European Online Journal of Natural and Social Sciences 2023; www.european-science.com
Vol.12, No 2 pp. 233-240
ISSN 1805-3602

Design and Analysis of the Basic Physics Practicum Model Based on the Higher Order Thinking Laboratory as a Model for 21st Century Learning Practicum

Ana Dhiqfaini Sultan*, Ma'ruf Ma'ruf, Riri Kurniawan, Nurfadillah Nurfadillah, Ariani Ariani, Muhammad Hasbi Assidiq
Department of Physics Education, Faculty of Teacher Training and Education, Universitas Muhammadiyah Makassar, Makassar, Indonesia
*E-mail: anadhiqfaini@unismuh.ac.id

Received for publication: 24 January 2023.
Accepted for publication: 24 March 2023.

Abstract

The type of research used is development research, with a Research and Development (R&D) research design. This research design is used to produce a product and test the effectiveness of a product. The development procedures are (1) needs analysis; (2) product development (design, manufacture and product validation); (3) product trials; and (4) product revision. The participants for the product trial were physics education students at the University of Muhammadiyah Makassar who programmed the Basic Physics I Practicum course with a total of 13 people. In order to obtain complete data and for the sharpness of data analysis, several research instruments will be used, namely: Higher-order thinking skills test. The student response questionnaire in this study was used to determine student responses about the HOTS-based physics practicum model that was developed and its implementation process. Based on the results of the development of the HOTS-based practicum model starting from the design stage to the revision stage of the HOTS-based practicum model product that the HOTS-based practicum model products produced for Basic Physics practicum activities as a 21st century practicum model, have the following characteristics: (a) based on constructivism theory , (b) oriented towards solving problems through practicum activities, (c) consisting of nine practicum activities which are included in three parts of the HOTS-based practicum model, namely: introduction, core, and closing, (d) Setting of activities is cooperative-collaborative, (e) digital data processing system. The use of the HOTS-based practicum model has high effectiveness in improving the HOTS skills of physics teacher candidates. The use of the HOTS-based practicum model in Basic Physics practicum activities received positive responses from all test subject students implementing the HOTS-based practicum model in Basic Physics practicum activities.

Keywords: Practicum Model, Basic Physics, 21st century skills

Introduction

Higher education should consider several related matters in terms of preparing students to face internal and external challenges in the 21st century (Menon & Melendez, 2017). The external challenge of higher education is in the form of globalization with the enactment of the ASEAN Economic Community; environmental problems; advances in information technology; convergence of science and technology; knowledge-based economy; the rise of creative and cultural industries; shifts in world economic power; technoscience influence and impact; quality, investment and transformation in the education sector (Shimizu, 2021). Other external challenges require that university graduates have the ability to communicate; ability to think clearly and critically; the ability to consider the moral aspect of an issue; ability to be a responsible citizen; the ability to try to understand

and be tolerant of different views; ability to live in a globalized society; have broad interests in life; have readiness to work; have intelligence according to their talents or interests and have a sense of responsibility towards the environment (Zulaikha & Sowiyah, 2021)).

The demands for learning outcomes according to the new Curriculum, especially for graduates of the Bachelor of Physics Education in the aspect of knowledge include: mastering the basic concepts of education which include the development of students, learning theories, the nature of science and scientific mindsets; mastering innovative learning methods that are oriented towards personal, social and academic skills (life skills) in learning physics; mastering the principles of science-based physics learning media development, contextual technology, especially Information and Communication Technology (ICT), and the surrounding environment; mastering resource management in class administration, physics laboratories and educational institutions and mastering physics concepts based on natural phenomena that support physics learning in schools (Ma'Ruf, M., Marisda, D. H., & Handayani, 2019). Learning outcomes in the aspects of attitudes and values include: having high morals, ethics, work ethic, and responsibility for assignments and being proud to be a physics teacher candidate; open-minded, critical, innovative, creative and confident in carrying out their duties as a physics teacher; work together and have social sensitivity and high concern for society and the environment (Ma'Ruf, M., Handayani, Y., Marisda, D. H., & Riskawati, 2020). Learning outcomes in the aspect of specific work skills include: planning, implementing, and evaluating physics learning based on learning activities to develop thinking skills according to the characteristics of physics material, and scientific attitudes according to the characteristics of students in curricular, co-curricular and extra-curricular learning by utilizing various sources knowledge-based learning, contextual technology and the surrounding environment; review and apply various innovative learning methods that have been tested; managing resources and activities which include organizing classes, physics laboratories and educational institutions in a comprehensive manner; make strategic decisions based on studies of issues of quality, relevance and access in the field of education in organizing classes, physics laboratories and educational institutions which are their responsibility (Marisda, D. H., & Ma'Ruf, 2021).

Higher education should be able to produce human resources who are able to compete in the 21st century, namely human resources who master the various skills needed to face the challenges of the 21st century (Yamin, 2019). Various skills that need to be trained and developed for students in facing 21st century competition include problem solving skills, critical thinking skills, creative thinking skills, decision making skills, written and verbal communication skills, information and technology literacy (Latorre & Rodríguez-Martínez, 2021).

While face-to-face activities in class are usually more oriented towards providing mastery of concepts, practicum activities in the laboratory can be more oriented as a means of providing higher-level thinking. The implementation of practicum activities in Physics learning in the context of facing the 21st century has been highly recommended by physics education experts, because there are many benefits to be gained from practicum activities (Arista & Kuswanto, 2018). Strom & Viesca (2021) state that there are at least four reasons for the importance of physics practicum activities. First, practicum can generate motivation to learn physics. Second, practicum can develop basic experimenting skills. Third, practicum as a vehicle for learning uses a scientific approach, through scientific methods students can inquire to reveal the object being observed. Fourth, practicum can support mastery of the concepts discussed in a lesson. The objectives of practicum in the field of education have also been grouped into four categories, namely actualizing conceptual learning, training technical skills, training investigative skills and producing effective learning outcomes

(Garris, R., Ahlers, R., & Driskell, 2017). Thus, through practicum activities like this, students can get the widest possible opportunity to develop their reasoning and thinking skills through scientific process activities in constructing or applying concepts.

Actually there are several practicum models that have been developed by experts that can be used in Basic Physics practicum activities, such as the inquiry practicum model (Inquiry Lab) and the problem solving oriented practicum model (Problem Solving Lab). The Inquiry Lab model was developed for practicum activities that are oriented towards understanding Physics concepts in depth while the Problem Solving Lab is oriented towards solving problems through practicum activities (Ugwuanyi, 2022).

Therefore, it is necessary to develop a practicum model that can simultaneously train several skills included in 21st century skills. So that later in real life these higher order thinking skills are needed when faced with real world problems, so these higher order thinking skills are very appropriate if provided in the context of problem solving. In order for the practicum model developed to truly facilitate the development of various skills and abilities included in 21st century skills, it is necessary to consider the contents and activities of the relevant practicum model (Setyosari & Widiati, 2021). The practicum model developed has the seven characteristics above so it is closely related to the provision of higher order thinking skills. The practicum model developed can be said to be a practicum model that is oriented towards the provision of higher-order thinking skills.

Methodology

The type of research used is development research, with a Research and Development (R&D) research design (Ebneyamini & Sadeghi Moghadam, 2018). This research design is used to produce a product and test the effectiveness of a product. The development procedures are (1) needs analysis; (2) product development (design, manufacture and product validation); (3) product trials; and (4) product revision. The participants for the product trial were physics education students at the University of Muhammadiyah Makassar who programmed the Basic Physics I Practicum course with a total of 32 peoples.

In order to obtain complete data and for the sharpness of data analysis, several research instruments will be used, namely: Higher-order thinking skill tests, Questionnaires or student response questionnaires in this study are used to find out student responses about the HOTS-based physics practicum model developed and the process its implementation. The questionnaire was prepared in the form of closed questions with the answer choices strongly agree, agree, disagree, and strongly disagree. The validation sheet is to obtain an expert assessment of the HOTS-based physics practicum model.

The data in this study are grouped into three data groups, namely HOTS-based practicum model validation data, questionnaire data. The data collection technique is as follows: Data validation, which is validated qualitatively and quantitatively. Qualitative validation is carried out by basic physics practicum experts to examine and test the feasibility of the courseware. Quantitative validation is carried out to test the feasibility of the product on the user, or the resulting courseware functions according to its purpose. Questionnaire data, namely to obtain student response data to the HOTS-based physics practicum model, data on higher-order thinking tests.

Results

The development of a HOTS-based physics practicum model is based on three activities, namely preliminary activities, core activities and closing activities. All practicum activities always facilitate 21st century skills for students, namely higher order thinking. To be clearer in seeing how student conceptions can be seen in table 1.

Table 1. The results of the HOTS-based physics practicum model activity design

No	Practical activity	Student activities	21st Century Skills
1	Preliminary activities	Study the problem Discuss the solution to be used Proposing a hypothesis	Higher Order Thinking Skills
2	Core activities	Determine the tools and experimental materials Conducting concept exploration activities Carry out measurements and collection of experimental data Perform processing and analysis of experimental data Draw conclusions and compare with hypotheses	Higher Order Thinking Skills
3	Closing activities	Presenting the results of activities Summarize the results of activities	Higher Order Thinking Skills

Based on the design of practicum activities, the practicum model based on high-level thinking skills that has been developed can be carried out entirely and with full responsibility by all physics education students who are the test subjects in this study. The results of the recapitulation of students' higher-order thinking skills after applying the practicum model based on higher-order thinking skills on six basic physics subject matter. Things that are measured include: all practicum activities carried out by students starting with preliminary activities, core activities and closing activities, the data obtained is quantitative data which is analyzed descriptively by calculating the percentage results of higher-order thinking skills. The steps taken to process the data are calculating the total number of student scores for each aspect of higher-order thinking skills that are measured and then calculating the percentage of the total score achieved by each student. Complete data on students' higher-order thinking skills are presented in table 2.

Table 2. Recapitulation of the percentage results of higher-order thinking skills in basic physics practicum using a practicum model based on higher-order thinking skills

No	Basic physics concepts	Higher order thinking skills test results	
		percentage	Category
1	Free fall motion	85,00	high
2	Simple pendulum	84,00	high
3	Ice melting	85,00	high
4	Prism	86,00	high
5	Lens	86,00	high
6	Melda's Law	88,00	high

Discussion

Based on the results of the development of the HOTS-based practicum model which starts from the design stage to the revision stage of the HOTS-based practicum model product that the HOTS-based practicum model products produced for Basic Physics practicum activities as a 21st century practicum model, have characteristics that are based on constructivism theory, oriented towards problem solving through practicum activities, consisting of nine practicum activities which are included in three parts of the HOTS-based practicum model, namely: introduction, core, and closing, cooperative-collaborative activity settings, digital data processing systems.

Based on data from the trial results of the implementation of the HOTS-based practicum model product in Basic Physics practicum activities, it is known that the application of the HOTS-based practicum model has high effectiveness in improving HOTS skills. The results of this study are in line with the essence of the HOTS-based practicum development itself. HOTS-based practicum activities are problem-solving-oriented activities that are constructed based on a 21st century skills framework.

The use of the HOTS-based practicum model can further improve higher-order thinking skills. These results can be accepted and understood because the ordinary practicum model is only oriented towards proving the correctness of physics concepts that have been previously informed in face-to-face activities in class. Ordinary practicum activities are more oriented towards proving the applicability of the principles, laws, principles and concepts being studied. Students in ordinary practicum activities are only required to carry out or follow all the stages of the given activity without being allowed to make creations or modifications so as not to facilitate and promote higher-order thinking skills.

The practicum phase, which is oriented towards data collection, can also train higher-order thinking skills. In practicum, sometimes there are problems with limited tools or there are tools that are needed in damaged condition. In order for practicums to be carried out, sometimes students have to think alternatively to determine practicum models that can be used. In this case the skills of elaborative creative thinking can be awakened. Regarding the measurement data, validity must be evaluated, adequacy for drawing conclusions and errors that may occur in the measurement. Evaluation of validity, data adequacy and error in measurement is part of the reasoning category critical thinking skills. The use of ICT can support students' ICT literacy, while the involvement of multirepresentation in the presentation and processing of data can train written communication skills in aspects of multirepresentational ability. Latorre et al. (2021) classifies communication skills into: 1) seeking information, 2) scientific reading, 3) listening and observing, 4) scientific writing, 5) representing information in various modes of representation (multi-representation), and 6) presenting knowledge. In addition to practicing communication skills, the data processing stage also trains critical thinking skills in the hypothesis testing category. (Park, 2020) states that the domains of specific HOT skills for this category include: interpreting a relationship between variables, inferring a correct statement from a given data set, and judging the credibility of an information source. The conclusion drawing stage also trains critical thinking skills in the hypothesis testing and argument analysis categories. The domain of specific critical thinking skills that are appropriate for these categories is recognize the need for more information in drawing conclusions, identify when causal claims can and cannot be made, draw valid inferences from a given tabular or graphical information, check for adequate sample size and possible bias when a generalization is made, and criticize the validity of generalizations in an experiment. At the conclusion drawing stage in HOTS-based practicum activities there is a process of confirming conclusions with predictions, if the conclusions obtained from the practicum activities are in accordance with the predictions submitted before the practicum activities are carried out, then there is no problem, but when the conclusions obtained do not match the predictions submitted, then the group of practitioners faces a problem, they must immediately explore and evaluate to decide whether the conclusions are incorrect or the predictions are wrong. The presentation stage of the results of practicum activities in the post practicum session can train oral communication skills. The existence of feedback and comments from lecturers every time they present the results of practicum activities, will gradually continue to improve their skills in communicating orally. This is observed from these skills which continue to develop from one meeting to another and in the end they are able to achieve high verbal communication skills. The results of this study are in line with the results of research that has been conducted previously by researchers in various countries which state that problem-solving-based activities can train higher-order thinking skills, in this case critical and creative thinking skills (Reddy, Sharma & Chaudhary, 2020). HOTS-based practicum activities that use ill-defined problem types, train students to think alternatively so that students' skills in producing ideas can be trained.

The effectiveness of the HOTS-based practicum model in improving critical thinking skills, creative thinking skills, and written and oral communication skills, is also supported by the successful implementation of HOTS-based practicum stages during Basic Physics practicum activities. Good results from an activity will be obtained if the process is carried out properly (Goldingay & Boddy, 2017). Because the possession of higher-order thinking skills is largely determined by the will and hard work of the individual concerned, students who follow part by part of the HOTS-based practicum model seriously and carefully all the instructions given will certainly get the maximum benefit in efforts to improve higher-order thinking skills. In the results section it has been explained that almost all stages of HOTS-based practicum activities can be carried out either by students as practitioners or by lecturers as facilitators. It is believed that the increase in higher-order thinking skills and scientific communication skills achieved by students is greatly supported by the implementation of all stages of HOTS-based practicum activities.

The good role of the HOTS-based practicum model developed in facilitating the improvement of critical thinking skills, creative thinking, and written and oral communication skills is also well felt by the students. At least this can be seen from their response to the statements given about the HOTS-based practicum model and its use in the Basic Physics practicum activities which are given at the end of each practicum activity. Almost all students agreed that: the HOTS-based practicum model used by lecturers can facilitate the improvement of critical thinking skills, creative thinking skills, and written and oral communication skills so that it is quite promising to be used for Basic Physics practicum activities which are oriented to debriefing and training high-level thinking skills for Physics teacher candidates.

Conclusion

Based on the results of processing and analysis of research data related to the development of the HOTS-based practicum model, the following conclusions can be drawn: 1. A tested and valid HOT-Lab model product has been produced for Basic Physics practicum activities for prospective Physics teacher students related to Basic Physics material, which has the following characteristics: following: (a) based on constructivism theory, (b) oriented towards solving problems through practicum activities, (c) consisting of nine practicum activities included in three parts of the HOTS-based practicum model, namely: introduction, core, and closing, (d) Cooperative-collaborative setting of activities, (e) digital data processing system. 2. The use of the HOTS-based practicum model has high effectiveness in improving the HOTS skills of physics teacher candidates. The use of the HOTS-based practicum model in Basic Physics practicum activities received positive responses from all test subject students implementing the HOTS-based practicum model in Basic Physics practicum activities.

References

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.

Ebneyamini, S., & Sadeghi Moghadam, M. R. (2018). Toward developing a framework for conducting case study research. International journal of qualitative methods, 17(1), 1609406918817954.

Garris, R., Ahlers, R., & Driskell, J. E. (2017). Games, motivation, and learning: A research and practice model. In Simulation in Aviation Training (pp. 475-501). Routledge.

Goldingay, S., & Boddy, J. (2017). Preparing social work graduates for digital practice: Ethical pedagogies for effective learning. Australian Social Work, 70(2), 209-220.

Latorre-Cosculluela, C., Suárez, C., Quiroga, S., Sobradiel-Sierra, N., Lozano-Blasco, R., & Rodríguez-Martínez, A. (2021). Flipped Classroom model before and during COVID-19: using technology to develop 21st century skills. Interactive Technology and Smart Education, 18(2), 189-204.

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. In Journal of Physics: Conference Series (Vol. 1157, No. 3, p. 032068). IOP Publishing.

Ma'Ruf, M., Handayani, Y., Marisda, D. H., & Riskawati, R. (2020). The needs analysis of basic physics learning devices based on hybrid learning. In Journal of Physics: Conference Series (Vol. 1422, No. 1, p. 012029). IOP Publishing.

Marisda, D. H., & Ma'Ruf, M. (2021). Situation analysis of mathematical physics learning with online learning during the COVID-19 pandemic. In Journal of Physics: Conference Series (Vol. 1806, No. 1, p. 012034). IOP Publishing.

Menon, J., & Melendez, A. C. (2017). Realizing an ASEAN economic community: Progress and remaining challenge. The Singapore Economic Review, 62(03), 681-702.

Park, H., Kim, H. S., & Park, H. W. (2020). A scientometric study of digital literacy, ICT literacy, information literacy, and media literacy. Journal of Data and Information Science, 6(2), 116-138.

Rana, K., & Rana, K. (2020). ICT Integration in Teaching and Learning Activities in Higher Education: A Case Study of Nepal's Teacher Education. Malaysian Online Journal of Educational Technology, 8(1), 36-47.

Reddy, P., Sharma, B., & Chaudhary, K. (2020). Digital literacy: A review of literature. International Journal of Technoethics (IJT), 11(2), 65-94.

Setyosari, P., Kuswandi, D., & Widiati, U. (2021). Reading Comprehension Skills: The Effect of Online Flipped Classroom Learning and Student Engagement during the COVID-19 Pandemic. European Journal of Educational Research, 10(4), 1613-1624.

Shimizu, K. (2021). The ASEAN Economic Community and the RCEP in the world economy. Journal of Contemporary East Asia Studies, 10(1), 1-23.

Strom, K. J., & Viesca, K. M. (2021). Towards a complex framework of teacher learning-practice. Professional development in education, 47(2-3), 209-224.

Ugwuanyi, C. S. (2022). Developing sound knowledge of basic science concepts in children using flipped classroom: A case of simple repeated measures. Education and Information Technologies, 27(5), 6353-6365.

Yamin, M. (2019). Information technologies of 21st century and their impact on the society. International Journal of Information Technology, 11(4), 759-766.

Zulaikha, Z. F., Hariri, H., Rini, R., & Sowiyah, S. (2021). Analysis of vocational education curriculum in ASEAN Economic Community: a literature review. Journal of Social, Humanity, and Education, 1(3), 157-170.