüzalp, S. (2021). 21 st century skills for sustainable education: Prediction level of teachers' information literacy skills on their digital literacy skills. *Discourse and Communication for Sustainable Education, 12(1),* 85-101. https://doi.org/10.2478/dcse-2021-0007

Hursen, C. (2021). The effect of problem-based learning method supported by web 2.0 tools on academic achievement and critical thinking skills in teacher education. Technology, Knowledge and Learning, 26, 515-533. Retrieved from https://link.springer.com/article/10.1007/s10758-020-09458-2

Keebaugh, C., Marshman, E., & Singh, C. (2019). Improving student understanding of corrections to the energy spectrum of the hydrogen atom for the Zeeman effect. *Physical Review Physics Education Research, 15(1),* 010113.1-010113.14. https://doi.org/10.1103/PhysRevPhysEducRes.15.010113

Laloë, Franck. Do we really understand quantum mechanics?. Cambridge University Press, 2019. Retrieved from http://webéducation.com/wp-content/uploads/2019/03/Franck-Laloe-Do-We-Really-Understand-Quantum-Mechanics_-Cambridge-University-Press-2019.pdf

Lee, H., & Choi, H. S. (2022). Independent self-concept promotes group creativity in a collectivistic cultural context only when the group norm supports collectivism. Group Dynamics: Theory, Research, and Practice, 26(1), 71-84. https://psycnet.apa.org/doi/10.1037/gdn0000129

Loeng, S. (2020). Self-directed learning: A core concept in adult education. *Education Research International, 2020,* 1-12. https://doi.org/10.1155/2020/3816132

Nadya, N., & Sari, D. (2021). Analysis of Distance Learning (PJJ) in PGSD Umsu Students. *EJoES (Educational Journal of Elementary School), 2(1),* 13-17. http://dx.doi.org/10.30596%2Fejoes.v2i1.6612

Pandiangan, P., Sanjaya, M., Gusti, I., & Jatmiko, B. (2017). The validity and effectiveness of physics independent learning model to improve physics

problem solving and self-directed learning skills of students in open and distance education systems. *Journal of Baltic Science Education, 16(5).* 651-665. http://dx.doi.org/10.33225/jbse/17.16.651

Pandiangan, P. (2022). The Validity and Practicality of The PEPSA Teaching Model to Improve Critical Thinking Skills through Online Tutorials in Open and Distance Education. International Journal on Research in STEM Education, 4(1), 39-54. https://doi.org/10.31098/ijrse.v4i1.930

Pandiangan, P. (2023). The Power of the Physics Independent Learning Model Instrument in Online Tutorials to Enhance Independent Learning Skills and Critical Thinking Skills. Advances in Social Sciences Research Journal, 10(4), 269–287. https://doi.org/10.14738/assrj.104.14564

Kemdikbud No.73. (2013). Application of the Indonesian national qualification's framework. Jakarta: Ministry of Education and Culture of the Republic of Indonesia. Retrieved from http://kkni.kemdikbud.go.id/asset/pdf/permendikbud_no_73_tahun_2013.pdf

Robinson, J. D., & Persky, A. M. (2020). Developing self-directed learners. *American Journal of Pharmaceutical Education, 84(3)*, 292-296. https://doi.org/10.5688/ajpe847512

Ross, B. H. (2007). Cognitive science: problem solving and learning for physics education. *Physics Education Research, 951,* 11-18.

Schweder, S. (2020). Mastery goals, positive emotions and learning behavior in self-directed vs. teacher-directed learning. European Journal of Psychology of Education, 35(1), 205-223. https://doi.org/10.1007/s10212-019-00421-z

Sedikides, C. (2021). Self-construction, self-protection, and self-enhancement: A homeostatic model of identity protection. Psychological Inquiry, 32(4), 197-221. https://doi.org/10.1080/1047840X.2021.2004812

Shahroom, A. A., & Hussin, N. (2018). Industrial revolution 4.0 and education. International Journal of *Academic Research in Business and Social Sciences, 8(9),* 314-319. http://dx.doi.org/10.6007/IJARBSS/v8-i9/4593

Singh, C., Maries, A., Heller, K., & Heller, P. (2023). Instructional strategies that foster effective problem-solving. arXiv preprint arXiv:2304.05585. https://doi.org/10.1063/9780735425477_017

Sun, Z., Xie, K., & Anderman, L. H. (2018). The role of self-regulated learning in students' success in flipped undergraduate math courses. *The internet and higher education, 36,* 41-53. https://doi.org/10.1016/j.iheduc.2017.09.003

Syaharuddin, S., Mutiani, M., Handy, M. R. N., Abbas, E. W., & Jumriani, J. (2022). Putting transformative learning in higher education based on linking capital. *Journal of Education and Learning (EduLearn), 16(1),* 58-64. https://doi.org/10.11591/edulearn.v16i1.20373

Umaralieva, M. (2021). Some challenges in encouraging independent learning. *Academic research in educational sciences, 2(4),* 1878-1882. Retrieved from https://cyberleninka.ru/article/n/some-challenges-in-encouraging-independent-learning

Viberg, O., Grönlund, Å., & Andersson, A. (2023). Integrating digital technology in mathematics education: a Swedish case study. Interactive Learning Environments, 31(1), 232-243. https://doi.org/10.1111/modl.12818

Wong, J., Baars, M., Davis, D., Van Der Zee, T., Houben, G. J., & Paas, F. (2019). Supporting self-regulated learning in online learning environments and MOOCs: A systematic review. *International Journal of Human–Computer Interaction, 35(4-5),* 356-373. https://doi.org/10.1080/10447318.2018.1543084

Yang, F., & Gu, S. (2021). Industry 4.0, a revolution that requires technology and national strategies. *Complex & Intelligent Systems, 7(3),* 1311-1325. https://doi.org/10.1007/s40747-020-00267-9