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Higher Order Thinking Laboratory (HOT Lab)-Based Physics Learning: A Systematic Literature Review

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Abstract. This study aims to analyze physics learning based on HOT Laboratory. The research method uses a literature review. Data collection was based on the Scopus, DOAJ, IOP Science, and Google Scholar database sources. The types of documents come from journal articles and conference papers with the keywords "HOT-Laboratory", "HOT-Lab", "Higher order thinking laboratory" and "HOT Lab" from 2015-2021. Based on a search through Harzing's Publish or Perish with these keywords, 957 articles were found. Articles that are eligible and reviewed are 21 articles. The literature review used a procedure adapted from PRISMA. Published documents are checked based on pre-determined content analysis criteria involving a year of publication, author, article source, the topic of practicum material, research subject, HOT Laboratory model innovation. The results showed that the topic of physics material that is often used in research is electricity. The dependent variable that is often used for research on the HOT Laboratory model is critical thinking skills. Other dependent variables used creative thinking skills, problem-solving skills, decision-making skills, collaboration skills, and scientific communication. The HOT Laboratory model is mostly applied to prospective physics teacher students. The HOT real laboratory is a practicum model that is often used in research. The HOT real laboratory provides real experience and laboratory skills for students. The innovation of the HOT Laboratory model was developed into a HOT Virtual Laboratory based on considerations of effectiveness and efficiency, the development of ICT. The e-module-based HOT Laboratory is based on the easy accessibility of e-modules and the development of ICT. The HOT Laboratory model can be applied to material topics related to the student context, and to develop habits of minds.

Key words: HOT laboratory; physics learning; critical thinking skills; electricity

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INTRODUCTION

21st-century skills can be trained and developed in classroom learning and practical work in the laboratory. Practical activities have an important role in the science education curriculum *(Mamlok-Naaman & Barnea, 2012).* Practicum is understood as a core activity in science education (Ha & Kim, 2020). Practicum in the laboratory is an integral part of teaching and learning physics that can generate motivation and achievement in learning physics; develop basic experimenting skills; become a vehicle for learning to apply the scientific method; develop higher-order thinking skills; provide practical skills; and a vehicle for confronting students' preconceptions (Hofstein & Lunetta, 2004; Srisawasdi & Kroothkeaw, 2014; Susantini et al., 2012).

Physics practicum activities can be carried out through real laboratories and virtual laboratories. A virtual laboratory is very important to support practical activities for students of educational institutions (Potkonjak et al., 2016). The virtual laboratory has several advantages compared to a real laboratory including saving learning time; developing independent learning; increasing flexibility and interactive learning; making it easier to understand various abstract concepts; having the ability to demonstrate theory; generating satisfaction in acquiring theoretical knowledge (Darrah et al., 2014; Hut, 2006; Odeh et al., 2015).

The main objective of physics practicum is to increase knowledge of physics; develop practical skills; arouse interest, develop creative thinking and problem-solving abilities; improve scientific thinking skills and provide practice in experimental methods (Deacon & Hajek, 2011). Practical activities also offer context-rich learning experiences, improve conceptual understanding, develop practical skills (Byers, 2002), and is the best way to reflect on the nature of science (Brewe et al., 2009).

The facts show that laboratory activities in several schools in West Java mostly use cookbooks that lead to verification laboratory model activities, teachers have difficulty designing, implementing, and evaluating laboratory activities, the lack of physics practicum equipment, practicum activities are separate from theory, practicum activities are held twice in one semester (Malik & Setiawan, 2015; Malik, Aliah, Susanti, Ubaidillah, &

Ramdani, 2020). The cookbook verification experiment style often dominates science in schools (Ha & Kim, 2020). Practicum using cookbooks is limited in task instructions and focuses on procedures (Millar & Abrahams, 2009). *The traditional "cookbook" practicum emphasizes more on proving facts and concepts and does not involve mental processes and students' habituation of thinking during the learning process (Saribas et al., 2013).* Verification laboratory activities tend to teach students to use formulas in worksheets in solving elasticity problems without reasoning conceptually (La Braca & Kalman, 2021).

HOT Laboratory is a combination of creative problem-solving learning model and problem-solving laboratory model (Lisdiani, Setiawan, Suhandi, Malik, & Safitri, 2019). HOT Laboratory has five stages: 1) understanding the challenges, 2) producing ideas, 3) preparing for practicum activities, 4) carry out practicum activities, and 5) communicate and evaluate the results of activities, then decomposed into 11 activities, namely: real-world problems, determining and evaluating ideas, experimental questions, tools and materials, predictions, method questions; exploration, measurement, analysis, conclusion, and presentation. The verification practicum model consists of 9 stages, namely: objectives, theoretical basis, tools and materials, preliminary assignments, trial procedures, measurements, analysis, conclusions, and final reports (Malik, Setiawan, Suhandi, & Permanasari, 2018; Setiawan et al., 2018; Safitri, et al., 2019; Lisdiani et al., 2019). The verification laboratory consists of 9 stages: objective, theoretical basis, tools and materials, preliminary assignment, experimental steps, measurement, analysis, conclusion, and final report (Setiawan et al., 2018).

The Higher Order Thinking Laboratory (HOT Lab) has been applied as an experimental model in colleges and schools. The HOT Laboratory model shows good results in student achievement after using it as a learning activity. The results show that the practice of developing competence is good if it is used more than once (Setiawan et al., 2018). HOT Laboratory improves decision-making skills (Erlina et al., 2018), critical thinking skills (Malik et al., 2018), scientific communication skills (Malik et al., 2018; Malik & Ubaidillah, 2021), creative thinking skills (Malik, Setiawan, Suhandi, & Permanasari, 2018), and problem-solving (Sutarno et al., 2019)

Studies on higher order thinking laboratories are still relatively new, so a literature study was conducted to reveal the scope of the HOT Laboratory topics from 2015 to 2021. This research answers the following research questions: 1) How is the topic classification of physics practicum material used in HOT laboratory research? 2) What is the research objective (bound variable) in HOT laboratory studies? 3) What are the characteristics of HOT laboratory research subjects? 4) How is the innovation of the HOT Laboratory model? 5) Why is HOT Real Laboratory much in demand by researchers in research? 6) Why was HOT Laboratory developed into a HOT Virtual Laboratory and an integrated HOT Lab e-module and what was the impact? For this reason, a literature review approach was carried out with the aim of analyzing the results of previous research on HOT Laboratory in physics learning.

METHODS

Based on research questions about the scope of HOT Laboratory research systematically. A systematic review using a modified procedure of Systematic Review and Meta-Analysis (PRISMA) (Page et al., 2021). The procedure consists of identification, screening, eligibility, and inclusion. The research procedure is shown in Figure 1.

Research data collection was carried out using online searches from data-based journal indexers such as Google Scholar, IOP Science, DOAJ, Scopus published between 2015-2021. The keywords used in the search were: "HOT-Laboratory", "High order thinking laboratory", and "HOT Lab". From the search data using Publish or Perish obtained 957 articles. The articles reviewed were 21 articles that were considered eligible.

All data used in this study are considered eligible if they meet the following criteria: the research was conducted at the primary, secondary, and higher education levels, the subjects used as the object of research were the field of physics education, the research subjects were students, students, teachers or lecturers, references came from journals and published online national and international proceedings. Publications in the form of theses, theses, or dissertations that have not been published as journals are not used in this study. Types of articles that come from book chapters, book reviews, editorials, and commentaries are excluded from the analysis. Data that meets the criteria are then coded for further analysis. All articles were analyzed based on 4 categories: 1) classification based on topic/practical material, 2) classification based on research objectives (research independent variable), 3) classification based on research subjects, 4) classification based on HOT Laboratory model innovation. Data were analyzed and completed with frequency and percentage.

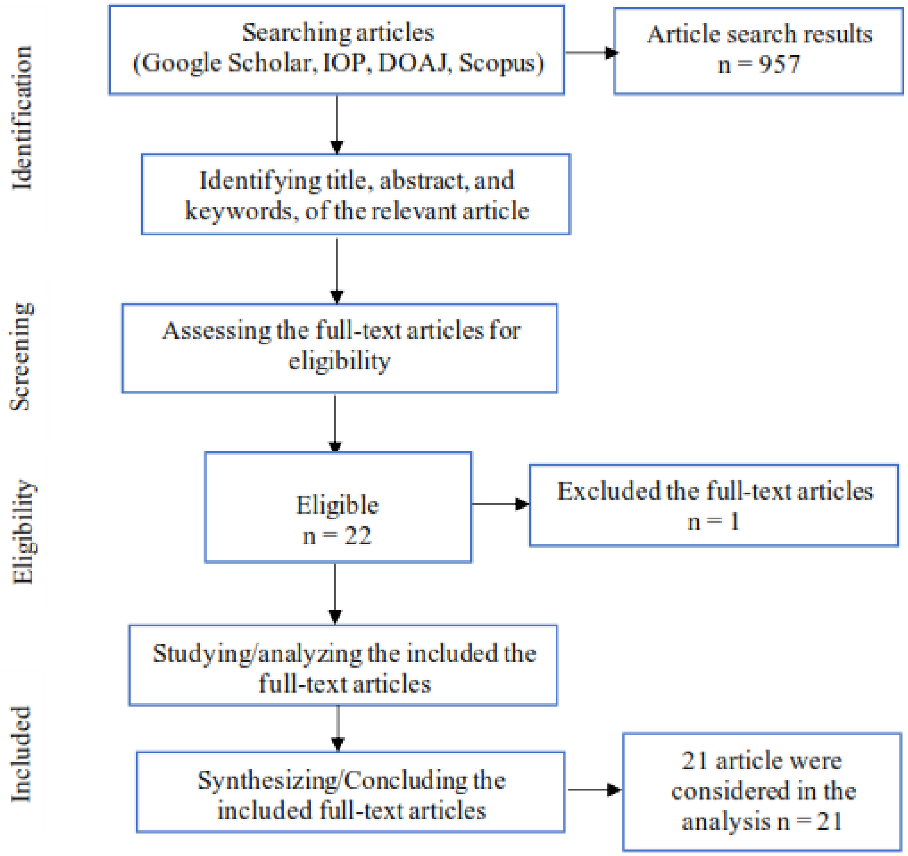

Figure 1. Research procedure

RESULTS AND DISCUSSION

Distribution of physics material topics in HOT Laboratory

Research with the topic of HOT Laboratory in physics practicum learning with a variety of diverse materials. Based on a study of 21 articles related to HOT Laboratory in physics practicum, the classification of materials is shown in Table 1.

Table 1. Distribution of physics material topics in HOT Laboratory

No	Material topics	Frequency	Percentage (%)
1	Electrical circuits	6	28.57
2	Heat transfer	3	14.29
3	Elasticity	3	14.29
4	Force	1	4.76
5	Hooke law	1	4.76
6	Concept and physics law	1	4.76
7	Basic physics practicum	1	4.76
8	AC Transformer	1	4.76
9	Photoelectric effect	1	4.76
10	Basic physics practicum 2	1	4.76
11	Wave	1	4.76
12	Kinetic theory of gases	1	4.76
	Total	21	100

The data in Table 1 shows that for HOT Laboratory research, the most electrical circuit materials used in research (Malik et al., 2018; Setiawan, Suhandi, & Permanasari, 2018; Malik et al., 2018). Research studies using electrical circuit materials in the HOT virtual laboratory model have been carried out by Sapriadil et al. (2019). Research that applies the HOT Laboratory model to force (Setiawan et al., 2018), Hooke law (Safitri et al., 2019), heat transfer (Malik et al., 2019; Lisdiani et al., 2019), concepts and laws of physics (Ismail et al., 2019), elasticity (Malik et al., 2018; Malik & Ubaidillah, 2020), photoelectric effect (Sutarno et al., 2019), basic physics practicum 2 (Putra, Agustina, et al., 2021), basic physics practicum (Malik & Setiawan, 2015), AC transformer (A. Malik et al., 2017), Kinetic theory of gases (Erlina et al., 2018).

Electrical material is a basic material and is studied by other science majors (Tiruneh et al., 2017). The concept of electricity is one of the main concepts in physics and requires experimentation (Gunawan et al., 2017). The topic of electricity is a basic topic at all school levels, with a broad scope and often misconceptions (Masson et al., 2014; Memiş & Seven, 2015). Students often have difficulty understanding electrical circuits (Baser, 2006).

Research objectives (research variables) in HOT Laboratory research

Based on an analysis of 21 articles on HOT-Laboratory, the research objectives revolve around descriptively comparing the effect of HOT-Laboratory as a treatment in the experimental class and verification of lab models as a treatment in the control class. The research objectives studied ranged from critical and creative thinking skills that were measured simultaneously, critical thinking skills, creative thinking skills, scientific communication skills, creative problem-solving skills, and decision-making skills. The classification of research objectives of the 21 research articles is presented in Table 2.

Table 2. Research objectives in HOT Laboratory research

No	Research purposes	Frequency	Percentage (%)
1	Critical thinking skills	9	42.86
2	Creative thinking skills	5	23.81
3	Scientific communication skills	3	14.29
4	Critical and creative thinking skills	2	9.52
5	Critical thinking skills and creative problem solving	1	4.76
6	Decision-making skills	1	4.76
	Total	21	100

Research related to testing the effect or impact of the HOT Laboratory, among others, is research that aims to compare students' creative thinking skills and critical thinking skills taught using the HOT Laboratory model and laboratory verification model. (Setiawan et al., 2018). Study form Safitri et al. (2019) aims to measure differences in students' creative thinking skills given two different models of laboratory activities. Other research related to critical thinking skills and decision making (Erlina et al., 2018) by applying HOTVL physics practicum in the experimental class and virtual verification lab in the control class. Research related to scientific communication skills provides two different models of practice (Malik et al., 2018; Malik & Ubaidillah, 2021; Sapriadil et al., 2018).

The data in Table 2 shows that studies that focus on critical thinking skills by applying the HOT Laboratory model using e-modules (Putra et al., 2021). HOT Laboratory research that focuses on improving students' creative thinking (Safitri et al., 2019; Ismail et al., 2019), and the influence of HOT Laboratory on creative thinking skills in prospective physics teachers (Malik et al., 2018). Based on the information in Table 2, the critical thinking skills variable is the most dependent variable in the HOT Laboratory research. HOT Laboratory has succeeded in improving students' 21st century skills.

Characteristics of research subjects HOT Laboratory

Research that examines the HOT laboratory using a variety of research subjects. Based on the 21 articles studied, the distribution of research subjects was obtained from prospective physics teacher students from various universities, and high school students. The data on the distribution of research subjects are presented in Table 3.

Table 3. Characteristics of research subjects HOT Laboratory

No	Research subjects	Frequency	Percentage (%)
1	Pre-service physics teacher	16	76.19
2	High school student	5	23.81
3	Middle school students	0	0.00
4	Elementary School Students	0	0.00
	Total	21	100.00

The data in Table 3 shows that research related to the HOT Laboratory is the most widely used research subject by prospective physics teacher students, followed by high school students. Meanwhile, research has never been conducted with students from junior high school and elementary school as the subject.

HOT Laboratory research on prospective physics teachers has been carried out by (Setiawan et al., 2018) which uses research subjects from pre-service physics teacher students at one of the universities in Bandung. Study by Malik et al. (2018) using the research subject of prospective physics teacher students at the physics education study program at UIN Sunan Gunung Djati Bandung. Study by Sutarno et al., (2019) using the research subject of pre-service physics teachers in the Physics Education study program at Bengkulu University with 35 prospective physics teachers consisting of 9 men and 26 women with an age range of 19-22 years. Study by Malik & Ubaidillah (2020) using the subject of prospective physics teachers at 4 Islamic colleges. Pre-service physics teacher are future agents of change in laboratory learning.

Research has been carried out by Safitri et al., (2019) using research subjects of high school students in class XI in one of the districts of Sukabumi, West Java with a total sample of 61 (consisting of 30 experimental class students who were taught by the HOT laboratory and 31 students were taught using the verification lab model). Study by (Lisdiani et al., 2019) using research subjects of class XI high school students in one of the Tasikmalaya districts, West Java. The research subjects were 72 students. Study by Ismail et al. (2019) using research subjects of high school students in Indonesia.

The research subject if viewed from Piaget's cognitive theory of students aged 11 years and over is a formal operational stage. High school students and prospective physics teachers have a better level of abstraction and are able to think better when compared to the concrete operational stage (students aged 7-11 years) (Baptista et al., 2019; Nakiboglu, 2008). HOT Laboratory is designed to develop higher-order thinking skills, students are required to abstract, plan actions, make decisions from several choices of ideas, design experiments, and evaluate actions. So it is natural that the research subjects in junior high and elementary students have not become research subjects. There is an opportunity for junior high school students to be used as research subjects using the HOT Laboratory, but they need extra support from the teacher. The cognitive characteristics of junior high school students are the transition from the formal operational thinking stage to the concrete operational stage.

HOT Laboratory Innovation

Based on an analytical review of 21 articles related to the HOT Laboratory, there are several variations of the types of strategies used by researchers in physics practicum activities. The HOT Laboratory strategy study data is shown in Table 4.

Table 4. Classification based on HOT Laboratory innovation

No	Type	Frequency	Percentage (%)
1	HOT Real Laboratory	17	80.95
2	HOT Virtual Laboratory	3	14.29
3	HOT Laboratory based e-Modul	1	4.76
	Total	21	100

The data in Table 4 shows that the HOT Laboratory development innovation is based on a literature study. HOT Laboratory innovation carried out by Erlina et al., (2018) in practical activities using virtual laboratory media, HOT Virtual Laboratory. Giving HOT Virtual Laboratory treatment in student practicums can train students to identify problems through observation, make several alternative decisions, make the best decisions and act to find decisions. HOT Virtual Laboratory in physics practicum activities gave a positive effect as much as 78% of students experienced a high increase, 19% of students experienced a moderate increase and 3% experienced a low increase in decision-making ability. Research recommendations can be carried out on other physics learning materials and at different levels (Erlina et al., 2018).

Other research conducted by Putra et al., (2021) by innovating the e-Module-based HOT Real Laboratory. The e-Module-based HOT Real Laboratory was developed with ADDIE model development research with valid results. The results showed that the e-Module-based HOT Real Laboratory improved the critical thinking of prospective students for physics teachers.

HOT Real Laboratory

HOT real laboratory is a real practicum activity carried out in a laboratory and oriented to the development of higher-order thinking skills (Makiyah et al., 2019; Malik et al., 2017). HOT Laboratory in its implementation is categorized into HOT real laboratory and HOT Virtual Laboratory. HOT Laboratory as an initial practicum model designed for real experimental activities in the laboratory.

HOT Laboratory is a development of the integration of design problem solving laboratory and creative problem solving (Malik & Setiawan, 2015). The HOT Lab in the electrical circuit practicum consists of 5 processes which include understanding challenges, generating ideas, preparing practicum, implementing practicum and communicating and evaluating results, in which there are 11 stages which include: answering context-rich problems, determining and evaluating concepts, answering experimental problems, prepare materials and tools, answer predictions, answer method questions, explore, measure, analyze, draw conclusions, and present results (Malik et al., 2018).

HOT Laboratory in its development underwent a syntax change in the RLC electrical circuit experimental activities, namely the existence of a session before the practicum, the practicum implementation session, and the session after the practicum. Sessions before practicum (understanding real world problems, defining and evaluating ideas, answering experimental questions, answering conceptual questions, answering predictions); during the practicum session (preparing tools and discussing: exploration, measurement, processing and analyzing data, writing conclusions); session after practicum (presenting) (Malik et al., 2018).

The HOT real laboratory model is most widely used in practical activities compared to the HOT virtual laboratory. HOT real laboratory activities have advantages, namely, training science process skills, skills in using measuring instruments, collaboration skills, skills in measuring physical quantities, and training in thinking habits. Collaborative skills in HOT real laboratory activities can be developed because, at each stage, students work together in groups that allow constructing knowledge through social interaction with peers (Altan et al., 2017).

Impact of using HOT real Laboratory can improve scientific communication skills (Malik, et al., 2018), critical thinking skills (Malik et al., 2018) and creativity (Malik et al., 2018), problem-solving, decision-making, and collaboration skills (Malik & Setiawan, 2015). HOT real laboratory activities in the presentation stage students are trained to communicate the results of the practicum. Presentation activities are an opportunity to exchange scientific ideas between students. Students' scientific argumentation skills improve after group presentations (Belland, 2010). Students can argue to reject or accept hypothesis testing from the results of other students' investigations.

HOT Virtual Laboratory

Technological developments have changed the direction of laboratory-based physics learning in order to prepare students for diverse careers in the future (Holmes & Lewandowski, 2020). Lack of laboratory experience theory and laboratory learning pedagogy are proposed to guide the use of laboratories in laboratory-based science education (Kelley, 2021). Laboratory-based physics learning has developed towards a virtual laboratory as many previous studies have done. Virtual laboratory activities in essence still adhere to the pedagogical goal, which is to help students develop attitudes, skills and knowledge (Darrah et al., 2014; De Jong et al., 2013; Martínez-Jiménez et al., 2011; Saribas et al., 2013).

HOT Virtual laboratory is a practicum model oriented to higher order thinking skills integrated with computer simulation technology that represents actual laboratory conditions (Sapriadil et al., 2019). HOT Virtual laboratory is here as a solution to the limitations of practical tools in terms of number and function, real laboratory activities that spend a lot of time assembling equipment and measurements (Sapriadil et al., 2018), improve information technology literacy, facilitate high-level abstraction of microscopic material concepts (Sutarno et al., 2019).

The HOT Virtual Laboratory model was developed by Sutarno et al (2019) by combining the problem solving laboratory model from the University of Minnesota (Heller & Heller, 2010) and the HOT Lab model developed by researchers from Universitas Pendidikan Indonesia (A. Malik et al., 2017). At each stage of the HOT Virtual Laboratory, it refers to the development of aspects of critical thinking skills and problem solving (Sutarno et al., 2019).

HOT Virtual Laboratory model syntax developed by Sutarno et al (2019) consists of a pre-laboratory phase and a laboratory activity phase. The pre-laboratory phase consists of preparatory steps, problem description, problem formulation, pre-prediction questions, group predictions, and determination and selection of ideas. The practicum activity phase consists of an exploration phase (equipment functions, procedures, data collection, and data analysis), an explanation phase, and a conclusion drawing phase. The HOT Virtual Laboratory model has a difference from the PSL and HOT Laboratory models, namely that there is a difference in the explanation stage. At the explanation stage, students explain the results and process of the experiment (Sutarno et al., 2019).

HOT Virtual Laboratory syntax developed by Sapriadil et al. (2019) adopting the design stages of the HOT Laboratory model developed by Malik et al., (2018) which consists of 11 phases of activities which include: real world problem; define and evaluate ideas; experimental questions; tools and materials prediction; questions about methods; exploration; measurement; analysis; conclusion; and presentation. The use of virtual laboratory Phet is integrated in the exploration and measurement stages.

Research shows that HOT Virtual laboratory improves creative thinking skills in electrical circuit materials (Sapriadil et al., 2019), problem solving skills, critical thinking skills, practicum time efficiency, explaining microscopic concepts (Sutarno et al., 2019) and improve scientific communication skills (Sapriadil et al., 2018). *Through meaningful practicum design students can solve real problems and students can build scientific concepts through interaction in groups (Deacon & Hajek, 2011).*

Study by Sapriadil et al. (2019) develop HOT Virtual laboratory. The results of the study show that the HOT Virtual Laboratory improves creative thinking skills and improves students' scientific communication skills on electrical circuits (Sapriadil et al., 2018), and decision making skills (Erlina et al., 2018). HOT Virtual Laboratory overcomes the limitations of practical tools available in schools but still pays attention to learning objectives that access higher-order thinking skills, and students can manipulate variables without fear of errors that cause fire.

The use of virtual laboratories is useful for improving the quality of teaching, students can conduct experiments independently before they come to the laboratory, students can revise practicum activities anytime anywhere, manipulate independent variables, improve understanding of concepts (Martínez-Jiménez et al., 2011), interactive, increase motivation, and interest of students (Granado et al., 2007), and cost efficiency (De Jong et al., 2013). The use of virtual laboratory in physics learning is more effective than hands-on laboratory (Darrah et al., 2014). Virtual laboratory computer-assisted physics learning can improve student achievement and attitudes (Azar & Şengüleç, 2011), improve teaching experience and quality of education (Daineko et al., 2017). However, the lack of a virtual laboratory is that it does not develop practical skills such as skills in using measuring instruments, skills in measuring physical quantities, and mastery of experimental methods (Daineko et al., 2017).

Sari et al. (2019) conducting research comparing real laboratory activities with the help of computers and virtual laboratories with computer assistance in physics practicum. The results showed that computer-assisted real laboratory research was more effective in improving students' attitudes, motivation, understanding and graphic interpretation skills than virtual laboratories (Sari et al., 2019). Several HOT Laboratory developments that have been carried out by previous researchers provide information that has not been done before.

HOT Laboratory based e-Module

The HOT Laboratory-based e-Module design was developed referring to the HOT Laboratory model which has 5 stages and decomposed 11 activities. Stages of HOT Laboratory real-world problems, determine and evaluate ideas, experimental questions, tools and materials, predictions, questions about methods, exploration, measurement, analysis, conclusions, *and presentations (Makiyah et al., 2019; A Malik et al., 2017). The e-module was developed from the HOT Laboratory model that integrates a virtual laboratory by emphasizing problem-solving and critical thinking skills consisting of processes, namely understanding challenges/problems, creating ideas, conducting laboratory activities, producing results, or solving problems (Putra, Agustina, et al., 2021).*

The background of the development of the e-module-based HOT Laboratory by Putra et al. (2021) the development of information technology is increasingly rapid, electronic modules can be accessed anywhere at any time, e-modules are integrated in a virtual laboratory system to create interactive learning. The use of e-modules in physics learning is more effective than using print modules (Astalini et al., 2019). The advantages of e-modules can be accessed via smartphones, computers and make it easier for educators to assess student performance reports (Dhina et al., 2019), fun and improve student understanding (Sari et al., 2019). E-modules are interactive and can be accessed anywhere and anytime by students (Fadieny & Fauzi, 2019), e-modules in learning physics improve the competence of educators in terms of teaching methodologies, general values and culture (Krasnova & Shurygin, 2019).

Research opportunities that can be carried out based on literature reviews to integrate virtual laboratory activities in pre-laboratory activities with HOT Real Laboratory. Virtual laboratory activities are carried out before students carry out real experiments in the laboratory. Martínez-Jiménez et al. (2011) stated that pre-experimental virtual laboratory activities make students more ready to carry out real experiments in the laboratory. Deacon & Hajek (2011) pre-laboratory activities can improve performance when students do practicum activities.

After studying the syntax of the HOT Laboratory, students can practice habits of mind. Habits of mind are seen as important in the learning process because it will show that learning the material is not only result-oriented but also implied in the learning process (Costa & Kallick, 2012). Indicators on habits of mind need to be applied to students in order to act smart, be successful in academics and as a provision to face life. Habits of mind can be integrated in laboratory activities and science learning in the classroom (Volkmann & Eichinger, 1999).

CONCLUSION

Based on a review of 21 research articles about the HOT Laboratory, information was obtained: 1) most of the material applied in the research is electrical circuits, electrical material is the basic material for physics and other science education, contains abstract concepts and students often experience misconceptions. 2) most of the research objectives from the implementation of the HOT Laboratory are to improve critical thinking skills, critical thinking skills are important for students as part of 21st-century skills, some higher-order thinking skills are also used as dependent variables in the study. 3) most of the research subjects are physics teacher candidates, physics teacher candidates as agents of change in physics learning are equipped with a laboratory experience that trains and develops high-level skills. Physics teacher candidates are able to think abstractly, design experiments, and make decisions in every choice. 4) The innovation of the HOT Laboratory model is the type of HOT real laboratory, HOT virtual laboratory, and HOT laboratory based on e-module. 5) HOT real laboratory is the most widely used model in research. HOT real laboratory contributes to accessing science process skills, skills in using measuring instruments, measuring physical quantities, and providing hands-on experience to students, and improving 21st-century skills. 6) HOT Virtual laboratory was developed to bridge the limitations of practical physics tools, delivery of microscopic concepts, developments in information and communication technology, and time and cost-efficiency. The use of virtual laboratories during exploration and measurement activities. HOT Virtual laboratory can improve creative thinking, critical and problem-solving skills. The e-module-based HOT laboratory was developed in order to make it easier for students to access modules online, e-modules can be accessed anytime anywhere, and involve ICT. The e-module-based HOT laboratory can improve students' critical thinking skills. The HOT Laboratory model can be developed with virtual laboratory activities placed in the pre-experiment before students do the practicum. The HOT Laboratory model can be applied to material topics related to the student context and is applied to develop students' habits of mind.

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