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Chatbot-facilitated Nursing Education: Incorporating a Knowledge-Based Chatbot System into a Nursing Training Program

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ABSTRACT: Conventional nursing courses have solely adopted lecture-based instruction for knowledge delivery, which tends to lack interaction, rehearsal, and personalized feedback. The development of chatbot technologies and their broad application have provided an opportunity to solve the abovementioned problems. Some knowledge-based chatbot systems have been developed; however, it is still a challenging issue for researchers to determine exactly how to effectively apply these chatbot technologies in nursing training courses. Intending to explore the application mode of chatbot technologies and their effectiveness in nursing education, this study integrated a knowledge-based chatbot system into the teaching activities of a physical examination course, using smartphones as the learning devices, and guiding students to practice their anatomy knowledge in addition to analyzing their learning efficacy and pleasure. A quasi-experiment was conducted by recruiting two classes of university students with nursing majors. One class was the experimental group learning with the knowledge-based chatbot system, while the other class was the control group learning with the traditional instruction. Based on the experimental results, the knowledge-based chatbot system effectively enhanced students' academic performance, critical thinking, and learning satisfaction. The results indicate that the application of chatbots has great potential in nursing education.

Keywords: Chatbots, Knowledge-based chatbot system, Nursing Training, Mobile learning

1. Introduction

Physical examination is the most common method used for the diagnosis of diseases, and it is the basic foundation of understanding the physiological structures and their characteristics. Human Anatomy refers to the program that systematically introduces each of the human organ systems, such as the nervous system and muscle distribution (Kurniawan & Witjaksono, 2018). It aims to cultivate students' concepts of human organ systems from both macro and micro perspectives, and enable them to have the ability to combine physical examination in the workplace, that is, performing accurate inspection, auscultation, palpation, and percussion. As such, they will be able to gather the physical examination data of inpatients and give it to doctors for further assistance and accurate diagnosis of diseases (Narula et al., 2018). Intending to offer students a sense of authenticity, the traditional training in Medical Schools has been supported by voluntary body donation to assist teachers in guiding medical students to have a deep understanding of the structures or systems of different organs, nerves, and muscle distribution in the human body.

Nowadays, challenges have been posed to medical study because of the rapid changes in and advancement of medical knowledge owing to new diseases and medicines (Innocent, 2016; Rather et al., 2017). With the aim of helping students to make correct decisions when dealing with real cases, it is necessary to engage them in authentic problem-solving contexts (Hwang & Chang, 2020; Trasmundi & Linell, 2017). Accordingly, the notation of "precision medicine" has been proposed; this refers to the process of making precise medical decisions based on detailed and well-analyzed information (Kim, 2019). Cook et al. (2018) referenced the analysis of empirical evidence in precision education and formulated the best strategy to intervene in some students' learning so as to enhance their learning achievements including diagnosis, prediction, counseling, and prevention. One of the basic competences for conducting prevision medicine is physical assessment. No matter serving in which types of medical institutions, medical staffs are requested to learn and pass the exam of physical assessment before entering the workplace.

Researchers have further indicated that one potential solution to this aim is to apply chatbot technologies with the provision of personalized learning guidance and feedback in nursing training programs (Chang et al., 2021; Hernandez, 2019; Tsai et al., 2020). It is a possible direction which fits the goals of precision education (Tsai et al., 2020). Several previous studies have further reported the importance of guiding students to think in depth (e.g., why this happens and how to deal with a problem?) and to search for additional information to complete an assessment-oriented learning tasks; for example, Chu et al. (2010) developed employed a two-tier test approach in a mobile learning context of a natural science course; Chou et al. (2007) also used the two-tier test to guide students to think in depth in the learning activities related to digital copyright laws; Hwang and Chang (2011) adopted a formative assessment approach in a mobile learning activity of an elementary school social studies course. Although such assessment-based approaches have been recognized to be effective, the students were generally "guided to think" rather than "encouraged to explore and make decisions." To this end, many scholars have attempted to apply chatbot technologies to boost students' active learning behaviors as well as enhancing their learning efficacy (Tegos & Demetriadis, 2017). For instance, Beaumont (1994) applied a human anatomy tutorial system in the medical courses in a university, while Tegos et al. (2016) applied a chatbot-based agent which permitted learners to practice making decisions in a virtual learning environment, and found the approach effective in terms of improving students' learning performance in an "academically productive talk" course.

As mentioned in the above literature, educational technology researchers have started examining how the usage of chatbot technologies can boost the efficiency of teaching and learning. Simultaneously, learners can connect the learned knowledge with the actual problems encountered in their practice through the use of chatbot systems. For most nursing students, physical examination, which is a complex procedure aiming at making judgment on a patient's physical status based on the data collected by observing and inquiring the patient as well as the medical test results, has been recognized as an important and challenging task. The nursing students need to have accurate physiological knowledge as well as the competences to execute inspection, auscultation, percussion, and palpation to correctly complete a physical examination task (Narula et al., 2018). With the aim of solving these problems, this research attempted to integrate a knowledge-based chatbot system into a physical examination course and to overcome the shortcomings of traditional teaching in order to improve students' learning efficacy. A knowledge-based chatbot system refers to the chatbot that communicates with users based on the expertise stored in a knowledge base (Kumar, 2020). Several previous studies have reported that the use of knowledge-based systems to provide learning supports or guidance in making decisions has great potential in improve students' critical thinking (Jerome et al., 2019) and learning satisfaction (Chen, 2012). Intending to prove the effectiveness of this model, this experiment aimed to answer the following questions:

- Does the integration of the knowledge-based chatbot system into the learning mode of physical examination facilitate students' learning achievement when compared to conventional teaching?
- Does the integration of the knowledge-based chatbot system into the learning mode of physical examination improve students' critical thinking when compared to conventional teaching?
- Does the integration of the knowledge-based chatbot system into the learning mode of physical examination effectively improve students' learning satisfaction when compared to conventional teaching?

2. Literature review

The term chatbot refers to a computer application or system which interacts with users in a chat-based mode using natural language (Hwang & Chang, 2021; Smutny & Schreiberova, 2020). There are several roles of chatbots such as information or knowledge providers (Lan, 2020), convention partners (Shawar, 2017), interactive agents (Erickson & Kim, 2020), learning partners (Fryer et al., 2019) and tutors (Pérez et al., 2020). For example, when users ask some questions or raise new topics, chatbots respond with natural language-like statements based on the data or knowledge stored in the database (Balsmeier, 2018; Smutny & Schreiberova, 2020). Researchers have indicated that such a natural language-based interactive mode makes chatbots highly accepted by most people (Chang & Tseng, 2019; Shorey et al., 2019). Stuij et al. (2020) further stated that the use of chatbots could improve learners' communication skills.

In the past decade, researchers have applied chatbots to several application domains, including learning about employability issues (Wang et al., 2021; Ward et al., 2016), social networks (Pérez-Soler et al., 2018), specific languages (Pérez-Soler et al., 2019), learning Chinese (Chen et al., 2020a), basic computer learning (Yin et al., 2020), and healthcare and smart home domains (Valtolina et al., 2020). For example, Samarakou et al. (2018) found that the usage of chatbots in an informatics course in a university can provide learning opportunities for diagnosis, guidance, and assessment, which resulted in improvements in the students' learning efficacy. Lin and Chang (2020) applied a chatbot in a post-secondary writing course and found that the approach improved the students' writing quality more than traditional instruction did. It can be predicted that advances in wireless networks, sensing technology, and mobile technology will further encourage the use of chatbots in various applications, as indicated by Yin et al. (2020).

Researchers have also tried to employ chatbots in different ways based on the educational objectives and contexts (Abbasi & Kazi, 2014; Van Seters et al., 2012). For instance, Xin et al. (2020) proposed a conceptual model to train students to solve problems with learned knowledge, through the means of analyzing the subjective materials and conducting tests with the provision of learning suggestions, aiming at better assistance for them to combine the knowledge learned from textbooks. Thirumalaraju et al. (2019) proposed the installation of an application on smartphones, and suggested applying chatbot technologies to online health education, in particular enabling patients to receive education on personal hygiene and personal healthcare, as well as enabling them to make relevant decisions to manage their health goals. The implementation of online education for healthcare and obesity management in the United States is an example that illustrates this idea. Moreover, Song et al. (2019) suggested an interaction between online courses, chatbot evaluating strategies, and relevant academic content stated in the literature. The course coordinators can flexibly maintain the content of academic courses, conduct virtual conferences, and provide announcements. The results have shown that participants agree unanimously with the benefits of applying chatbots to online courses.

In addition to the user interface, scholars have emphasized the key to the value of chatbots, that is, the information or knowledge included in the chatbot systems (Shum et al., 2018; Smutny & Schreiberova, 2020; Tegos & Demetriadis, 2017). For example, Beattie, Edwards, and Edwards (2020) indicated that the positive impacts of chatbots in education highly rely on the quality and quantity of the information and knowledge included. This implies the importance of incorporating an effective knowledge or data collection mechanism in chatbots (Sheth et al., 2019). A knowledge-based chatbot is a chatbot system that includes a mechanism to extend the quality content in the database (Kapočiūtė-Dzikienė, 2020). Knowledge-based systems emphasized the use of knowledge provided by domain experts to solve problems (Zhang et al., 2017). Researchers have indicated that the knowledge base is the key to enable computer systems to imitate intelligent behaviors of human (Hwang et al., 2020a; Yulianto et al., 2020). Some researchers have predicted that chatbots can even play the role of "smart teachers," "smart learning partners" or "smart students" in educational settings if domain knowledge can be properly acquired, organized and employed in chatbots using knowledge acquis ion or machine learning approaches (e.g., deep learning) (Darshan Singh et al., 2018). For example, Smutny and Schreiberova (2020) reported the trends of using chatbots to analyze individual students' learning status and provide personalized learning paths, user interfaces and learning content. The advancement of wireless communication and sensory technology has further provided an environment for applying chatbots in diverse ways, and has led to the innovative thinking of educational researchers in implementing chatbots in education studies, such as guiding students to solve problems in the real-life environment with the support of chatbot applications (Chang & Hwang, 2018). As a result, the use of chatbot technologies has gradually changed the role of teachers in school settings. Teachers therefore have more time to guide students to think, practice and apply knowledge based on individual students' needs. This can assist teachers in improving the quality of their teaching (Hsu, 2020).

It can be seen that education has become more humane and personalized, which can enhance students' learning achievement (Chang et al., 2018). There is, therefore, an increasing need to consider individual differences in developing digital learning systems and to analyze the applications of chatbots in education (Yin et al., 2020). Educational developers have not only engaged in innovative research and teaching, but have also adopted technologies to help students learn efficiently in professional training without being limited by location or time through an integration of cross-field cooperation (Tsai et al., 2020). This research, therefore, applied a knowledge-based chatbot system to improve university students' learning efficacy in a physical examination course.

3. Experimental design

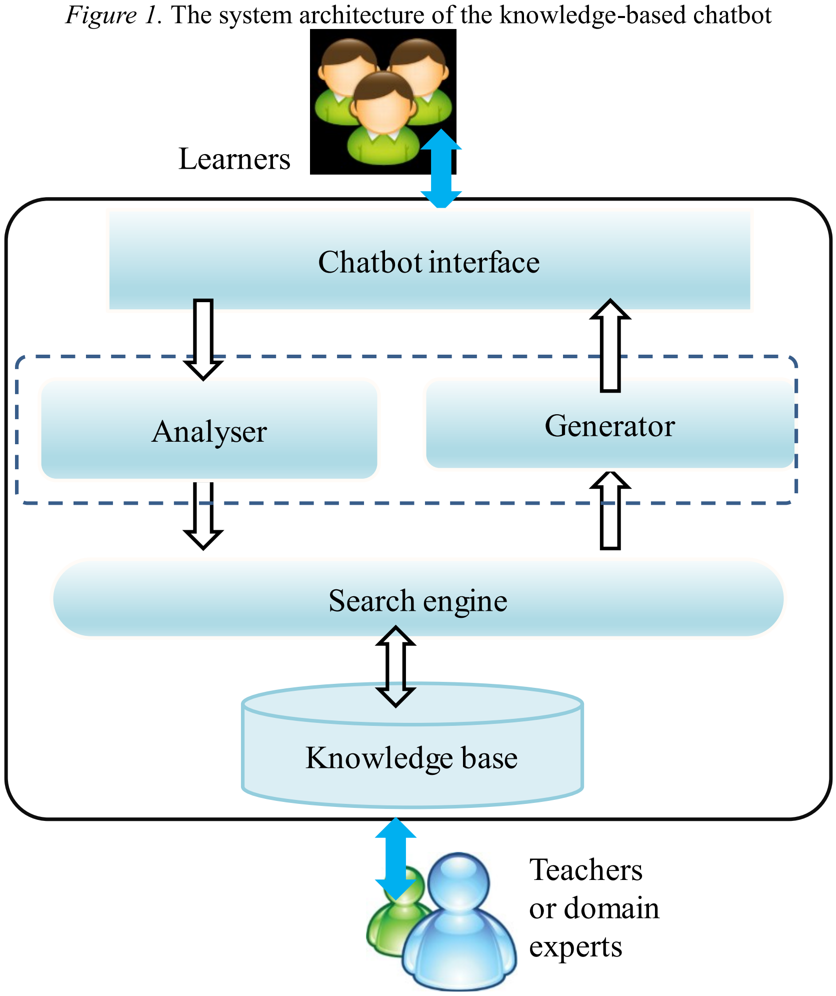
3.1. Participants

This research intended to show the effectiveness of a knowledge-based chatbot system in a nursing school in Taiwan by allowing students to attend training on physical examination, which is a compulsory course for the basic care in nursing schools and hospitals, and a necessary component of nursing training. Intending to evaluate the effectiveness of the proposed method, this study included an experimental group and a control group. A total of 32 nursing students with an average age of 21 participated in this study, with 16 students in the experimental group learning with the knowledge-based chatbot system, and the other 16 students in the control group learning via conventional teaching of physical examination. In order to compare the academic performance, critical thinking and learning satisfaction of the students in the two groups, they were asked to take a pre-test and complete a pre-questionnaire.

3.2. The knowledge-based chatbot

A knowledge-based system refers to the systems that make decisions or provide assistance based on the expertise stored in a knowledge base (Chen et al., 2020b; Hwang et al., 2020; Saura et al., 2019). The expertise in the knowledge base could be domain knowledge as well as experts' experiences of making decisions on different cases (Abbas et al., 2021; Gil et al., 2019; Hwang et al., 2020b). With the aim of educating students about Human Anatomy, this research adopted a knowledge-based system named "Anatomy Quiz," which was developed by Alexander Streuer (see https://is.gd/b6j77n). "Anatomy Quiz" uses the concepts of the tree searching algorithm and rational agent to establish a medical knowledge database. This knowledge-based system has 56 courses and 833 anatomical structures including anatomical knowledge of the skeleton, muscles, and organs. As the original "Anatomy Quiz" system is a knowledge based system, a chatbot interface was provided in the present study to enable the students to use the knowledge base in an interactive way, as shown in Figure 1. When a student talks to the chatbot, the "Analyzer" interprets the sentences submitted by the student, and searches for the relevant information from the knowledge base. The "Generator" then summarizes and organizes the searched information, and replies to the student.

Figure 1. The system architecture of the knowledge-based chatbot



This knowledge-based chatbot provides three different interactive learning models: (1) selecting and marking anatomical structures; (2) providing correct professional vocabulary such as *humerus*; and (3) making a diagnosis of the tagged anatomical structure, as shown in Figure 2.

Students can learn professional vocabulary from each system and make a diagnosis of the tagged anatomical structure through "Anatomy Quiz," thus increasing the interactivity of their learning. Moreover, they can repeatedly take the quiz to familiarize themselves with the knowledge of anatomical structures such as bones, muscles, and organs. During the learning process, the knowledge-based chatbot system guides the student in the learning tasks related to the selected topic, and in answering a series of questions. If the student makes a correct decision or choice in the specified time, the record is updated, as shown in Figure 3; otherwise, the system provides hints or complementary materials as well as calculating the time the student spent on the task and updating the record.

Figure 4 shows the learning scenario of using the knowledge-based chatbot system to learn via smartphones. One of the learning tasks was to determine the type of heart conditions based on the patient's' systolic heart murmurs. The students can interact with the chatbot to find evidences to support their assumptions.

Figure 2. User interface of the knowledge-based chatbot system

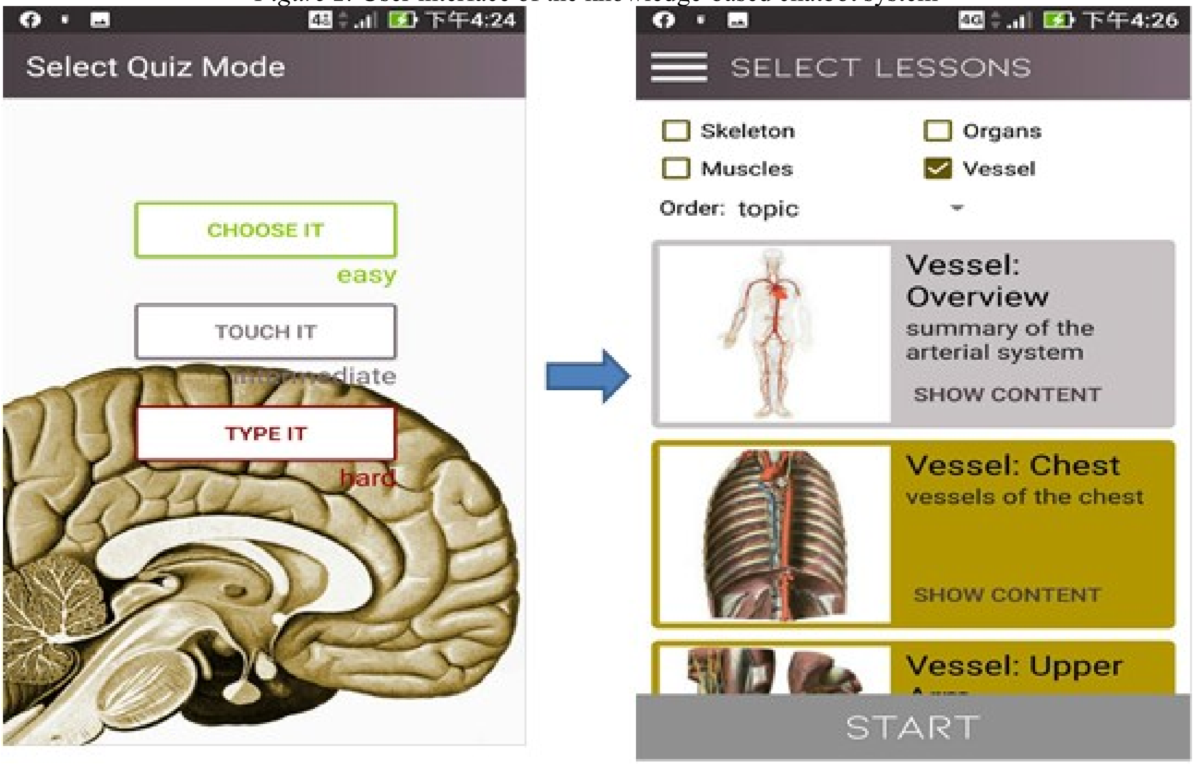


Figure 3. Interactive screen of the knowledge-based chatbot system

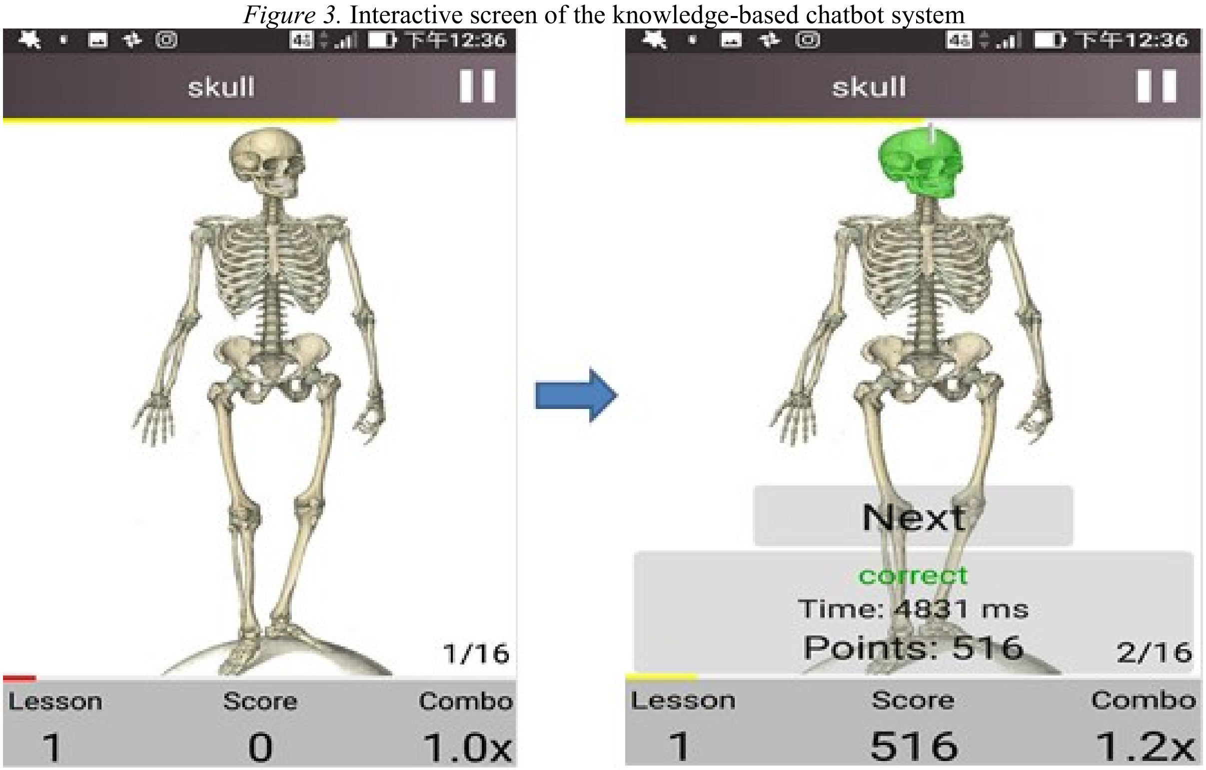
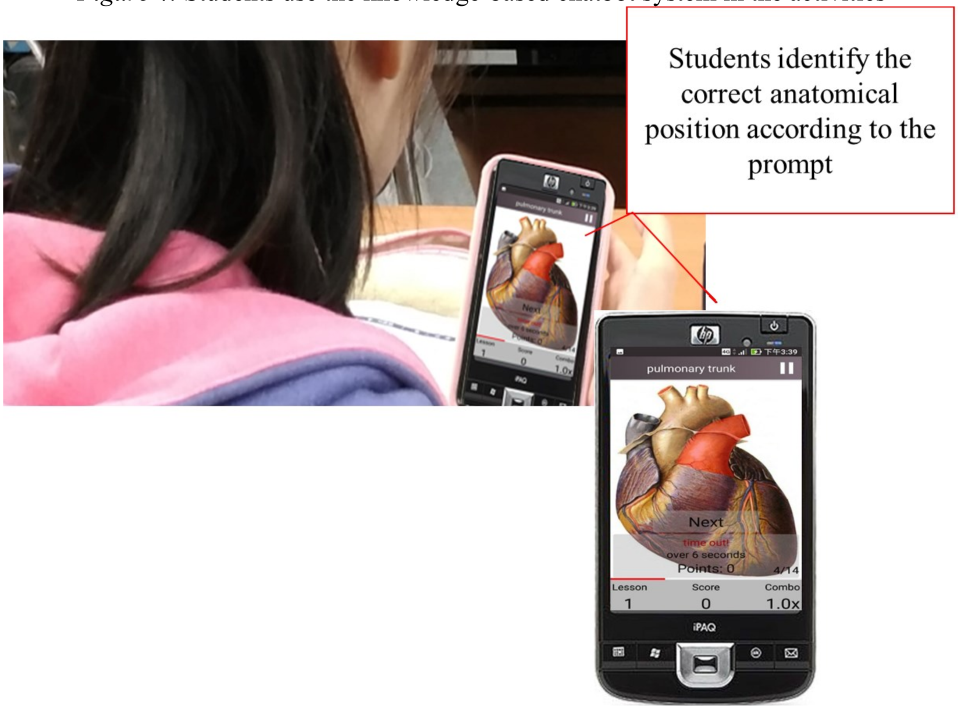


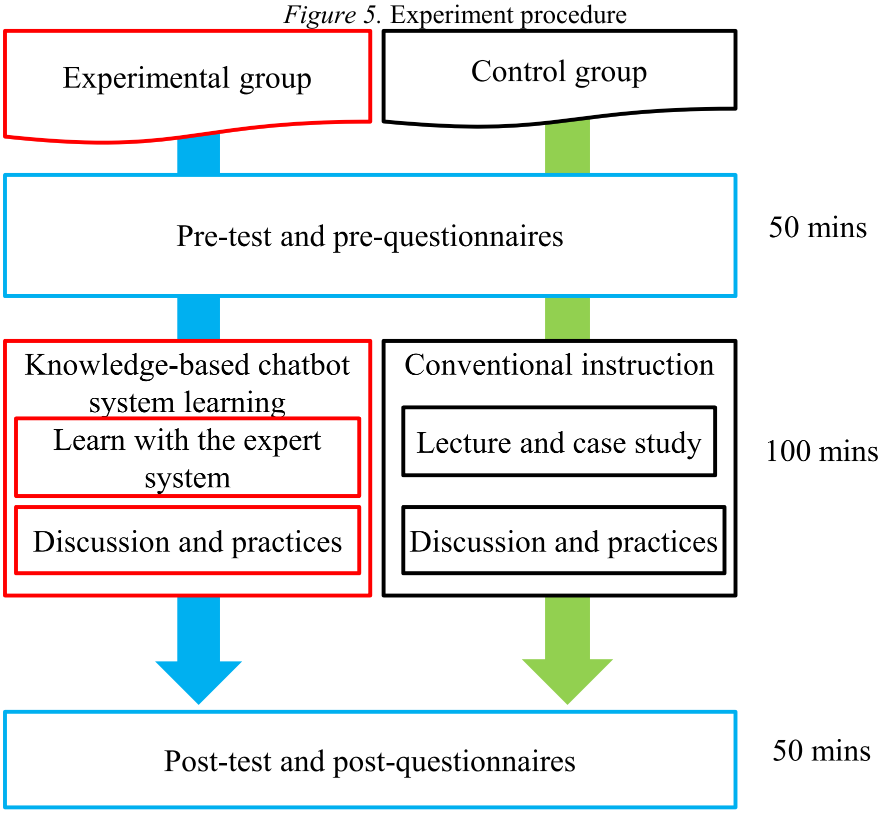
Figure 4. Students use the knowledge-based chatbot system in the activities



3.3. Experimental process

Figure 5 shows the experimental procedures illustrating the synopsis. This experiment consisted of four lessons of 50 minutes each, with a total of 200 minutes. Before the start of the experiment, the teacher introduced the physical examination course and illustrated the content of the activities. Subsequently, the students took the pre-test and completed the pre-questionnaire relating to critical thinking and learning satisfaction to measure the prior knowledge they had already learned and their feelings before the activities.

Figure 5. Experiment procedure



During the learning stage, the experimental group applied the knowledge-based chatbot system to learn the course content related to physical examination. For example, in one of the body assessment units, the cardiac assessment, the students not only need to understand the location of the four chambers of the cardiac anatomy, the location of the four chambers of the heart, the left atrium (LA), the right atrium (RA), the left ventricle (LV) and the right ventricle (RV) as well as the blood vessels, but also need to make judgments on different cases of physical examination to distinguish abnormal heart murmurs by seeking help from the knowledge-based chatbot.

On the other hand, the conventional teaching was applied to the control group, that is, the teachers illustrated the teaching content of Human Anatomy using relevant images and videos. The learning content of both groups was the same. During the stage of practice and discussion, the two groups of students could pose questions relating to physical examination and discuss them with their teachers or classmates. They were guided to use the knowledge they had learned to deal with the physical examination cases provided by the teacher; moreover, they were encouraged to discuss their case decisions or treatments, such as inspection, auscultation, percussion, and palpation, with their peers.

After the learning activity, the students completed the post-test and post-questionnaire relating to critical thinking and learning satisfaction.

3.4. Measuring instruments

This research evaluated students' nursing concepts as well as the decision-making or inference performances using 10 cases in the form of multiple-choice questions with a total score of 100. The pre-test and post-test were similar items with different cases. The questions were designed by two teachers who have taught nursing courses for more than 10 years. For example, one of the questions was related to the physical examination of the patient: "For a patient with the starting point of heart rhythmic pulsation is located at: (A) sinoatrial node (B) atrioventricular node (C) left atrium (D) left ventricle." The correct answer is (A) sinoatrial node. Another question was "During the auscultation of heart sounds, if clicks are found in the middle or late systole, which of the following conditions may be presented? (A) aortic regurgitation (B) aortic valve stenosis (C) mitral valve prolapse (D) ventricular septal defect." The correct answer is (C) mitral valve prolapse.

The critical thinking scale was proposed by Hwang and Chen (2017). It consists of five items, such as "I find myself pausing regularly to check my comprehension" and "I ask myself how well I accomplish my goals once I am finished." A 5-point Likert scoring scale was adopted and its Cronbach's α value was .83.

The learning satisfaction scale was proposed by Chu et al. (2010). It is composed of nine items, such as "The guidance provided by this system is helpful to me in observing the differences within the target learning objects." and "When using this system, I learned how to observe the target learning objects from new perspectives." A 5-point Likert scoring scale was adopted in the measure. Its Cronbach's α value was .91.

4. Experimental results

4.1. Learning achievement

This study used academic performance in the pre-test as the covariate, and academic performance in the post-test as the dependent variable. The Levene's test revealed that the homogeneity assumption was confirmed with $F(1, 30) = 0.66$ ($p > .05$). In addition, the verification did not violate the assumption of regression homogeneity ($F(1, 28) = 0.17$ ($p > .05$). ANCOVA was used for the post-hoc analysis in the scores given to the two groups. Table 1 shows the ANCOVA results of the two groups with $F(1, 29) =15.08$ ($p < .001$), indicating that the knowledge-based chatbot system (Mean = 87.90; SD =11.33) had a better effect when compared with conventional teaching (Mean = 62.32; SD = 14.95). The adjusted values of the experimental group and the control group were 86.77 and 63.45 respectively, indicating that the knowledge-based chatbot system could effectively enhance students' academic performance when compared to conventional teaching. Besides, the correlation coefficient (η^2 =0.342) was greater than 0.138, indicating that representing the knowledge-based chatbot system had a great impact on students' academic performance. In other words, the knowledge-based chatbot system could effectively enhance students' academic performance.

Table 1. ANCOVA of learning achievement by comparing the experimental and control groups

Group	N	Mean	*SD*	Adjusted mean	Std. error	*F*	η^2
Experimental group	16	87.90	11.33	86.77	3.83	15.08^{***}	.342
Control group	16	62.32	14.95	63.45	3.83		

Note. *** $p < .001$.

4.2. Critical thinking

This study used critical thinking in the pre-test as the covariate and critical thinking in the post-test as the dependent variable. The Levene's test revealed that the homogeneity assumption was confirmed with $F(1, 30) = 0.002$ ($p > .05$). In addition, the verification did not violate the assumption of regression homogeneity ($F(1, 28) = 0.65$ ($p > .05$). ANCOVA was used for the post-hoc analysis of the scores given to the two groups. Table 2 shows the ANCOVA results of the two groups $F(1, 29) = 14.06$ ($p < .001$), indicating that the knowledge-based chatbot system group (Mean = 4.07; *SD* = 0.65) had better critical thinking when compared with the conventional teaching group (Mean = 2.83; *SD* = 0.68). The adjusted values of the experimental group and the control group were 3.99 and 2.92 respectively, indicating that the knowledge-based chatbot system could effectively enhance students' critical thinking when compared to conventional teaching. Besides, the correlation coefficient ($\eta^2 = 0.327$) was greater than 0.138, representing that the knowledge-based chatbot system had a great impact on students' critical thinking. The experimental results indicated that the knowledge-based chatbot system could effectively enhance students' critical thinking.

Table 2. Results of ANCOVA on students' critical thinking

Group	N	Mean	*SD*	Adjusted mean	Std. error	*F*	η^2
Experimental group	16	4.07	0.65	3.99	0.19	14.06^{***}	.327
Control group	16	2.83	0.68	2.92	0.19		

Note. *** $p < .001$.

4.3. Learning satisfaction

This study used learning satisfaction in the pre-test as the covariate, and learning satisfaction in the post-test as the dependent variable. The Levene's test revealed that the homogeneity assumption was confirmed with $F(1, 30) = 0.95$ ($p > .05$). In addition, the verification did not violate the assumption of regression homogeneity with $F(1, 28) = 0.27$ ($p > .05$). ANCOVA was used for the post-hoc analysis of the scores given to the two groups. Table 3 shows the ANCOVA results of the two groups $F(1, 29) = 20.66$ ($p < .001$), indicating that the knowledge-based chatbot system group (Mean = 4.19; *SD* = 0.72) had better learning satisfaction when compared with the conventional teaching group (Mean = 2.83; *SD* = 0.68). The adjusted values of the experimental group and the control group were 4.20 and 2.83 respectively, indicating that the knowledge-based chatbot system could effectively enhance students' learning satisfaction when compared to conventional teaching. Besides, the correlation coefficient ($\eta^2 = 0.416$) was greater than 0.138, representing that the knowledge-based chatbot system had a great impact on students' learning satisfaction. The experimental results indicated that the knowledge-based chatbot system could effectively enhance students' learning satisfaction.

Table 3. Results of ANCOVA on students' learning satisfaction

Group	N	Mean	*SD*	Adjusted mean	Std. error	*F*	η^2
Experimental group	16	4.19	0.72	4.20	0.19	20.66^{***}	.416
Control group	16	2.83	0.68	2.83	0.19		

Note. *** $p < .001$.

5. Discussion and conclusions

This research integrated a knowledge-based chatbot system into a physical examination course and used smartphones as learning devices to guide students to practice anatomy knowledge during teaching activities. The experimental results indicated that the knowledge-based chatbot system enhanced students' academic performance, critical thinking, and learning satisfaction when compared with conventional teaching.

Regarding the students' academic performance, this study found that the nursing students who used the knowledge-based chatbot system as their learning method provided evidence showing the learning effectiveness of physical examination. It is because the knowledge-based chatbot system provided an interactive learning mode that students could learn what they needed to know according to their learning progress; in other words, it provided personalized learning opportunities. The results echo those of Abubakar et al. (2019), who indicated that the enhancement of academic performance depends on the learning design. That is, if the needs of individual students can be taken care of, their learning efficacy could be improved.

In terms of critical thinking, the experimental data indicated that the implementation of the knowledge-based chatbot system can promote students' critical thinking. This finding is consistent with previous studies relating to the application of knowledge-based chatbot systems in teaching activities. For example, Goksu (2016) developed a knowledge-based chatbot system to support sex education courses for eighth-grade students, and found that it guided the students to make judgments in different scenarios. Therefore, it strengthened their critical thinking, and the students had better learning performances than those learning via conventional teaching. In the past, many scholars have mentioned that the learning mode with a combination of scenarios and guidance in nursing courses can improve students' critical thinking (Hwang & Chang, 2020; Hwang & Chang, 2021).

Referring to the students' learning satisfaction, this research has shown that participants in this study were in favor of using the knowledge-based chatbot system in learning activities. In conventional teaching mode, teachers usually give lectures using graphic pictures for illustration, but there is generally a lack of opportunities for interaction between teachers and students, not to mention the provision of instant feedback to the students. The major benefit of the knowledge-based chatbot system was possibly the provision of instant feedback that enabled the students to study efficiently according to their needs (Giraud et al., 2017). As indicated by Hwang et al. (2019), the use of an appropriate interactive learning system could improve students' learning satisfaction.

The knowledge-based chatbot system can assist users in making suitable choices and enable them to conduct systematic study with a focus on particular learning content. At the same time, the system can provide practices for different learning levels according to the students' learning progress as well as helping them identify their misconceptions during the practice. Therefore, the knowledge-based chatbot system can provide individual practice and guidance that can improve students' learning efficiency and effectiveness (Tegos & Demetriadis, 2017). In terms of this learning process, students are required to actively engage in knowledge construction while the knowledge-based chatbot system plays the role of an assistant or a learning facilitator.

The findings of the present study further echo the suggestion by Yin et al. (2020) that chatbots play many different roles in education. Many chatbot applications in education focus on the methods of analyzing and predicting students' learning behaviors. This study, however, revealed that chatbots have the ability to assist with an active learning mode. The knowledge-based chatbot system can be considered as a tutor, allowing teachers to have more time to understand students' learning problems in class, and enabling students to engage in personalized learning according to their needs. The knowledge-based chatbot system will become a "Smart Learning Partner" if students download it onto their tablets or smartphones. Thereafter, they can change their learning mode; that is, they can learn the teaching materials in a way that suits them, and repeatedly revise unfamiliar content. It makes them feel as if they have a learning partner with common learning goals, and it can enhance their cognitive development.

Despite this study having obtained the expected results, there are some limitations due to the research design and the teaching site. For instance, the objective of this experiment only focused on student midwives. It is recommended that future studies focus on students from different backgrounds and disciplines. Moreover, this study did not record students' learning processes, so it is not possible to understand the difficulties they encountered and their learning status during the process. The relatively small sample is another limitation of the present study. Based on the findings and the limitations of the present study, we recommend some suggestions for research relating to chatbots in education in the future as follows:

- It would be interesting to further investigate the chatbot system-based learning approach in relation to the learning performances and perceptions of students with different personal characteristics, such as knowledge levels, learning anxiety or self-efficacy, since the incorporation of new technologies might have different impacts on students with different personal characteristics or learning status.
- In addition to nursing students, school teachers, patients, family members of patients and nursing staff also need to continuously learn and update their knowledge. Therefore, it is important to conduct research on the benefits of using knowledge-based chatbot systems for these potential learners.
- In the traditional instruction mode, teachers generally have difficulty knowing the learning status and problems of students who need additional support. It is expected that the students' learning process can be analyzed using chatbot applications in the future. It is suggested that researchers who intend to develop chatbot applications for educational purposes not only record students' learning behaviors and status, but

also provide the logs and analysis results to teachers, such that the teachers have the opportunity to understand students' learning status and provide personal support to them, as suggested Xie et al. (2019). More importantly, the teachers would then be able to improve the learning content or learning design accordingly. That is, researchers can consider developing a class management module in chatbot-based education applications.

- A number of previous studies have mainly focused on the development of chatbot-based education applications. This may be because a majority of such studies were conducted by the researchers with a background in computer science. It is therefore recommended that cross-disciplinary research should be conducted in the future. For example, collaboration between computer science, education, and various disciplines could be extremely productive. It is expected that in-depth investigations on chatbot-based education applications can be performed. Moreover, it is also suggested that future studies can be conducted by incorporating different learning strategies (such as gamification, peer-assessment, and problem-based learning) into the learning designs using chatbot-based applications.
- It is also important to explore the long-term effects of the chatbot-based learning approach on students' learning motivation, engagement and self-efficacy as well as their learning achievements since one of the benefits of using chatbot-based applications is the provision of a personalized learning opportunity, which is related to active learning and self-directed learning.
- Similar approaches can also be employed in other nursing training programs or other fields, such as science, social science or language courses.

The major contributions of the present study are to propose a chatbot system-based learning approach and to show the effectiveness of the approach in several dimensions. The findings reported in this study could be a reference for those researchers who intend to implement research on chatbots in education as well as school teachers who intend to improve students' learning performances via the use of chatbot technologies. Moreover, in facing the recent COVID-19 problem, the use of chatbots could be a potential approach to reducing the risk of face-to-face instructions while encouraging students to explore and think in depth in professional training programs.

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