Learning Models in the Laboratory and Simulator in Practical Learning in the Ship Engineering Study Program on the Quality of Learning

R. Bagus Wicaksono[1*], Siswanto[2]

[1,2]Jurusan Permesinan Kapal, Politeknik Pelayaran Malahayati, Indonesia
[*] Corresponding author:
Email : baguswicaksono1909@gmail.com

Abstract.
This study aims to analyze the learning models in laboratories and simulators in practical learning of the Ship Machinery Study Program on the quality of learning at the Malahayati Maritime Polytechnic. This study uses a descriptive quantitative approach supported by qualitative data. The research subjects consisted of 50 cadets, 2 lecturers teaching the Construction and Working Principles of Refrigerator Auxiliary Machinery course, and the Head of the Ship Machinery Study Program as informants. Data were collected through questionnaires, observations, and interviews, then analyzed using frequency distribution and percentages. The results showed that the use of laboratories and simulators helped cadets understand auxiliary machinery systems on board ships, increased engagement in practical learning, and made the learning process more interesting. E-learning was also considered useful as a supporting medium because it facilitated the delivery of materials and communication between lecturers and cadets. However, this study found several obstacles, such as suboptimal laboratory and simulator features, unstable internet networks, limited free internet access, and less than optimal support for laboratory space and computer simulators. In addition, e-learning cannot replace direct practical learning because ship machinery competency requires real-life experience in laboratories and simulators. Thus, the most appropriate learning model is the integration between e-learning, laboratories, and simulators to support the quality of practical learning more effectively.
Keywords: *Laboratories, quality of learning and simulators.*

I. INTRODUCTION

Practical learning plays a central role in maritime vocational education, particularly in the Ship Engineering Study Program, because vocational education is designed to develop work competencies that are not simply achieved through mastery of theory but must be directly practiced through learning experiences contextualized to the maritime workplace. In the context of ship engineering, learning effectiveness is largely determined by the suitability of activities, tools, machines, and learning environments to real-world working conditions on board, so that cadets can develop thinking habits, manipulative skills, and operational readiness that are truly relevant to the demands of the profession [1]. This need is increasingly important because there is still a gap between classroom-based learning and the reality of engine room operations, while the competencies required include the ability to understand systems, operate equipment, solve technical problems, and adapt to mechanical, electrical, digital, and sustainability challenges in the modern maritime industry [2].

The development of maritime technology and the ever-changing demands of the shipping industry encourage maritime educational institutions to adapt their learning strategies to remain relevant to the needs of work competencies [3]. Conventional learning that focuses on lectures in class is not enough to form complete technical competencies, because maritime education requires mastery of theory, practical skills, problem solving, and readiness to face real operational situations [2]. Therefore, an experiential learning approach is important to connect theoretical understanding with practices that resemble conditions on board, especially through activities that require active student involvement in observation, experimentation, reflection, and problem solving [4].

Practical learning plays an important role in maritime vocational education, particularly in the Ship Engineering Study Program, because maritime education demands mastery of measurable competencies that are aligned with real work needs in the industry [5]. In the field of ship engineering, practical and laboratory activities help cadets understand components, systems, working principles, and equipment usage more concretely, because engineering laboratories function to introduce tool working systems, support experiments, and build technical skills through direct experience [6]. Through practice, cadets can also develop the ability to inspect, measure, operate, collect and analyze data, and solve problems that are an important part of professional skills in engineering and maritime environments [7].

In addition to laboratories, simulators also have a strategic position in learning ship engineering practices because modern maritime education and training use simulators as a complementary tool to help cadets acquire initial competencies before carrying out real duties on ships [8]. Simulators allow cadets to learn engine room operational conditions in a safe, controlled, and repeatable environment, so they can practice without the risk of equipment damage, pollution, or occupational safety hazards. In the context of ship engineering, simulators support exercises that mimic real-world situations, including system operation, changes in operating conditions, handling start-up and shutdown procedures, fault recognition, as well as troubleshooting and technical decision-making under conditions that mimic real-world work pressures [9].

In the context of the Malahayati Maritime Polytechnic, the existence of laboratories and simulators is part of the institution's efforts to support the achievement of graduate competencies, especially for participants in the Level III Technical Expert training. These facilities are expected to be able to support the practical learning process in accordance with seafarer competency standards, including the demands of the 1978 STCW Amendment 2010. Through competency demonstration activities in the laboratory and simulator, cadets are expected to not only understand the material theoretically, but also be able to demonstrate the technical abilities needed in the Seafarer Skills Examination and real work practices on board ships.

The laboratory in ship engineering learning functions as a means for cadets to understand the components, systems, and working principles of machines more concretely through practical experiences that support the mastery of real work competencies [10]. Through laboratory activities, students can develop experimental skills, instrument operation, data processing, as well as disciplinary competencies and higher-order thinking which are indeed the main learning outcomes of laboratory learning. Actively designed practicums also encourage analytical skills, problem solving, and cooperation, especially when cadets are involved in open-ended tasks, inquiry-based experiments, and collaborative problem solving [11]. The laboratory is not only a place for tool demonstrations, but also a vehicle for developing scientific thinking, systematic work, and operational readiness of cadets to be more aligned with the needs of the maritime industry [10].

Although laboratories and simulators have become an important part of maritime vocational education to support the achievement of competencies and practical readiness, their effectiveness is not automatically optimal without competency-oriented learning planning, the selection of clear learning objectives, and an assessment system that can consistently prove competency achievement [12]. Several studies also show that virtual, remote, and simulator media can improve learning outcomes, motivation, and access efficiency, but have not completely replaced direct practice, so their integration needs to be adjusted to the material, cadet experience, and the context of the skills being trained. Therefore, lecturer readiness, the provision of digital materials, e-learning, video tutorials, and more objective and standardized evaluation tools need to be considered as part of an integrated learning system, especially since technological support, industry collaboration, and strengthening assessment instruments have been proven to contribute to the quality of learning and work readiness of maritime graduates [7, 13]. This study aims to analyze the learning models in laboratories and simulators in practical learning in the Ship Engineering Study Program on the quality of learning.

II. METHODS

This study uses a descriptive quantitative approach supported by qualitative data to describe the learning model in the laboratory and simulator in practical learning of the Ship Machinery Study Program on the quality of learning at the Malahayati Maritime Polytechnic. The study was conducted at the Malahayati Maritime Polytechnic with the research subjects being cadets of the Ship Machinery Study Program who took the Construction and Working Principles of Refrigerator Auxiliary Machinery course, lecturers in charge of the course, and the Head of the Ship Machinery Study Program as supporting informants. The primary data were obtained through distributing questionnaires to 50 cadets and 2 lecturers in charge of the course. In addition, the data were also strengthened through observations of learning support facilities, such as the availability of e-learning platforms, internet networks, and laboratory and simulator facilities, as well as interviews with the Head of the Ship Machinery Study Program to obtain more in-depth information regarding the implementation of learning.

The research instrument was an assessment questionnaire compiled based on the needs of practical learning, utilization of laboratories and simulators, learning outcomes, as well as various literature and guidelines related to the ATT-III competency standards, STCW 1978 Amendment 2010, and the implementation of the Seafarer Proficiency Examination. The assessment scale in the questionnaire used a graded choice, namely 1 for the category not achieved, 2 for less achieved, 3 for achieved, and 4 for very achieved. The collected data were analyzed using descriptive statistics through frequency distribution and percentages to determine the tendency of respondents' answers to each research indicator. The results of the questionnaire were then compared with the results of observations and interviews to obtain a more complete picture of the effectiveness of the use of laboratories, simulators, and learning support media on the quality of practical learning in the Ship Engineering Study Program.

III. RESULT AND DISCUSSION

Table 1. Frequency distribution of learning models in the laboratory and simulator in practical learning of the ship engineering study program on the quality of learning

Information	n	%
I understand the auxiliary machinery systems on board ships		
Rarely	5	10
Often	15	30
Always	30	60
Laboratory equipment and simulators on campus have good features and are used in learning machinery on ships		
Rarely	45	90
Often	5	10
I like the use of material in practical scenarios used in learning about machinery systems on ships.		
Never	20	40
Rarely	15	30
Often	2	4
Always	13	26
I utilize laboratory and simulator facilities to support learning well.		
Often	15	30
Always	35	70
I had the opportunity to discuss with the lecturer about material that I did not understand in learning using laboratories and simulators in the engineering course.		
Often	20	40
Always	30	60
I easily understand how to operate the laboratory and simulator according to the practical scenario.		
Often	15	30
Always	35	70
I had no difficulty in the learning process using the laboratory and simulator in the ship's machinery course.		
Rarely	5	10
Often	15	30
Always	30	60
Learning using laboratories and simulators is a lot of fun.		
Often	10	20
Always	40	80
While studying using the laboratory and simulator, I became confident in carrying out real work practices on ships.		
Rarely	35	70
Often	10	20
Always	5	10
The campus helps with credit/quota costs for e-learning.		

Rarely	50	100
E-learning makes it easier for me to communicate with lecturers		
Rarely	5	10
Often	15	30
Always	30	60
The material delivered by all lecturers via e-learning is easy for me to understand.		
Often	25	50
Always	25	50
For the e-learning material for the construction course and the working principles of refrigerator auxiliary machinery, it is easy for me to understand without the need for direct practice.		
Never	5	10
Rarely	35	70
Often	10	20

Table 2. Frequency distribution of the effectiveness of e-learning as an online learning medium for learning outcomes according to lecturers teaching the construction and working principles of refrigerator auxiliary machinery courses.

Information	n	%
I have a computer or laptop device that is adequate to access e-learning.		
Always	2	100
The internet network for accessing e-learning can be accessed well throughout the campus area.		
Rarely	2	100
I like the provision of e-learning materials in the following form for the construction and working principles of refrigerator auxiliary machinery courses.		
Offline Video	1	50
Document Files	1	50
I make good use of the facilities to support e-learning.		
Always	2	100
I have enough time to ask questions and answer with the students about the material that I don't understand in the e-learning learning in the construction and working principles of refrigerator auxiliary machinery courses.		
Often	1	50
Always	1	50
I can easily operate the e-learning application (platform)		
Always	2	100
I have no obstacles in the teaching process using e-learning in the construction and working principles of refrigerator auxiliary machinery courses.		
Always	2	100
Teaching using e-learning is very fun		
Always	2	100
While using e-learning, my internet network connectivity was smooth.		
Often	2	100
The campus helps with credit/quota costs for e-learning.		
Often	2	100
E-learning makes it easy for me to communicate with cadets		
Always	2	100
I assessed the cadets' responses through observations during the e-learning process.		
Often	1	50
Always	1	50
For e-learning materials for the construction and working principles of refrigerator auxiliary machinery courses, it is easy for cadets to understand without the need for direct practice.		
Never	1	50
Often	1	50
I compile e-learning materials in accordance with the learning outcomes of the construction course and the working principles of refrigerator auxiliary machinery.		
Always	2	100
I know what I want to achieve in each lesson from each e-learning meeting.		
Always	2	100
Learning outcomes are easily achieved in e-learning		
Always	2	100

Table 3. Results of observations of E-Learning in the construction and working principles of refrigerator auxiliary machinery course at the Malahayati Maritime Polytechnic

Statement	Highly Fulfilled	Fulfilled	Less Fulfilled	None
Availability of e-learning application platforms	√			
Availability of a good internet connection throughout the campus			√	
Availability of a free internet connection throughout the campus			√	
Availability of laboratory space and computer simulators for cadets who wish to access e-learning applications			√	

Table 4. Results of interviews with the head of the marine engineering study program

Question	Answer
How long has E-Learning been implemented at Malahayati Maritime Polytechnic?	Since 2020, this application has been used for learning for the first time during the COVID-19 pandemic.
What is your response to the availability of e-learning media, especially for construction and mechanical engineering courses? Does it help with refrigerators?	It is very good, because it can help lecturers to provide lessons to cadets if the lecturer cannot provide the material face to face due to constraints in the form of other activities.
Are there any obstacles in learning activities through e-learning media?	There are certainly challenges, including frequently unstable internet connections and difficult access, as not all campus areas have free internet access. Many cadets also lack laptops suitable for these learning activities. Meanwhile, the computer laboratories and simulators are not readily accessible for cadet use.
How is the presence of cadets in teaching and learning activities through E-Learning media?	Very good, every E-learning material uploaded by the lecturer is always accessed by the cadets, especially interesting materials such as in the form of videos and document files.
How to control the attendance of lecturers and cadets in learning using E-Learning?	Every day, study program staff will check the materials uploaded by lecturers conducting e-learning after the lecturer has previously informed them that the day's learning schedule cannot be conducted face-to-face. Meanwhile, cadet attendance is checked via G-Form, accompanied by a screenshot of access to the e-learning application.
Is learning using E-Learning media effective enough to achieve the learning targets that have been set?	Seeing from the beginning of the implementation of this E-Learning, the learning achievement targets are still met as in face-to-face learning, this is proven by the UTS (Mid-Semester Exam) and UAS (Final Semester Exam) scores of cadets which remain good. Therefore, we continue to maintain the existence of E-Learning learning media for cadets because in certain situations and conditions with a limited number of lecturers and many who hold concurrent positions, sometimes they cannot teach face-to-face to cadets so that even though lecturers cannot be present in class, learning activities are still fulfilled using online methods.
How to control the quality of teaching and learning activities using E-Learning media?	Every week, we will evaluate the e-learning materials uploaded by lecturers. We will assess their alignment with the learning outcomes. We also consistently encourage lecturers to upload engaging materials, not just document files but also engaging videos related to the learning material.
Can all learning achievement targets for the construction and working	Of course not, because this course requires practical learning that must be done face-to-face in the laboratory

Question	Answer
principles of refrigerator auxiliary machinery courses be achieved using only E-Learning media?	and simulator. Although there are numerous videos explaining this course, cadets still need to do practical activities directly in the practice room.
Are there any suggestions and input for learning using E-Learning media for the Construction and Working Principles of Refrigerator Auxiliary Machinery course?	Our suggestion as the head of the Marine Engineering study program is that lecturers who cannot teach face-to-face with cadets due to other work constraints outside the office should utilize this E-Learning learning media so that teaching and learning activities are not disrupted. In addition, the uploaded materials must be full of creativity, not only in the form of document files, but also in the form of videos that can be downloaded and replayed when offline. And hopefully the office can also facilitate this in the form of training activities or workshops on how to make short and interesting videos for learning materials.

The results of the study in Table 1 indicate that learning using laboratories and simulators is considered quite helpful for cadets in understanding auxiliary machinery systems on ships. Most cadets stated that they always understood the material, utilized the laboratory and simulator facilities, found it easy to operate the equipment according to practical scenarios, and found practical learning more enjoyable. However, there were still important notes, namely 90% of cadets stated that laboratory and simulator facilities rarely had good features, 70% of cadets rarely felt confident in undergoing real-world work practices on ships, and most cadets also considered practical materials difficult to understand if only through e-learning without direct practice. Meanwhile, Table 2 shows that according to lecturers, e-learning is quite effective as a learning support medium because lecturers are able to operate the platform, organize materials according to learning outcomes, and maintain communication with cadets. However, lecturers also emphasized the existence of major obstacles such as infrequent internet connections, lack of quota support, and the limitations of e-learning to replace direct practice in the refrigerator auxiliary machinery course.

The observation results in Table 3 reinforce this finding, stating that the e-learning platform is well-established, but other supporting facilities, such as the campus internet network, free internet access, and laboratory space and computer simulators for cadets, are still considered inadequate. This finding aligns with the interview results in Table 4, which indicate that e-learning has been used since 2020 and is considered helpful to lecturers when face-to-face learning cannot be implemented. However, the Head of the Study Program also emphasized that e-learning cannot replace direct practice because the construction and working principles of refrigerator auxiliary machinery courses still require face-to-face activities in laboratories and simulators to optimally achieve cadets' practical competencies.

The results of the study indicate that the use of laboratories and simulators in practical learning in the Ship Engineering Study Program provides a positive contribution to the quality of learning. Students generally find it easier to understand auxiliary machinery systems on board ships, are more active in utilizing practical facilities, and feel that learning becomes more interesting when using laboratories and simulators. This finding is in line with the views of Habib, et al. [14] that engineering laboratories help students understand the working systems of tools, understand the working principles of machines, and build technical skills through direct experience, because laboratory practice has been proven to support the development of technical abilities relevant to the industrial world, connecting theory with practical experience, and strengthening problem-solving and measurement skills. In addition, practical learning is not only a complement to theory, but is an important part in developing the work competencies of students, because engineering and maritime education still faces a gap between classroom learning and real operational demands, so that direct experience, practical guidance, and integration of industry-based learning are important elements in preparing graduates who are ready to work [15].

These findings are also in line with research Sakdapat [16] which explains that although laboratories and simulators have become an important part of maritime vocational education, the effectiveness of their use still needs to be studied scientifically because their impact is not automatically optimal without a learning design that is aligned with competency achievements, teacher readiness, and an appropriate assessment system. In the context of this research, cadets not only learn to understand the material conceptually, but also have the opportunity to experience a learning process that is closer to real working conditions on ships. This is important because the field of ship machinery requires graduates who not only know the theory, but are also able to apply this knowledge in operational and maintenance activities of the machine.

However, the research results also show that laboratory and simulator facilities are not yet fully optimal. Most cadets consider the features of laboratory and simulator equipment to be rarely considered good, and the level of confidence of cadets to undergo real work practice on board is also not optimal. These findings are not entirely in line with the ideals of simulator-based learning, because although simulators are seen as important to support competency achievement and bridge training before real practice, their effectiveness remains highly dependent on the learning design, scenario quality, facility readiness, and accompanying assessment system [17].

The results of research on e-learning show that this media is quite helpful in the learning process, especially in the delivery of material, communication between lecturers and cadets, and the continuity of learning when face-to-face meetings cannot be held. This finding is in line with Bali [18] that technology-based media allows students to learn without always being limited by space and time, because e-learning, mobile learning, and distance learning provide flexibility for students to access materials, determine study times, and participate in learning from different locations. However, this study also shows that e-learning has not been able to replace direct practical learning, especially in the Construction and Working Principles of Refrigerator Auxiliary Machinery course. This shows that e-learning is more appropriately positioned as a supporting medium, not as a primary replacement for practical activities in laboratories and simulators.

The main obstacle identified in this study was the suboptimal support for learning resources, particularly internet networks, free internet access, and limited laboratory space and computer simulators. Observations and interviews indicated that although e-learning platforms were available, technical support within the campus environment still needed improvement. This finding aligns with the view that technology-based media allows students to learn more flexibly without being constrained by space and time, as learning technology facilitates access to various learning resources anytime and anywhere and supports more adaptive learning tailored to individual needs [19].

While laboratory, simulator, and e-learning models all play a role in improving the quality of practical learning, their functions differ: e-learning primarily supports access to materials, learning flexibility, and learning communication, while vocational practical learning is stronger when combined with face-to-face activities, laboratories, simulations, and hands-on training. Laboratories, simulators, and practical experiences have proven to be more relevant for building operational skills and job readiness because hands-on experience, laboratory simulations, and practical training play a crucial role in developing vocational and maritime competencies [20].

IV. CONCLUSION

The learning model in the laboratory and simulator plays an important role in improving the quality of practical learning in the Marine Engineering Study Program, especially in helping cadets understand auxiliary machinery systems, operate equipment according to practical scenarios, and build a more realistic learning experience. E-learning also provides benefits as a supporting learning medium, especially in delivering material and communication between lecturers and cadets. However, e-learning cannot replace direct practice because learning marine engineering still requires operational skills acquired through laboratories and simulators. Therefore, future researchers are advised to develop research with a wider number of respondents, add direct measurement of learning outcomes, and examine the effectiveness of an integrated learning model between e-learning, laboratories, and simulators so that the research results are stronger and can be used as a basis for developing practical learning in maritime vocational education.

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