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# The use of designed E-book to improve a concept understanding and practical skill on a mammography machine quality control among radiological technologist students

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## Abstract

The fashion in education increasingly integrates technology as learning supporting tool. For undergraduate radiological technologist (RT) students, the concept understanding and practical skills in their professional field have a significant impact on their success. Quality control (QC) of mammography machine is one of the professional responsibilities. A problematic situation in traditional learning process is the lack of devices and the primarily used lecture-style. This makes studying outside classroom and frequent practice more challenging. The purpose of this study was to determine the effectiveness of the developed e-book in RT students about the concept understanding and practical skills of the mammography machine QC, compared with conventional methods. One-hundred and fifteen students were participants, whom were randomized into two groups. The experimental group was able to access the e-book for self-learning, while the control group received only the conventional class on the same topic. The five-scale questionnaires were used to assess the student's satisfaction. A strong increase in the test-scores of the experimental students indicated their in-depth knowledge and better performance in practical and evaluation skills. The experimental group performed better than the control group, with a statistically significant difference at  $p < 0.00001$ . It also found that the majority of the students agreed that the e-book media was an excellent choice for their self-learning and training. So, it can be concluded that the e-book learning media has a positive influence to students – as a low cost, easily accessible and attractive supporting tool to provide students with the better opportunities for learning and skills-training.

**Keywords:** E-book effectiveness, Health sciences education, Concept understanding, Practical skills, Self-learning



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## Introduction

Nowadays, a rapidly developing technology results in a life style changes, the quality improvement in all sectors is nearly absolute needed the electronic elements including in education section (Astuti & Santosa, 2017). An innovative creation of learning digital technology platforms was used to improve understanding and practical skills (Astuti & Santosa, 2017; Yalçintas Sezgin & Ulus, 2017). Electronic book (e-book) is one of the learning systems in electronic format which becomingly replaces a formal printed book (Astuti & Santosa, 2017; Yalçintas Sezgin & Ulus, 2017). E-book has several advantages compared to conventional books: convenience used anywhere and anytime, independent facility, lower cost, easy to carry (Astuti & Santosa, 2017; Komarudin et al., 2017; Saripudin et al., 2022). The International Reading Association emphasizes the importance of merging the digital book with conventional program as an e-book can contain many features that help the learning process more fun, interesting and attractive (Komarudin et al., 2017; Yalçintas Sezgin & Ulus, 2017). Thus, the most important contribution of an e-book in education is to motivate student's learning and improve the understanding of main concepts (Astuti & Santosa, 2017; Harjono et al., 2020).

For health science students in the university, the early period of the third year is mostly a critical importance for the development of concept understanding and practical skills in their professional field. The concept understanding and practical skills have a significant impact on the student's performance in apprenticeship as well as in overall individual success in the field. Mammography machine is one of the professional fields and must be included in the curriculum of undergraduate radiological technologist education program in Thailand. Theoretic learning and practicing about mammography machine quality control (QC) is also essential for radiological technologist (RT) students. Normally, university lecturer has the responsibility to instruct the students how to perform and how to evaluate the mammography machine QC results then divide them into several groups for the practical class. Students' problems of concept understanding are due to their proficiency level in English language – although the lecturers teach in native language, all the references data recommended for health science education programs are in English. Moreover, some research has found that textbooks are not impactful in the interest of new generation students (Astuti & Santosa, 2017; Kestenbaum, 2014). So, students perform learning outside the classroom is quite difficult. In consequence, students' low level of concept understanding can lead them to poorly perform a practical and evaluative skills as well. Another important key problem is the limited number of the mammography machine and QC tools. In our Radiological Technology faculty, we have only 1 mammography machine and 1 set of the QC tools to serve approximately 60 students per year. The student groups can reserve the laboratory room once per week for each group. So, it restricts the student's chances to practice.

The lack of understanding of the concept of mammography machine QC is one of the reasons for the daily QC failure that is the directly responsibility of radiological technologists. So, the students should receive a regular lecture and practice included the instruction media that are easily understandable and available to support their review of knowledge outside the classroom (Komarudin et al., 2017), especially for the topic that is difficult to understand in a short period of time and should have a frequent practice. The e-book is appropriate to improve students' concept understanding because the present generation of students are usually surrounded by mobile devices in the online and digital world that attracts them more (Beimers, 2014; Short, 2010; Sinaga et al., 2019). Many researchers confirmed that e-book can be an effective tool to attract and motivate students' attention (Dunas & Vartanov, 2020; Saripudin et al., 2022). The students can spend time reading text on the screen more than a printed version because it is similar to their daily behavior; and when they have a focus it can indirectly improve their understanding in the meantime (Dunas & Vartanov, 2020; Reid, 2016). Moreover, the image or video simulated the real labs in e-book is an alternative to review lab experiment and help the student visualize a concept (Gunawan et al., 2017). From this perspective, our purpose in this study was to determine the developed e-book can serve as a supporting tool to improve the concept understanding and practical skills of the mammography machine QC in third year RT students. In addition, we also compared the effectiveness of the e-book-using group with the control group in self-study improvements.

## **Material and methods**

### **Participants**

The sample consisted of 115 students whom were recruited in 2021 and 2022 from the third year students of the Faculty of Radiological Technology, Rangsit University, Thailand. All of the participants in this study were considered to have the similar knowledge and skill level about QC of mammography machine in the testing time. To determine the effectiveness of the mammography machine QC e-book that we developed, the students were randomly separated to two groups with an approximate equal size. The first group (n=57) was a control group which received only the regular class learning of the RT program and the second group (n=58) received the e-book using in the regular program. Since the research was conducted with students, a consent form and a brief description of the test's information based on the study's ethic approval have been done before collecting data.

### **The electronic book (e-book)**

This study designed the e-book based on the prior experience in the basis of the research design. They suggested four design principles (visibility, ease, efficiency and enjoyment) to ensure that the ease of usage and learning, high efficiency, high memorability, few errors and satisfaction during the use of e-book (Nielsen, 1994; Wang & Huang, 2015). Two central parts are emerged in the e-book in line with the undergraduate radiological technology curriculum: (1) theory and (2) practical. Textbook of the American College of Radiology (ACR), digital mammography quality control manual (American College of Radiology, 1999) was used as the main theory reference. This textbook contains 87 pages of the content relevant to the role of a radiological technologist. All of the 87 pages mainly give a detail description with 9 figures. The evaluation sheet of each QC test was separated in the appendices section which will not be read continuously. The 41-page e-book in this study was produced by using the software from Canva and exported to the Simplebooklet in the form of a web book of which the participants can access online freely inside and outside the classroom. The paper pages were set in A4-size as Wilson et al. mentioned that the longer or shorter than A4 page length could be difficult and annoying for the users (Wilson et al., 2002). The theory design contents in our e-book were written by a university lecturer derived from the theory-based knowledge textbook and validated by a team of experts comprising of radiological technologists, medical physicists and radiologists who had more than 5 years of mammography experience. The table of contents is available to show all subject included in the e-book. Designers considered to provide an interactive interface with simple and clear buttons for supporting the usability and readability of the e-book (Henderson, 2002). In the main pages (Figure 1), we inserted an interaction button which linked to the related page – this allowed the readers to choose the page that they would like to read. The readers would prefer images to quickly and easily relate to the contents. Thus, most of the e-book pages have a big color picture to stimulate the reader to relate to 2-7 written sentences – for students to improve the understanding of the text and might support their recognition. In addition, a real experience and daily common finding in mammography machine QC were included based on the design principle from Wang and Huang's study which proposed that the user can experience and evaluate through the interactive elements (Wang & Huang, 2015). Thus, we established the page that contains a short video clip about basic daily QC of mammography machine. Several of the e-books include an optional hidden spot, which can be activated by the user. It is mostly used for the practical part, an exercises test of mammogram QC equipment, setting parameter and result evaluation was attached in the page with true/false button and then users click on the button, the answer will appear on the screen with an explanation (Figure 2). So, the students can be more familiar to the mammogram QC procedures and more practice in evaluation at hand. A comparison between learning process of the conventional textbook with

laboratory room practice and the developed e-book with laboratory room practice was provided in Figure 3.

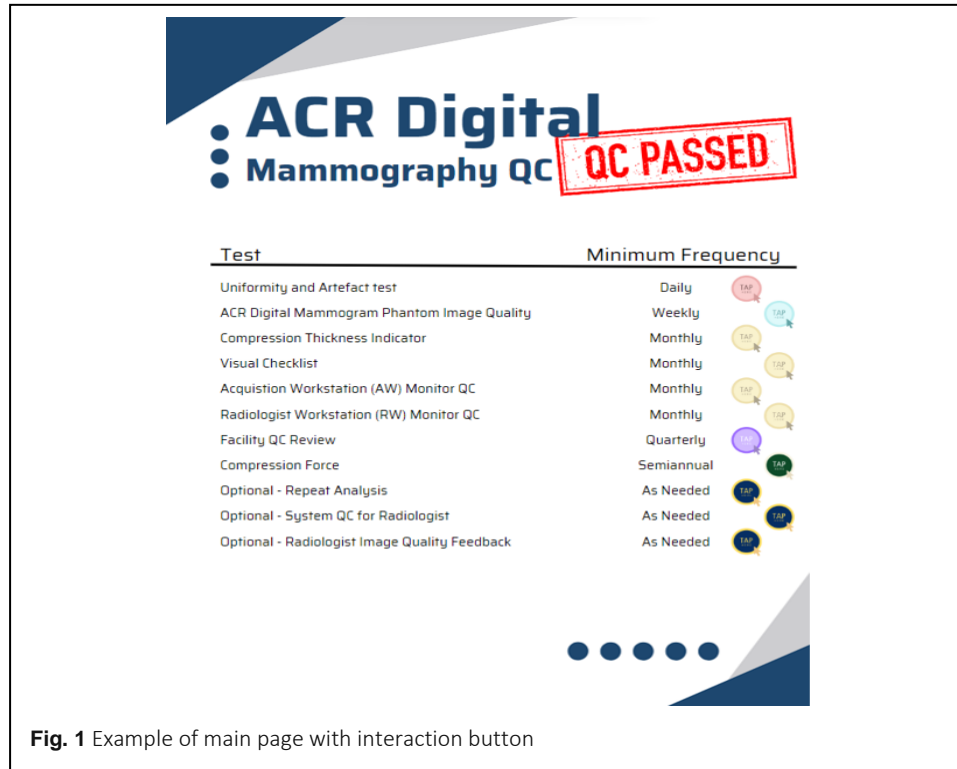


Fig. 1 Example of main page with interaction button

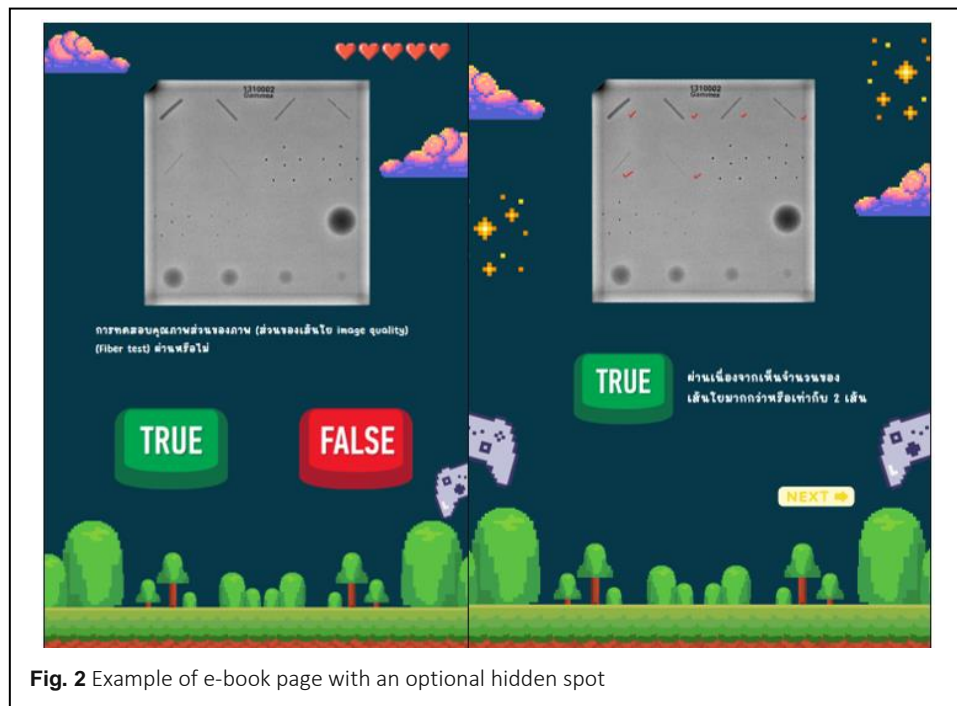
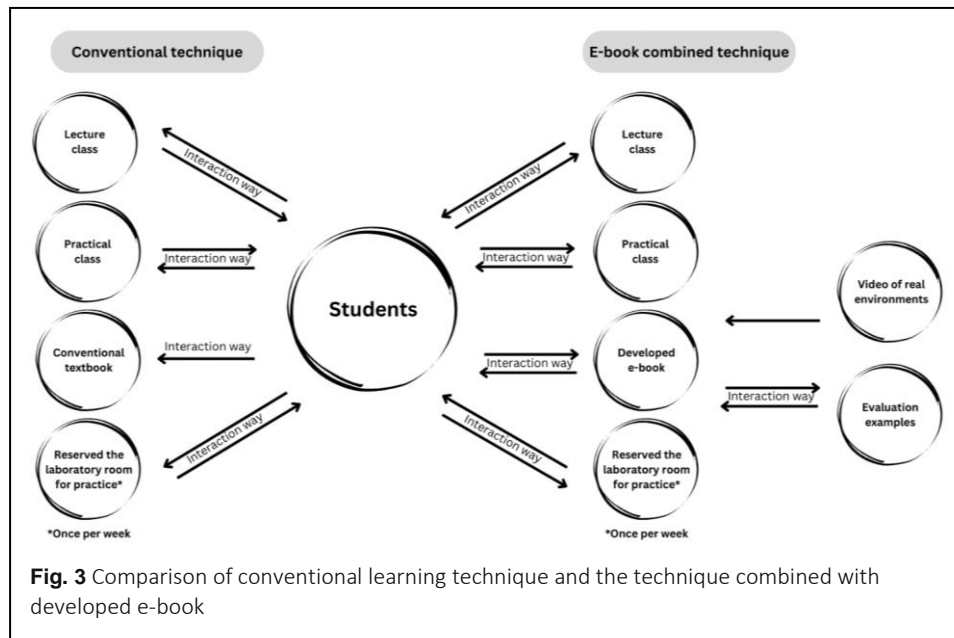


Fig. 2 Example of e-book page with an optional hidden spot



### Measurements of literacy level

The theory teaching was about 1 hour following with the practical teaching about 3 hours for each group. The interactive e-book was used as an extra feature only in the experimental class. Afterward, a student's literacy level was assessed using several tests same for both groups after the students attended the class immediately and 2 weeks later to evaluate the effect of e-book on self-study among the students. The tests used in this study were first checked and validated by the experts in the subject area; the content validity of a question item was proven by using content validity ratio (CVR). The results of the CVR on 20 questions got the +0.5 to +1 score which suggested that the questions were feasible. The Cronbach's Alpha formula was used to measure the reliability of the test. The alpha score for this test was 0.88. For the multiple choice test, the definitions, QC frequencies, QC devices, QC procedures and criteria evaluation were included in 20 questions representing the student's conceptual understanding. The questions consisted of a low to high difficulty levels which close to the formal university exam. The practical exam focused on basic daily QC of mammography machine, including the analysis of the QC results. Two raters attended the practical exam to rate a student score ranged from 1 to 5; having 1-, 2-, 3-, 4- and 5-point mean that the student can do 0-19, 20-39, 40-59, 60-79 and 80-100% of the daily QC procedures, respectively. The reliability of the inter-rater for this study using Cohen's kappa coefficient, was 0.80.

## Measurements of satisfaction level

The students in the e-book-using group were asked to rate their satisfaction with the mammography machine e-book in terms of theory/practice learning and the level of interest by using a 12-item questionnaire. The questionnaire covered the dimensions of “easily accessible information”, “good design”, “learning support in theory” and “practice benefits of using e-book”. Likert scale was applied to the evaluation with 5-level score for indicating the degree of satisfaction with the subjects, from “very dissatisfied” (1) to “very satisfied” (5) (Bertram, 2007; Pärn et al., 2017). An open-ended question for opinions from students was also included in the satisfaction survey.

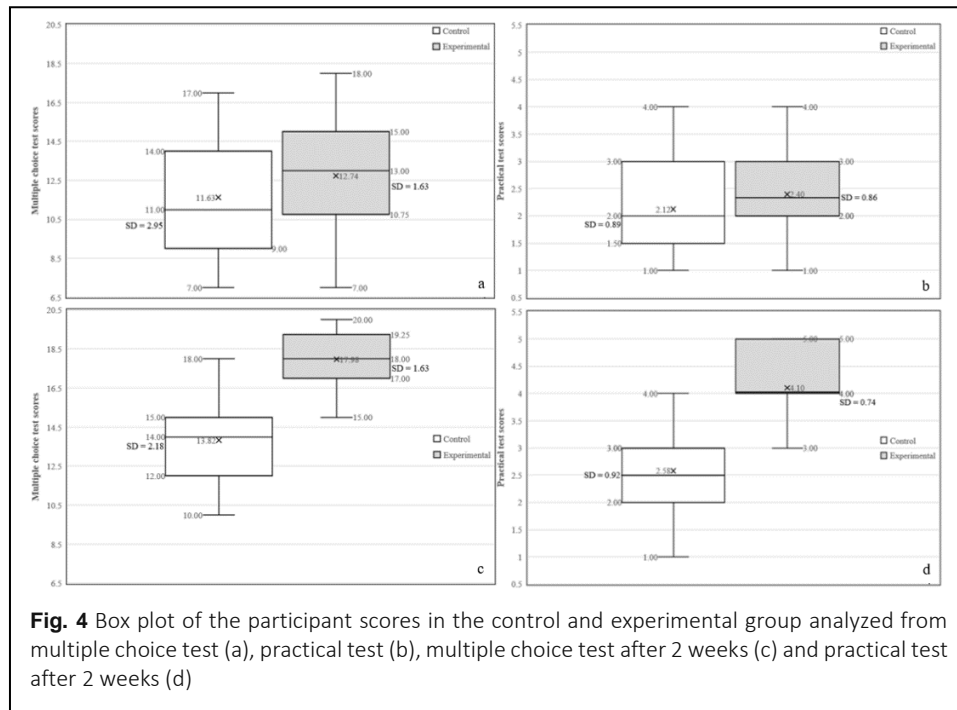
## Data analysis and interpretation

The data collected were quantitatively analyzed to identify that the e-book can improve knowledge, recognition and practical skill for mammography machine QC. The percentage difference (%Diff) of the test's score between the control and experimental groups was calculated (Equation 1) (Moonkum et al., 2023). Students pair t-test statistics were calculated to determine a significant difference in comparing the use of e-book with the regular technique. All statistical analyses were performed using OriginPro software at 95% confidence levels.

$$\%Diff = \left( \frac{Avg_{exp} - Avg_{con}}{Avg_{con}} \right) \times 100 \quad (\text{Equation 1})$$

## Results

The study designed was to find an improvement rate as a function of the mammography machine QC e-book. Our hypothesis assumed that student in the experimental group would show a better understanding and practical skills than the control group. The performance tests were carried out to measure the student's scores with multiple choice and practical tests to represent the concept understanding and practical skills, respectively. The data sets of maximum, minimum, averages and standard deviations (SD) values of the participants were reported. Figure 4a-4b show the scores of the control and experimental groups on the teaching date immediately after college hour. The results showed that the score from each group was slightly different which confirmed that the student in two groups has a similar knowledge level. Subsequently, the effectiveness of the e-book to improve self-study outside the classroom was measured after two-week later. The results indicated an increase in the student's mean scores on the multiple choice tests across the experimental group (17.98 versus 13.82 points) as shown in Figure 4c. The box chart in Figure 4d revealed that the overview of practical scores recorded from the experimental group was 4.10 points, which was higher than 2.58 points of the control group. In terms of SD, the lower SD for

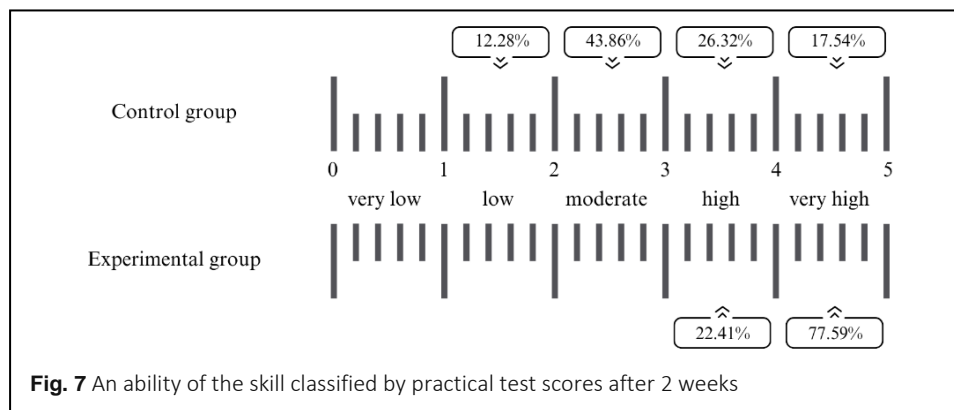
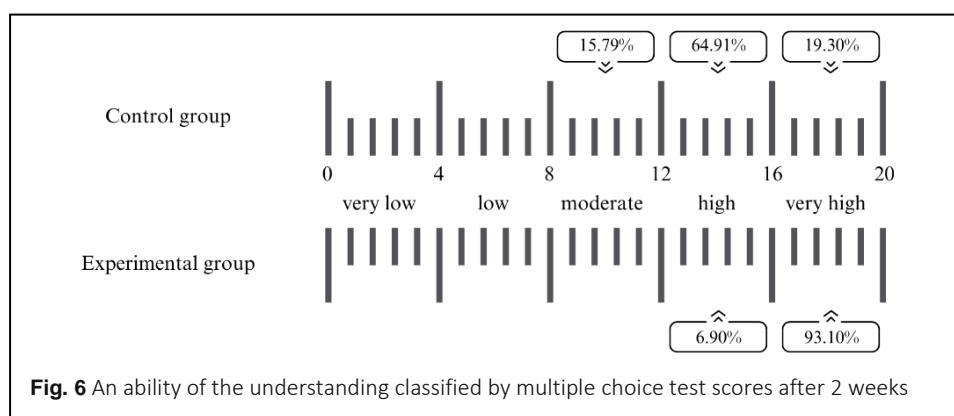
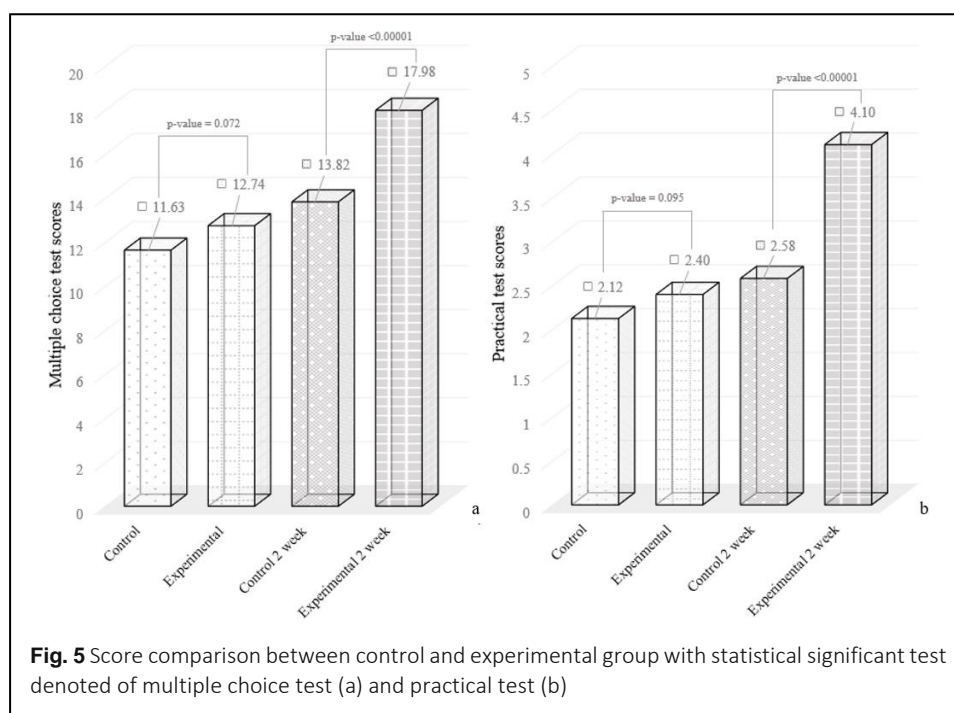


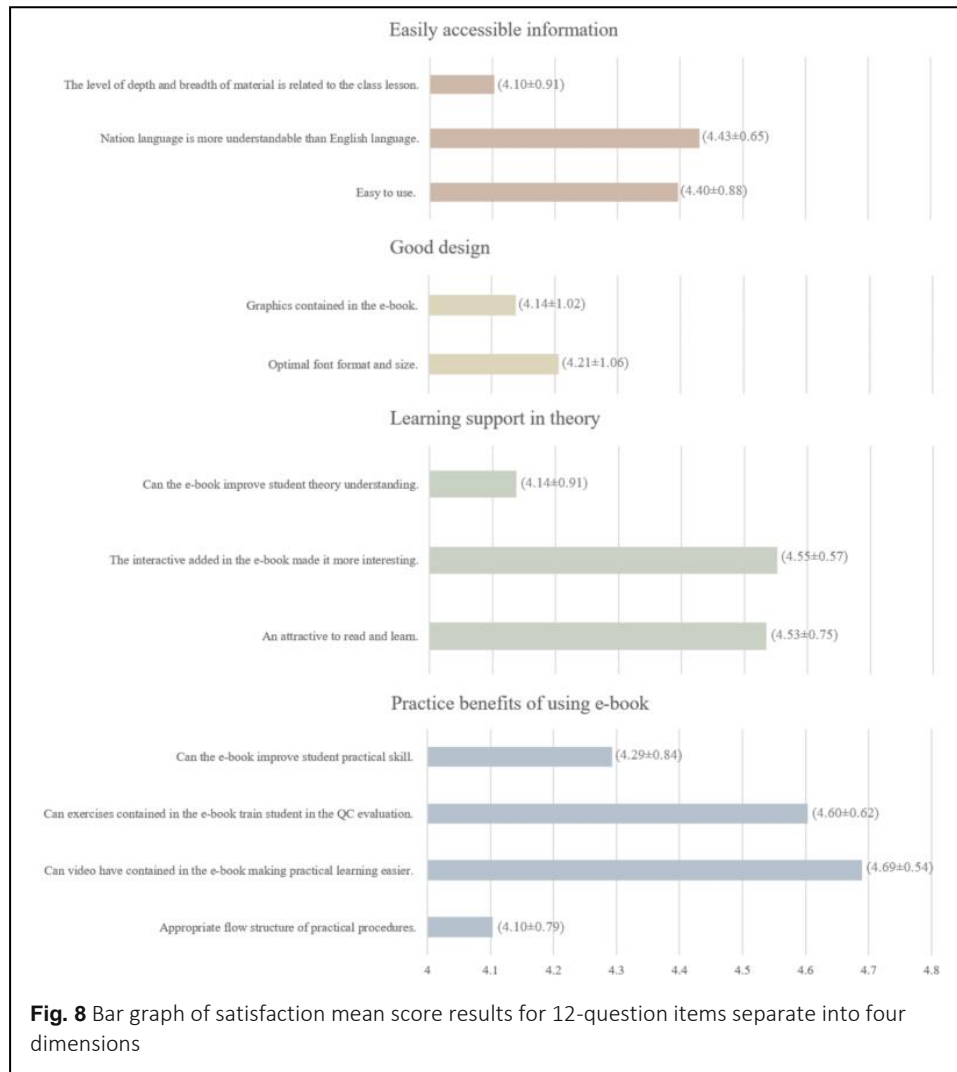
the experimental group was found which showed the minor distinction of the participants in the concept understanding and practical skill.

According to Figure 5, approximately 30 percentage difference of the choice score was noted while the percentage difference from the practice test was far greater around 59% between the two groups. The student t-tests were done to determine the significant differences between the control and experimental group's score. Non-statistically significant difference in class consequentially was found determined by p-value – 0.072 and 0.095 at  $p < 0.05$ . In contrast, it was found that the p-value  $< 0.00001$  which indicated the extremely significant differences at  $p < 0.05$  in after two weeks. So, it can be declared that the e-book promotes student's mastery of concepts and skill performance. A classification of the student's ability to understand the theory and perform the practical from the data obtained are shown in Figure 6 and Figure 7. For the control group students' understanding and skill, the majority of the control group students were in a high category (64.91%) and moderate category (43.86%), respectively. Meanwhile, the better ability was shown in the experimental group which was dominant in the very high category for both of the understanding (93.10%) and the skill (77.59%).

Figure 8 presents the satisfaction evaluation results of each of the four dimensions after classifying responses from 12 survey questions. The average score of the overview on the e-book was 4.35 – in the range of 3.50 to 4.49, indicating students' satisfaction. Referring to the diagram, the highest rated dimension was “practice benefits of using e-book” at 4.42 and the lowest rated dimension was “good design” at 4.17. Open-ended feedback showed







that the students thought the e-book was “get straight to the point”, “practice exercises are very helpful”, “interactive features are interesting” and “easy to review the lessons at dormitory”. Some improvement required were also suggested such as “need more exercise tests” and “should increase the image resolution”.

## Discussion

In this study, a teaching of mammography machine QC topic with conventional class technique and using an e-book as the additional supporting material in the third year of RT students were compared by multiple choice and practical tests. The main challenge of the new generation of the students is the influence of digital platforms on the students practice, communication and interaction (Hammarlund et al., 2015; Saripudin et al., 2022). They can be considered as digital natives which have a habit to spend time with their

smartphones or tablets which cause the less focus on the class period (Dunas & Vartanov, 2020; Sinaga et al., 2019). So, the teacher is responsible to provide some digital media beyond the conventional teaching to improve the learning efficiency. Agreeing with Astuti and Santosa et al.'s study, the learning process with appropriate supporting media provided can affect the learning outcomes of students (Astuti & Santosa, 2017). The new generation of students do not like a long description but prefer learning from more illustrations and get excited to solve questions in an interactive format. The e-book was chosen as the digital technology recently is highly improved, the touchscreen devices (i.e., mobile, tablet, etc.) make the use of e-book interesting and easier (Komarudin et al., 2017; Saripudin et al., 2022; Sinaga et al., 2019; Yalçintas Sezgin & Ulus, 2017). E-book are useful with an easy access; students can download the e-book to their digital devices which are available even when offline. Students will be able to decide the location and time for learning by themselves (Astuti & Santosa, 2017; Yee & Zainuddin, 2018). Additionally, several studies show the successful result of using e-learning tools to improve the learning process in healthcare professional fields including in practice (Gormley et al., 2009; Hammarlund et al., 2015; Hugenholtz et al., 2008; Morente et al., 2014). The e-book would be an effective learning support as it offers the available features for better qualities in graphic resolution, brightness, video show and interactivity compared to traditional book – which lead to more attractiveness in reading and learning activities (Astuti & Santosa, 2017; Komarudin et al., 2017; Zhang-Kennedy & Chiasson, 2016). The suitable designed e-book would be able to alter the students habit behavior to increase the intensity of reading by making them feel interesting through their interactivity and convenience (Hugenholtz et al., 2008; Schugar et al., 2013). Thus, the students should have a benefit from the e-book attractiveness that induces more fun in their learning environment. Consequentially, it can hold on to their concentration to spend more time reading the e-book without getting bored – that helps them to understand more in the content, superior than traditional reading. In this study, our students accepted that the designed e-book activated their interest, which can help them to achieve the learning academic goals – this is in line with the Ebied and Rahma's study (Ebied & Rahman, 2015). 81% of students mentioned that the optimal font format and size are comfort for the eyes and 91.4% stated that the e-book format is more attractive to read and learn than the textbook format. Flexibility in learning materials that learner can have faster, easier and opportunities for self-accessed anywhere and anytime is a key important benefit compared to the learning with only lecture mode. The strong support by Regmi and Jones' study also showed that students reading in their own time instead of fitting time in lecture rooms can gain more amount of detail information (Regmi & Jones, 2020).

Based on the literature reviews, we questioned that (1) Is it possible that in-house developed e-book could be an alternative learning media alter from the laboratory room for mammography machine QC? (2) What is the efficacy of using the e-book to improve

the exam score and practical skill? and (3) If the e-book can improve a student learning outcome which components in the e-book that served the most student satisfied? This study was started by a random selection of undergraduate RT students into two separated groups with a comparable initial knowledge condition. The concept understanding outcomes of students in the control and experimental groups were comprised of two tests data: immediately after class test data and two weeks later test data – which are multiple choice and comprehensive tests. The multiple choice test was chosen, as stated in Simkin and Kuechler's study, that the test was easy to assess and basic for analysis and comprehensive test is a standard test for practical skill in health science program in nation university (Simkin & Kuechler, 2005). The average scores of the two groups in the immediately test was closer to each other in 11.95 points for concept understanding and in 2.26 points for practice skill which did not reach the minimum standard level (lower than 60% or letter grade C). Through the t-test analysis of the first test data, there was a p-value more than 0.05 which indicated a non-statistically significant difference in the conceptual mastery and practical skills. The findings of this study suggested that the student participants had a similar knowledge background level. This is because the students did not have time to summarize their information yet and this result might express their lack of focus in the class. Additionally, the concept of science and practical skills normally need to recall and more activity after studying (Bencze, 2010). A slightly higher average score of the experimental group might be owing to their interest in the e-book provided, that would be superior in maintaining their focus in the class. Applying the familiar technology use in students' daily life such as an e-book to learning based material can help students to easily recall the concept. Interactive learning process through the specific designed e-book could encourage students to integrate their science knowledge to answer the questions (Komarudin et al., 2017). Therefore, the e-book provided by our study was separated into two sections of the concepts and practice of mammography machine QC. The multiple static modes of definition, pictures, graphs and criteria description were used for the conceptual part. Not only static modes represented, it also contained the dynamic modes such as a video and interactive button. We developed the e-book with several modes as the studies by Ainsworth and VanLabeke, Simbolon et al. and Sinaga et al. reported that the integration of various modes could support students to increase their cognition and skill than the use of single modes (Ainsworth & VanLabeke, 2004; Simbolon et al., 2017; Sinaga et al., 2019). Via the combined features, the students can understand the concept mastering in the field easier and enhance confidence in performing the task because the visual effects in line with the studies of Harjono et al. and Sumtsova et al. (Harjono et al., 2020; Sumtsova et al., 2018). In accordance with the argument of those studies, most of our students responded that the use of the e-book with integrated modes made practical learning easier (96.5%), the graphics used made more efficient to understand the concepts

(79.3%) and interactive buttons used made it more interesting to learn (96.5%). Based on the previous studies and our students' opinion, the e-book is proven to be a capable tool for learning supporter.

As expected, the students who received the e-book showed the improvement in their academic performance following the 2 weeks later tests. The students showed that they could get more correct answers for theory concept in the multiple choice test and increase scores for practical comprehensive in practical test compared to the first test. The improvement in understanding of mastery among students in the experimental group was greater than those of the control group as related to their practical performance. The research findings show a great improvement in the mean scores with the mean increased from 12.74 to 17.98 points and 2.40 to 4.10 points in multiple choice and practical tests, respectively. In the meantime, the control group student scores for each test showed only a slightly increase. More specific information including a strongly significant difference ( $p < 0.00001$ ) between the two student groups was observed in the second test. Moreover, the small value of the SD in the experimental group stated the similar cognitive domains of each student. Based on our results, it revealed that the e-book was an effective helping tool to make a significant impact on students learning process in their professional field. The information was similar to that of the studies by Morente et al. and Kibona and Rugina that the experimental group students received the significant benefit in their improved concept understanding from using the e-book which further affected their GPA (Kibona & Rugina, 2015; Morente et al., 2014). To review the practical lesson, the advantage of the e-book is that the students can learn the procedures of the basic QC with a video. There are many exercises expressed in the game features that help students to trial the practice concept from the first to the last step (Segal-Drori et al., 2013). The special activities of exercise is in the form of chosen answer. The students can select the button to answer the question, if the answer is correct then an explanation comment will appear. On the other hand, the incorrect answer will provide the "try again" audio. So, the students can get the self-reflection on their knowledge based on their mistakes which influenced them to improve themselves in mastery. Followed the e-book approach, the students were able to choose a suitable device for the QC procedure and make a quick and better decision on the QC analyzed process. The studies by Gormley et al. and Hugenholtz et al. experienced the usefulness of e-learning in clinical skills for medical and occupational health care students. These reports were a good agreement with the present study about the e-book provides more opportunities to access the various situation environments probably found in actual life. So, the impact of the e-book on the students appeared to have the professional necessary skills to complete the task (Gormley et al., 2009; Hugenholtz et al., 2008). Moreover, the research conducted by Adawiyah et al. corresponded well that the e-book has the ability to improve student skill. Video of basic QC procedure and exercises were

the most attractive modes in the e-book (Adawiyah et al., 2019). Most of the students (96.6%) admired the summary of the procedure in the video, of which taking only a few minutes to watch is very helpful to increase their confidence in performing the practical test. Also, 93.1% of the students said the exercises can make them familiar to the mammography machine QC results displayed pattern and the interactive form of the exercises made them more interested than working on static exercises. Based on the students' perspective of the e-book suggested that the interactive and dynamic design can improve the understanding and skill of students. Thus, the improvement in student learning outcomes could achieve through the use of the e-book which was more important in the practice special needs education lesson (Williams et al., 2015). Therefore, the excellent feature of the e-book with integrated modes showed the positive impact and high potential for assisting students to easily understand the concepts and reduce their cognitive loss compared to traditional learning process. The analysis of the results found that the e-book was effective to improve the mastery of mammography machine QC in third year undergraduate students. These findings were supported with previous research by Darlen et al., Harjono et al., and Morente et al., that indicates the enhancement of the student's concept understanding and allows them to link their knowledge for improving the practice skill through solving tasks of simulation situation provided based on real scenarios by integrating the e-book in new era learning process (Darlen et al., 2015; Harjono et al., 2020; Morente et al., 2014).

The percentage difference between the two student groups in the practical test results was greater than that of the multiple choice test. It might be due to the big difference in learning support materials between theory and practice in the control group in which the students can read and learn from conventional instruction media or recommendation textbook while reviewing the practical concepts only in text descriptive instruction with less training, the students might not be able to connect between theory and practice, which leads to the low self confidence in the testing time. It is a good agreement with Asyari et al.'s study that the learning process can stimulate the students to integrate their knowledge to perform the practical skills and analysis tasks (Asyari et al., 2016). The less exercises and practice time can cause more fear to errors in the students. So, the students in the experimental group expressed more strong confidence than the control group when performing the practical test. This confirmed the results of several previous research that using the e-book learning media as an independent learning course can improve the depth of understanding and the competency to be mastered in their professional fields (Astuti & Santosa, 2017; Johnson & Buck, 2014). The second reason was the multiple choice questions, the students had the chance to guess the right answers much more than the practical tests (Harjono et al., 2020). Another factor that assumed to affect student test scores was the design for mobile devices based is easily to carry and can be read anywhere anytime they desire. In general, the

students have to reserve the laboratory room for practice on the QC procedures with limited number of machines and time period compared to the number of students. So, the e-book can offer the student opportunity to have more practice time apart from the traditional laboratory style. That is why the test score from the experimental group was higher than the control group.

In the satisfaction ratings, the most dominant rating was in the “very satisfied” category with the maximum average rating at 4.69 and the lowest average rating at 4.03 from 5 full scores, as similar to the finding of Radović et al.’s study (Radović et al., 2020). Several improvements were still needed in the development issue including the images of the e-book must be enhanced in image quality and more exercise samples. However, the overall aspect of the present study was considered to be sufficient with some improvements (Saripudin et al., 2022). With the result, it can be concluded that the overview towards the e-book was interested and helpful to students understanding and practical concepts. Based on the open-end opinion surveys conducted, several of the students said that the video and example tests were excellent in their learning process. Further development of the e-book needs to update according to the students’ suggestions. In addition, we were aware that a different version of the e-book would be needed for the different types of learning between theoretical and practical purposes. Future studies should be designed for a better improvement in theory understanding.

## Conclusion

In conclusion, the results of this study suggest that the attractive features of the e-book can be an effective supporting tool for undergraduate RT students. Due to the new generation of students have a different expectation and behavior with familiar to the technologies, the e-book should be able to help students focus on their lesson by using technology learning environments that they prefer. Appropriate e-book designing pattern with multiple static and dynamic modes showed a better potential for promoting the students in RT expertise to develop conceptual understanding and practical skill. The graphics, video and interactive game elements allowed students to learn more interestingly, easier understand the concept and make better practical performance. The significant differences in the concept mastery and the practical skills between the students in the control and experimental groups indicated the usefulness of the e-book in health sciences education. The satisfaction level of the e-book as a whole component from the majority of the students were agreed in the “very satisfied” category. However, some elements needed to be improved including the increase of image resolution and provision of more exercise tests for the future development.

### Abbreviations

RT: Radiological Technologist; QC: Quality Control; ACR: American College of Radiology; CVR: Content Validity Ratio; SD: Standard Deviations.

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### Authors' contributions

NM, MM and KS performed data analysis and drafted the initial manuscript. GT provided insight, conducted the log data analysis and edited the manuscript. All authors read and approved the final manuscript.

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### Availability of data and materials

Please email to the corresponding author to get the data.

### Declarations

### Competing interests

The authors declare that they have no competing interests.

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