Effect of Computer-Based Training Materials Using Flat Diagrams and Graphics Animations on Students’ Familiarization of Marine Auxiliary Machinery

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ABSTRACT

The technological advances that have occurred in recent years have inspired maritime institutions to look for more advanced and efficient teaching strategies. This quasi-experimental study aims to determine the effect of the 2D flat diagrams and 3D graphic animations as instructional materials on Marine Engineering students’ familiarization with auxiliary engine machinery. The participants were second-year students taking up BS Marine Engineering for the second semester of the school year 2021–2022. Two instruments were used. The first was a 30-item multiple-choice questionnaire focusing on Marine Refrigeration systems and Air Conditioning systems. The questions relate to the components of each system, its functions, and its operation. The second instrument was the assessments at the end of the CBTs. Mean, Standard Deviation, Paired t-test, and T-test for independent samples were used to analyze the data. The finding showed that using 2D flat diagrams and 3D graphic animations is essential for the Marine Engineering students’ familiarization with auxiliary engine machinery. Students exposed to the Refrigeration System and Air Conditioning System CBTs with 3D graphic animation have a higher level of familiarization than students exposed to the use of a 2D flat diagram. Moreover, simultaneously, students’ performance increases when they are exposed to the Refrigeration System and Air Conditioning System CBTs with 3D graphic animation. This study recommends upgrading the CBTs used by the school from 2D or flat diagrams to more sophisticated CBTs with 3D graphic animations.

Keywords: 3D graphics animations, computer-based training materials, engine room simulators, marine auxiliary machinery.

1. INTRODUCTION

1.1. Background of the Study

Due to the ever-changing environment of the shipping industry brought about by new international legislation and the growing impact of technology, maritime education and training (MET) institutions are faced with the challenge of coping with and meeting the requirements needed to produce students and trainees of high quality and competence. According to Gierusch and Lisowski (1998), it is not even possible to satisfy all the requirements needed by the STCW during the four-year system of studies in marine engineering.

The technological advances that have occurred in recent years have inspired maritime institutions to look for more advanced and efficient teaching strategies. Marine engineering courses are centered on training in practical problem-solving and hands-on ability. Marine engineering education and training using several strategies such as enhanced practical training, problem-solving, and student-centered learning. All these methods require large and systematic facilities. The main problem faced by marine engineering training is how to meet the increasing requirements of engineers facing complex financial issues (Gierusch & Lisowski, 1998). One adaptive solution is systematic training systems, including computer-based training (CBT).
Computer-based training (CBT) applications have been used as tutors, skill practice, simulators, and assessments in marine engineering education. There is a trend that computer-based simulators will replace some practical engineering exercises, as research shows that computer simulations are an improvement to traditional instruction, especially with laboratory activities, as they give students more opportunities to understand some concepts (Rutten et al., 2012).

The Standards of Training, Certification and Watchkeeping (STCW) highly recommend applying CBT programs and simulators in the professional training of marine engineering (STCW, 1978 as amended in 1995/2010, as cited in Yabuki, 2011). Thus, several maritime schools and training centers adopted this tool to support their teaching processes (Cwilewicz et al., 2003).

It is worth mentioning that marine engine room simulators also have some fundamental disadvantages. It is often simplified with many abbreviations and schematic presentations because they are presented only in 2D visualization. Therefore, students with a deep understanding of simulator operation may still have trouble with actual ship operation because the operating technique and graphical presentation of the simulator are different from reality (Tomczak, 2005).

To answer these problems, computer-based training with 3D graphic visualization is widely used in different fields of education and training, such as live military training (Bhagat et al., 2016), maintenance and operation of high-voltage overhead power lines (Ávala García et al., 2016), and training of emergency medicine personnel (Ferracani et al., 2013) and are proven to be more effective than traditional computer-based training that employs 2D simulation technology because of high immersion, interactivity, and imagination.

Considering these, developers of these simulators began to design applications with 3D graphical presentations resembling actual machinery configurations. Developers of engine room simulators employ 3D graphics visualization of auxiliary machinery systems that are identical to reality. It has become easy to apply these 3D simulation techniques due to the advancements in computers and processors. Trainees who underwent this kind of simulator were better equipped to deal with the real-life operation of machinery, increasing the standards of ship operational safety.

As a result, the standards of ship operating safety are significantly raised, and trainees are much more equipped to handle the actual operation of machinery. Additionally, it is feasible to familiarize students with emergencies in simulation settings that may not be performed in real-world settings due to safety requirements (Tomczak, 2005, 2008).

The main problem in 3D simulators is providing proper navigation through the system’s elements. The engine room is a complex, multi-level, complicated set of sub-systems, equipment, and machinery. This is a new challenge for entities creating such simulators, making the production of these simulators costly.

Currently, the Philippines remains the largest market for crewing, advantaged by several factors: (1) High population growth rate in the country; (2) absence of more attractive employment opportunities; (3) high unemployment rate; (4) country’s geographical position consisting of approximately 7,100 islands; (5) private sectors being encouraged to develop marine training facilities with the Philippines having the most number of MET institutions (159) with India as the second (130); and (6) fluency of Filipinos in communicating using English (Baylon & Santos, 2011). However, with the current global shipping market supply and demand scenario and the revised STCW Convention and Code implementation, the Philippines must not be complacent. The European Union (EU) has expressed concern over the Philippines’ “deficiencies” in complying with the STCW for seafarers recognizing and allowing Filipinos to be employed in seagoing ships. The Philippines must resolve outstanding deficiencies to fully comply with the STCW and the European Maritime Safety Agency (EMSA) audit and improve its maritime education, training, and certification system for Filipino seafarers (Lee-Brago, 2019).

As the first maritime school in the Philippines with a certified quality management system, the JBLF Maritime University’s vision of becoming the leading institution in Quality Education and Training through Total Quality Management drives the top management to go beyond quality (Tupas, 2013). John B. Lacson Colleges Foundation-Bacolod (JLBF-B) uses different CBT programs and materials to aid marine engineering students in their learning. Some CBT programs and simulators are already being used to augment their laboratory activities and assess their understanding level. Nevertheless, most CBT materials are visualized in 2D or flat diagrams. Only some CBTs have 3D graphic animations currently available in the school.

This study aimed to determine the effect of 2D flat diagrams and 3D graphic animations on JLBF-B Marine Engineering students’ familiarization with auxiliary engine machinery. This research can also determine if the school needs an upgrade from CBTs in 2D or flat diagrams to more sophisticated CBTs with 3D graphic animations.

1.2. Theoretical Framework

A clear and comprehensive set of criteria for creating effective multimedia instruction has not yet been offered by educational science. These educational resources are typically developed using designers’ aesthetic preferences and intuitions for what might work.

Multimedia learning theories can be categorized at several levels. Basic psychological theories explain how people process various forms of information and learn through various senses by describing memory systems and cognitive processes (Van Merriënboer & Kester, 2014). Examples of such ideas include Baddeley’s (2012) working memory model with a central executive and two slave systems, the visuospatial sketchpad and the phonological loop, as well as Paivio’s Dual Coding Theory (1986). The learner must be able to make spatial transformations to integrate information into long-term memory, retain an internal representation in working memory, and encode spatial information from sensory memory (Milik et al., 2008). Additionally, spatial ability involves the representation, rotation, and inversion of objects in three
dimensions when they are presented in two dimensions (Barnea, 2000). Barnea categorizes visualization abilities into three categories based on the degree of difficulty: spatial visualization, which is the capacity to accurately understand three-dimensional (3D) objects from their two-dimensional (2D) representation; spatial orientation, which is the capacity to envision how a representation will appear from a different perspective; and spatial relations, which is the capacity to see the effects of operations like rotation and reflection (Ferk et al., 2003).

1.3. Conceptual Framework

The support of 3D information representations is succeeded by different means in computer-based multimedia environments (Huk, 2006). The primary assumption of Wu and Shah (2004) is that with 3D animation, students can change and improve their incomplete mental models. Nevertheless, researchers like Gerjets and Scheiter (2003) and Paas et al. (2003) have demonstrated that in hypermedia-learning environments, cognitive overload problems may arise from using 3D models, as they generate a heavy cognitive load. On the other hand, Ferk et al.'s (2003) research revealed that some representations of the molecular 3D structure are better understood and used by students in solving tasks of different complexity. For all students, the concrete representations were more helpful than abstract representations. Primary school students scored better when using concrete 3D models, whereas secondary school and university students achieved the best results using illustrated graphics of 3D molecular models or computer-generated models.

In modern educational practice within a natural school environment, building an instructional virtual environment (VE) system to match the human perceptual and motor system is essential (Syliaiou et al., 2010). Moreover, it is evident that well-designed educational environments, which take both human cognitive architecture and multimedia principles into account, ensure that learners will work in an environment that is goal-effective, efficient, and appeasing. Following that direction, prior research (Korakakis et al., 2009) that was conducted with 13- and 14-year-old students confirmed that multimedia applications with interactive 3D animations and simple 3D animations increase students’ interest and interest, making the material more appealing to them. The findings also suggest that the most apparent and essential benefit of static visuals (3D illustrations) is that they leave the time control of learning to the students and decrease the cognitive load.

Given the concepts mentioned above and findings supported by the literature, this study explores if there is a difference in the level of familiarization of engine auxiliary machinery by JBLCF-B BSMarE 2 students if they were to use CBT with a flat diagram or CBT with graphical animation.

1.4. Statement of the Problem

This study aimed to determine the effect of the 2D flat diagrams and 3D graphic animations as instructional materials on JBLCF-B Marine Engineering students’ familiarization with auxiliary engine machinery. For this purpose, two groups were selected. A control group was exposed to 2D flat diagrams as instructional materials for learning auxiliary engine machinery, while an experimental group was taught the same topic using 3D graphic animations. Specifically, this paper sought to answer the following questions (see Fig. 1 for the conceptual framework):

1) What is the level of familiarization of the Control Group and the Experimental Group with engine machinery before their exposure to 2D flat diagrams and 3D graphic animations, respectively?
2) What is the level of familiarization of the Control Group and the Experimental Group on engine machinery after their exposure to 2D flat diagrams and 3D graphic animations, respectively?
3) Is there a significant difference between the pre-test and post-test levels of familiarization of the Control Group and the Experimental Group?
4) Is there a significant difference between the post-test levels of familiarization of the Control Group and the Experimental Group?

1.5. Hypotheses

The following hypotheses were formulated based on the topic under investigation:

1) There is no significant difference between the pre-test and post-test levels of familiarization of the control group and the experimental group.
2) There is no significant difference between the post-test levels of familiarization of the control group and the experimental group.

1.6. Significance of the Study

The result of this study can be beneficial to the following: Administration. The result of this study can help the Administrator and the Dean of Maritime Education, as well as the Marine Engineering Department, to decide if the school and the students need an upgrade from 2D flat diagrams to 3D graphic animations in the teaching engine auxiliary machinery. Determining a more effective tool would also enhance the quality of the graduates and prepare them to be competent on the global level.

Management Information System. This study could benefit the school’s MIS Department, which is mainly engaged in technology since they handle and control the information system and certain advancements in the field, which could be a new development in the system.

Marine Engineering Faculty. This study is highly beneficial for the instructors as they can choose which tool is more effective in delivering the topic to the students. If the topic is delivered efficiently, more ideas and learning can be imparted to the students.

Marine Engineering Students. The students could benefit from this study the most as whichever tool is more effective would help them learn the topic faster, and the quality of learning would be much higher. Suppose 3D graphic animations are more effective than 2D flat diagrams. In
that case, this tool could also help them familiarize the engine auxiliary machinery closer to reality and enhance their preparation with the equipment used onboard modern vessels.

Curriculum Planners. The result of this study could aid the curriculum planners in designing the Instructor's Guide and planning the topics, laboratory activities, and the time needed for the students to absorb the topic thoroughly.

Maritime Industry. Through effective education and training, it is only feasible to secure and preserve qualified human resources for the maritime industries and to ensure safe, secure, clean, and efficient operations.

Future Researchers. This study could link future researchers to analyze the findings further and try other perspectives or focuses.

1.7. Scope and Limitation

Currently, the CBTs available for marine engineering students of JBLCF-B are primarily in 2D flat diagrams, and only a few CBTs have 3D graphic animations. This study aimed to determine which type of CBT is more effective in familiarizing auxiliary engine machinery with the JBLCF-B Marine Engineering students.

The CBTs used in this study discussed marine refrigeration and air conditioning systems. In these CBTs, the students could determine the correct parameters, observe the fluids, operate valves, pumps, compressors, control panels, and other components, and experience some alarms and faults if the process is not done correctly. These CBTs are available in the 2D flat diagram and with 3D graphic animation, where you can see the actual appearance of the auxiliary machinery, the valves, pumps, and other components of the systems.

Two sections from BS Marine Engineering second-year students taking up Auxiliary Machinery 2 (AuxMach2) were chosen to take the researcher-made test instrument before they were exposed to the distinct types of CBT programs to assess their level of familiarization with the JBLCF-B Marine Engineering students.

The study occurred at the John B. Lacson Colleges Foundation during the second semester of 2021-2022.

After being exposed to the CBTs separately for six weeks, both groups were given the post-test to assess their familiarization with the Marine Refrigeration and Air Conditioning Systems.

This study's limitation was finding the sections of BS Marine Engineering second-year students with the same number, capacity, and time of AuxMach2 subject. The sections should also be handled by the same instructor only. However, some of these variables were compensated by adequately administering the methods.

This study was conducted at the height of the COVID-19 pandemic, so the instruments were administered online using the JBLCF-B learning management system (LMS). The interventions were performed using video conferencing software.

1.8. Definition of Terms

The following significant terms are conceptually and operationally defined to understand the study better.

Marine Auxiliary Machinery. Marine auxiliary machinery is machinery in the engine room that assists in working the propulsion plant: coolers, heaters, pumps, separators, etc., (Wärtsilä, n.d.). The auxiliary engine machinery used in this study included marine refrigeration and air conditioning systems.

Computer-based Training (CBT). CBT is any course of instruction whose primary means of delivery is a computer (TechTarget, 2011). Four CBTs used in this study, titled Air Conditioning Plant, Air Conditioning Plant 3D, Refrigeration Plant, and Refrigeration Plant 3D, all developed by UNITEST and are currently being used by JBLCF-Bacolod.

Familiarization. Familiarization is learning about a particular stimulus (Dambudzo, 2018). This study refers to the level of knowledge regarding identification, familiarity, and hands-on exposure of students with auxiliary engine machinery.

Flat Diagram. Flat diagrams are two-dimensional representations or displays of a system that include the connections of every component (Akpan & Shanker, 2019). In this study, flat diagrams are used in two CBTs, which will be employed to teach the Control Group some auxiliary machinery.

Graphical Animation. Graphical animation is a three-dimensional visualization technology that can provide

Fig. 1. Schematic diagram of the conceptual framework.
efficient tools to visualize and understand complex, high-dimensional data and objects (Geng, 2013). This study used CBTs with graphical animation to instruct the Experimental Group on some auxiliary machinery onboard the ship.

2. Methodology

This section of the study provides a thorough discussion of the research design, the methods of data gathering, the participants involved in the study, the research instruments, the data-gathering procedure, and the statistical tools employed in the study.

2.1. Research Design

This study utilized a quasi-experimental nonequivalent group pretest-posttest design. This is a classic pretest-intervention-posttest design in which two separate groups are compared (Shelley, 2014). When using quasi-experimental designs, a comparison group is chosen that is as similar to the treatment group as possible in terms of baseline (pre-intervention) characteristics, and the comparison group represents the results that would have occurred if the program or policy had not been implemented (i.e., the counterfactual) (White & Sabarwal, 2014). These non-randomized designs are frequently used when it is not logistically feasible to conduct a randomized controlled trial (Harris et al., 2006).

A quasi-experimental design is appropriate for this study because it involves creating a comparison group and is most often used when it is impossible to randomly select individuals or groups into treatment and control groups (White & Sabarwal, 2014).

BSMarE-2 students from two sections taking up the subject Auxiliary Machinery 2 were given a pre-test to determine their initial level of familiarization with auxiliary engine machinery. In this study, the marine refrigeration system and the air conditioning system.

2.2. Participants

This study used homogeneous sampling, a non-probability, purposive sampling technique focusing on participants who share similar traits or specific characteristics (Etican et al., 2016).

This study was conducted on two sections of JBLCF-B second-year students taking up BS Marine Engineering for the second semester of the school year 2021–2022. These sections were taught AuxMach2 by the same instructor in a parallel time slot and classroom to minimize other factors or variables that may affect their level of comprehension and familiarization with the auxiliary machinery.

2.3. Research Instrument

This study used two instruments. The first was a 30-item multiple-choice questionnaire with two parts focusing on the Marine Refrigeration System for the first part and the Air Conditioning System for the second part. Each part consists of 15 items, for a total of 30 items. The questions relate to the components of each system, its functions, and its operation. These questions were adapted from the CBTs that were used in this study.

The second set of instruments was the assessments at the end of the CBTs. Each CBT has a 10-item assessment after finishing the module.

The CBTs used in this study were all developed by Unitest, a world leader in creating maritime training software and fully interactive engine room simulators with realistic 3D visualization of the machinery space.

2.4. Validity of the Instrument

The validity of the assessments used in this study was not investigated. Unitest’s CBTs and simulators use state-of-the-art, proprietary, integrated checklists and fully automated assessment of the trainee competencies. These CBTs and simulators have been developed to comply with the STCW 2010 Code (with Manila Amendments) and ISM Code: Section 6 and Section 8 and have the type of approval certificate issued by the EU classification company.

2.5. Reliability of the Instrument

Reliability is about the consistency of a measure (Middleton, 2019). To establish the reliability of the instrument used in the study, Kuder-Richardson (KR-20) was used to assess the reliability of the test (α = 0.82). The instrument questionnaires were then distributed to the respective sections.

2.6. Data Gathering Procedure

A 30-item questionnaire was prepared by the researcher, retrieved from questions present in the CBTs discussing the two marine auxiliary machineries, the Marine Refrigeration System and the Marine Air-Conditioning System. This questionnaire was given as a pre-test to the students in four sections for them to answer. The results were used to determine the level of familiarization of the students with marine auxiliary machinery before they were exposed to the two types of computer-based training materials, the one with flat diagrams only and the other with graphic animations.

After discussing each topic, the students were exposed further to the CBT about the topic, either with the flat diagram or graphic animation, depending on which group they belong to. The students then took the assessment at the end of the CBT. One section was assigned to the control group, and the topics were taught using computer-based instruction employing flat diagrams. The other section was assigned to the Experimental Group, and the same topics were taught using computer-based instruction with 3-D graphic animations. After each CBT, an assessment was given to the students to determine their level of familiarization with the marine refrigeration system and the air conditioning system after they were taught separately using the two different computer-based methods of instruction.

The data gathered from these assessments determined the students’ final level of familiarization with the auxiliary machinery.

2.7. Research Instrument

Mean and Standard Deviation were used to determine the students’ level of familiarization before and after one
section was taught AuxMach2 using CBT with a flat diagram and the other with CBT with graphic animation (Problems 1 and 2). The mean raw scores in the different components and as a whole were distributed and interpreted in Table I, as adapted from the study of (Tupas & Yucarisa, 2011).

A paired t-test was used to determine if there is a significant difference in the level of familiarization with auxiliary machinery between the two sections after being taught Marine Refrigeration System and Marine Air Conditioning System using the two distinct types of CBT (Problem 3). A T-test for independent samples was used to test the students’ level of familiarization with the said topics under the two separate interventions (Problem 4).

3. RESULTS AND DISCUSSION

This part discusses the study’s results using the data gathered to determine the effect of the 2D flat diagrams and 3D graphic animations as instructional materials on JBLCF-B Marine Engineering students’ familiarization with auxiliary engine machinery.

Table II shows the level of familiarization of the Control Group and the Experimental Group with engine machinery before their exposure to 2D flat diagrams and 3D graphic animations. The data reveals that both groups have an average level of familiarization before their exposure to 2D flat diagrams and 3D graphic animations, respectively. This means that at least 40%–59% of the questions were answered correctly by both groups of students.

The students are not expected to answer all the questions correctly in the pre-test. However, students will use their prior knowledge and understanding of the topic as it is used to measure the amount of learning they initially have before the lessons are given (Kuehn, 2024).

Meanwhile, students exposed to the Refrigeration System and Air Conditioning System CBTs with 3D graphic animation (Experimental Group) have a higher level of familiarization ($m = 19; sd = 4.09$) than students exposed to the use of 2D flat diagram (Control Group) ($M = 15; SD = 3.73$) as shown in Table III. This result indicates a high level of familiarization among students in the Experimental Group on engine machinery after their exposure to 3D graphic animations. In comparison, students in the Control Group obtained an average level of familiarization after their exposure to 2D flat diagrams.

### Table I: Interpretation of Mean Raw Scores

<table>
<thead>
<tr>
<th>Mean scores</th>
<th>Interpretation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>24–30</td>
<td>Very high level of familiarization</td>
<td>At least 80% of the items in a component or as a whole were answered correctly.</td>
</tr>
<tr>
<td>18–23</td>
<td>High level of familiarization</td>
<td>At least 60%–79% of the items in a component or as a whole were answered correctly.</td>
</tr>
<tr>
<td>12–17</td>
<td>Average level of familiarization</td>
<td>At least 40%–59% of the items in a component or as a whole were answered correctly.</td>
</tr>
<tr>
<td>6–11</td>
<td>Low level of familiarization</td>
<td>At least 20%–39% of the items in a component or as a whole were answered correctly.</td>
</tr>
<tr>
<td>0–5</td>
<td>Very low level of familiarization</td>
<td>At least 0%–19% of the items in a component or as a whole were answered correctly.</td>
</tr>
</tbody>
</table>

### Table II: Level of Familiarization of the Control Group and the Experimental Group with Marine Auxiliary Machinery BEFORE their Exposure to 2D Flat Diagrams and 3D Graphic Animations

<table>
<thead>
<tr>
<th>Groups</th>
<th>Mean</th>
<th>SD</th>
<th>Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control group (2D flat diagram)</td>
<td>12</td>
<td>4.41</td>
<td>Average</td>
</tr>
<tr>
<td>Experiment group (3D graphic animations)</td>
<td>14</td>
<td>3.70</td>
<td>Average</td>
</tr>
<tr>
<td>Total</td>
<td>13</td>
<td>4.17</td>
<td>Average</td>
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### Table III: Level of Familiarization of the Control Group and the Experimental Group with Marine Auxiliary Machinery AFTER their Exposure to 2D Flat Diagrams and 3D Graphic Animations

<table>
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<tr>
<th>Groups</th>
<th>Mean</th>
<th>SD</th>
<th>Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control group (2D flat diagram)</td>
<td>15</td>
<td>3.73</td>
<td>Average</td>
</tr>
<tr>
<td>Experiment group (3D graphic animations)</td>
<td>19</td>
<td>4.09</td>
<td>High</td>
</tr>
<tr>
<td>Total</td>
<td>17</td>
<td>4.53</td>
<td>Average</td>
</tr>
</tbody>
</table>
These results show that learning CBTs with 3D graphical animation can improve the students' familiarity with marine refrigeration systems. The results of this study affirm the research of Bhagat et al. (2016), Ayala Garcia et al. (2016), and Ferracani et al. (2015) that 3D CBTs could provide an enhanced experience that could augment the learning processes of the students.

Moreover, the Control Group's levels of familiarization before and after their exposure to 2D flat diagrams significantly differed \((p < 0.001)\) with a mean difference of 3.

On the other hand, in the Experimental Group, the students' levels of familiarization before and after their exposure to 3D graphic animations significantly varied \((p < 0.001)\), with a mean difference of 5 (Table IV). These results imply that the students' levels of familiarization in both groups have significantly improved after their separate exposure to 2D flat diagrams and 3D graphic animations, respectively. This means that both interventions have been proven effective.

Table V shows that the post-test levels of familiarization between the Control Group and the Experimental Group significantly differ \((p < 0.001)\) with a mean difference of 4. This implies that students exposed to 3D graphic animations had a higher level of familiarization than students exposed to 2D flat diagrams.

### 5. Recommendations

Based on the findings and conclusions of the study, the following recommendations are formulated:

#### Administration

The school administration may invest in upgrading CBTs from 2D flat diagrams to 3D graphic animations in teaching auxiliary engine machinery. It is vital to determine better ways or strategies in teaching courses that are heavy with graphic materials to increase better comprehension of the topics presented.

#### Marine Engineering Faculty

They should utilize CBTs with 3D graphic animations to deliver mechanical topics to students, as this has been proven more efficient.

#### Curriculum Planners

They may utilize the result of this study in designing and revising the Instructor's Guide and in planning the topics, laboratory activities, and the time needed for the students to absorb the topics thoroughly.

#### Developers of Instructional Materials

Those in charge of developing supplementary instructional materials, particularly for the course dealing with auxiliary machinery, may consider developing a library of 3D-designed presentations in animated form, which can be utilized by the instructors teaching the course. These graphics may include a full view and a part-by-part description of the machinery. The school may consider purchasing this type of instructional material to augment the delivery of these topics in Auxiliary Machinery.

#### Future Researchers

This study was conducted at the height of the COVID-19 pandemic, so there were limitations in conducting this research. If given a chance, this study could be improved by applying the intervention in a face-to-face setting, having the students use the CBT materials themselves, and enhancing the instruments used in the pretest-posttest. More research may be conducted with other instructional materials that provide the same level of familiarization of auxiliary machinery to the learners, such as non-proprietary videos showing the machinery and its operation while connected to its system.

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**CONFLICT OF INTEREST**

The authors declare that they do not have any conflict of interest.

**REFERENCES**


