

ประสิทธิผลของบทเรียนคอมพิวเตอร์ช่วยสอน เรื่อง เภสัชวิทยาของยาต้านมะเร็ง Effectiveness of Computer-Assisted Instruction of the Pharmacology of Anticancer Drugs

นิพนธ์ต้นฉบับ

Original Article

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บทคัดย่อ

วัตถุประสงค์: เพื่อเปรียบเทียบผลของการทบทวนบทเรียนด้วยตนเองหลังเรียนภาคบรรยาย โดยใช้เอกสารประกอบการเรียน (handout) และบทเรียนคอมพิวเตอร์ช่วยสอน (computer-assisted instruction; CAI) เรื่อง เภสัชวิทยาของยาต้านมะเร็ง ในด้านผลสัมฤทธิ์ทางการเรียน ความคงทนทางการเรียนรู้และความพึงพอใจของนิสิตต่อสื่อ **วิธีการศึกษา:** กลุ่มตัวอย่าง คือ นิสิตเภสัชศาสตร์ ชั้นปีที่ 3 มหาวิทยาลัยมหาสารคาม ที่ได้ผ่านการเรียนภาคบรรยาย เรื่อง เภสัชวิทยาของยาต้านมะเร็งมาแล้ว 3 วัน จำนวน 91 คน สุ่มแบบแบ่งชั้นภูมิจากเกรดเฉลี่ยสะสม โดยสุ่มแบ่งนิสิตเป็น 2 กลุ่ม คือ กลุ่มควบคุม (n = 46) ทบทวนบทเรียนด้วย handout และกลุ่มทดลอง (n = 45) ทบทวนบทเรียนด้วย CAI โดยใช้เวลา 80 นาที กำหนดให้ทบทวนบทเรียนด้วยตนเอง 2 ครั้งห่างกัน 3 วัน ประเมินผลโดยเปรียบเทียบระหว่างกลุ่มควบคุมและกลุ่มทดลอง ได้แก่ คะแนนเฉลี่ยของแบบทดสอบก่อนทบทวน (PreInt) หลังทบทวนซ้ำสองครั้งทันที (PostInt2) หลังทบทวนซ้ำสองครั้งห่างกัน 15 วัน (Ret15) หลังสอบกลางภาค (หลังทบทวนซ้ำห่างกัน 25 วัน) และความพึงพอใจของนิสิตต่อสื่อ **ผลการศึกษา:** พบว่าหลังทบทวนซ้ำสองครั้งทั้งสองกลุ่มมีคะแนนเฉลี่ย PostInt2 สูงกว่า PreInt อย่างมีนัยสำคัญทางสถิติ (P -value < 0.001) แต่ไม่พบความแตกต่างเมื่อเปรียบเทียบระหว่างกลุ่ม เช่นเดียวกับการเปรียบเทียบคะแนนเฉลี่ยของการทดสอบความคงทนทางการเรียนรู้ระหว่าง PostInt2 และ Ret15 ในส่วนผลการสอบกลางภาค พบว่ากลุ่มควบคุมและกลุ่มทดลองได้คะแนนมากกว่าร้อยละ 90 โดยไม่พบความแตกต่างทางสถิติระหว่างกลุ่มเช่นกัน พบว่ากลุ่มทดลองมีความพึงพอใจในสภาพประกอบ ขนาดตัวอักษรและความกระชับของเนื้อหา มากกว่ากลุ่มควบคุม (P -value < 0.05) **สรุป:** การทบทวนบทเรียนด้วยตนเองหลังการเรียนภาคบรรยายซ้ำสองครั้งจาก CAI หรือ handout ช่วยส่งเสริมด้านความรู้ ความเข้าใจและความคงทนทางการเรียนรู้ได้ยาวนานถึง 25 วัน

คำสำคัญ: บทเรียนคอมพิวเตอร์ช่วยสอน, เภสัชวิทยาของยาต้านมะเร็ง, ผลสัมฤทธิ์ทางการเรียน, ความคงทนทางการเรียนรู้

Abstract

Objective: To compare learning effectiveness and retention and satisfaction of providing a traditional handout and computer-assisted instruction (CAI) for post-lecture review of information on the pharmacology of anticancer drugs.

Methods: A total of 91 3rd year pharmacy students of Mahasarakham University were enrolled in the study. All participants attended the lecture of pharmacology of anticancer drugs 3 days before the experiment. Students were allocated to 2 groups by stratified random sampling based on accumulated grade point average (GPAX). Of these, 46 students were assigned to control group (handout), and 45 students to test group (CAI). Eighty minutes was set for each of the two self-study sessions 3 days apart. All participants were assessed using a pre-test (PreInt), post-tests given immediately after the two self-study sessions (PostInt2), and retention tests given 15 days (Ret15) after the second self-study session. Midterm examination (given 25 days after the second self-study session) and student satisfaction were also identified. **Results:** At PostInt2, participants in both groups had significantly higher scores than PreInt (P -value < 0.001). However, no significant difference between groups was detected. In terms of learning retention, no significant differences were detected between PostInt2 and Ret15. Both groups scored well in their midterm examinations, with all scores over 90%, and no significant difference detected between groups. Regarding the average satisfaction scores for lecture reviewing materials, these were significantly higher for CAI than the handout (p <0.05), with students preferring the imagery, text size and conciseness of the CAI. **Conclusion:** Students' learning effectiveness and long-term learning retention (25 days) could be improved when lecture content was reviewed with either CAI or a handout. Further improvements could be achievable if a second self-study session with CAI or a handout was scheduled.

Keywords: computer-assisted instruction (CAI), pharmacology of anticancer drugs, learning effectiveness, learning retention

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Editorial note

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Introduction

In the 21st century, learning in all levels especially in the higher education has been moving to innovation and learning materials. Based on the Thailand 4.0 campaign, a sustainable learning emphasizes student-centered learning concept, well rounded knowledge, innovative creations, and communi-

cations based on technology and media. The learning could be done both in and out of classroom, as well as fulfilling the skills essential for given learners. Based on such requirements, the instructor need to acquire more learning experience, seek new teaching and learning techniques and

diverse learning materials, and design learning activities. These strategies could encourage learners to build up self-motivation and drive to learn. To be effective in managing the learning, the instructor should take into account the individual learner's differences, encourage learners to improve based on their potential and interest, promote skill build-up, foster problem identifying and solving by themselves, allow for freestyle learning, and support learning from simulation.¹ All of strategies are crucial for preparing learners for future professional training. To serve such strategies, various learning media and learning materials have been developed, including computer-assisted instruction (CAI).

Computer-assisted instruction (CAI) has been considered one of the popular learning innovations. CAI has been used for systematically planned learning process. As suggested by the name, the content could be presented according to the learning objectives with multimedia platforms including text/ message, picture/ photo, videos, moving pictures, and sound. These multimedia resemble classroom presentation but could attract more attention from the learners. CAI could also stimulate active learning since individual learners could directly interact with CAI. With its partially tailor-made design, CAI allows learners with different learning potential and background knowledge to benefit from the course.^{2,3}

To improve learning effectiveness, the two-process theory of memory of Atkinson and Shiffrin explains the nature of human memory which consists of short-term memory, long-term memory, and sensory register. Short-term memory is temporary in nature. Therefore it needs to be constantly rehearsed or repeated; otherwise it will be lost within 30 seconds. Any information stored in the short-term memory for a relatively long time will be more likely to embed into the long-term memory, and permanent memory eventually. Once the learner could recall and rehabilitate the memory, learning retention is formed. This process needs at least 114 days.⁴ Based on the lecture-based learning, a widely popular learning modality in Thailand, a given topic is presented to the learners one time in a limited time. If not reviewed or repeated by the learners, understanding and ultimately learning retention could not be achieved.

CAI in health science has been proved to offer effective learning. Subramanian and colleagues compared knowledge scores on the topic of arrhythmia for 3rd year medical students between control group of usual lecture with Powerpoint® slide (n = 15) with test group of CAI (n = 15).⁵ They found that at

scores of test and control groups were comparable ($44.1 \pm 2\%$ and $44.9 \pm 3\%$, respectively); while higher score in test group than control group post-learning ($86.7 \pm 2\%$ and $61.7 \pm 2\%$, respectively). In their study, learning retention at 22 days post-learning in test group was significantly higher than that in control group ($70.1 \pm 3\%$ and $55.8 \pm 3\%$, respectively, P -value < 0.001). When changes of scores from pre-learning to 22 days post-learning were compared, significantly higher improvement was seen in test group compared with control group ($26 \pm 3\%$ and $10.9 \pm 4\%$, P -value = 0.002).⁵ This study indicated that CAI aided the learning retention better than the traditional lecture platform.

With its learning stimulating approach, CAI could be beneficial for difficulty subjects. Pharmacology of anticancer drugs is considered a difficult subject requiring imagination and conceptualization on mechanisms of the drugs at molecular levels. To make it more difficult, a vast extent of content is delivered in lecture and laboratory classes in a limited time. Instructors need to realize the necessity of the innovation to facilitate a more effective learning of difficult subjects in health science education including pharmacy. CAI could be used for reviews after lecture-based class as well as for self-directed learning. The integrative application of CAI in the topic of pharmacology of anticancer drugs is expected to foster understanding and imagination on the drug mechanisms, and to allow for as needed repetitive reviews and animal experiment simulations since no actual test animals are needed.⁶

In health science education including medicine, pharmacy, nursing and allied health sciences, CAI was used for substituting or complementing the traditional lecture and laboratory classes. In most research, CAI was exposed to students mostly with one CAI learning session; then learning effectiveness and retention were evaluated.^{7,8,9} In our present study, we aimed to test the effectiveness of CAI and traditional handout in two repeated self-study sessions on the same subject. Specifically, we aimed to compare 1) compare learning effectiveness as determined by scores before and immediately after the two self-study sessions of the two learning modalities (CAI and traditional handout), 2) learning retention as determined by the scores at 15 days after the two self-study sessions between the two learning modalities, and 3) satisfaction towards the two learning modalities. The use of CAI in the two self-study sessions was expected improve learning effectiveness by imitating the actual learning process.

Such effectiveness could lead to learning retention and long-term memory eventually based on the concept of Atkinson and Shiffrin.⁴

Based on the objectives stated previously, we hypothesized that know scores could be improved from before self-study sessions within each group; and knowledge score of test group (CAI) after the self-study sessions was higher than that of the control group (handout) to reflect learning effectiveness. For learning retention, the improved knowledge scores at 15 days after the two self-study sessions from those found right after the two sessions were expected both within and between the two groups. Finally, we hypothesized that students using CAI were more satisfied with their learning modality than those using traditional handout.

Methods

In this quasi-experimental study with the two-group pretest-posttest design, a sample was recruited with the purposive sampling method.¹⁰ The sample consisted of 3rd year pharmacy students of Mahasarakham University who had learned the lecture topic of pharmacology of anticancer drugs for 3 days. There were 91 students who passed the criteria stated previously and all of them were willing to participate in the study (response rate of 100%). The 91 students were then assigned into two groups using stratified random sampling regarding accumulated grade point average (GPAX) followed by simple randomization. The test group (n = 45) was given 80-minute CAI of 5 drug groups (10 – 15 minutes per drug group) for 2 post-lecture self-studies 3 days apart. The control group received traditional handout for 2 post-lecture self-studies. For the two post-lecture self-study sessions, the investigators provided usual classrooms for control group and computer laboratory room for test group, concomitantly.

Assessments on learning effectiveness and retention, in both groups, were done (1) before the post-lecture self-study or pre-intervention (PreInt), (2) after the two self-study sessions (PostInt2), and (3) 15 days after the two self-study session or 15-day retention (Ret15). Written by the investigators, the test questions on knowledge of pharmacology of anticancer drugs at these three assessments were identical with shuffled question orders. In addition, at the midterm examination which was held 10 days after the Ret15 assessment, i.e., 25 days after the two self-study sessions (or PostInt2), a midterm examination questions which were

written by the lecture instructor, not the investigator, were different from those at 3 prior assessments. The timeline of assessments is shown in Figure 1. The student's satisfaction toward CAI and handout at the end of the study was determined.

Students in the two groups were encouraged to self-study as planned with respective to their assigned experimental groups. During study period, students in the two groups were not assigned any works relating to pharmacology of anticancer drugs.



Figure 1 Timeline of the experiment and the assessments

on learning effectiveness and retention. **Note:** PreInt = assessment on learning effectiveness at pre-intervention (or before self-study sessions); Int1 = the first post-lecture self-study session; Int2 = the second post-lecture self-study session; PostInt2 = assessment on learning effectiveness after the two self-study sessions; Ret15 = assessment on learning retention at 15 days after the two self-study session or the 15-day retention.

Instruments

CAI course on pharmacology of anticancer drugs

The investigators developed the CAI using Adobe Captivate[®] 9 software which consisted of narration and close caption with light music in the background. The narration and close caption helped lower limitations related to language barrier and foster learning effectiveness. The video contained moving picture to stimulate and draw long attention for self-directed learning.

The course also had interactive interface on the practice questions after each topic of anticancer drugs. The practice questions were with diverse formats including filling the blank questions, 4-choice multiple choice questions, and matching questions. The score of each set of practice questions was presented to the learner right away after done.

The CAI also provided a one-screen summary of critical points of each given topic. The summary was expected to help form systematic thinking which could help the learner achieve learning retention.

Topics in the CAI included (1) fundamentals of cancer, (2) pathophysiology of cancer, and (3) 5 groups of anticancer drugs which consisted of mechanism of action, pharmacokinetics, side effects, adverse reactions, drug interactions, indications, contra-indications, and precautions. This CAI was evaluated for quality of multimedia by three experts. Revision was made by the investigators based on the

experts' suggestions before testing with a test sample. On the other hand, handout for control group contained 15 pages of content with summary tables and figures. The content of the handout was comparable to that of the CAI with practice questions similarly placed.

Questionnaire on learning effectiveness

Questions on the knowledge of pharmacology of anticancer drugs for three assessments namely (1) before the post-lecture self-study or pre-intervention (PreInt), (2) after the two self-study sessions (PostInt2), and (3) 15 days after the two self-study session or 15-day retention (Ret15). These questions on knowledge of pharmacology of anticancer drugs at these three assessments were identical with shuffled question orders. The content of the questions consisted of pathophysiology of cancer, specific anticancer drugs, mechanisms of action, pharmacokinetics, side effects, indications, contra-indications, and pre-cautions. Twenty multiple-choice questions with 4 choices included those assessing memorizing skill (4 questions), understanding skill (8 questions), and application skill (8 questions) with a total score of 20 points. These questions were modified from the work of Kumar and Patel.¹¹

The questions were examined for content validity by 3 experts on pharmacology of the Faculty of Pharmacy, Mahasarakham University. Each question was examined for its agreement with the test objective using the index of item-objective congruence (IOC). The higher IOC value close to 1, the higher agreement of the question with the objective.¹²

Test-retest reliability was conducted in 75 5th year pharmacy students of Mahasarakham University. These students were asked to answer the same questions twice 7 days apart. Intra-class correlation (ICC) coefficient was calculated to determine test-retest reliability. The higher the coefficient, the higher the reliability.¹³ With the test sample in our study, an acceptable reliability was found with an ICC coefficient of 0.719.

Difficulty of the questions was also determined. Difficulty of a given question was defined as the factor of number of students with correct answer divided by the total number of students answering the question. In the test sample of 75 5th year students, questions had difficulty factors in the range of 0.20 to 0.80 indicating difficulty appropriate for the target learners.

The effectiveness index (EI) of learning was defined as the progress of learning of a given learner. It was determined by the increased score from pre-learning divided by the difference of the product of student number times total score and the total score of pre-learning. As an indicator of the effectiveness of learning process and materials developed, EI of 0.5 or higher is considered acceptable.¹⁴

The questionnaire on satisfaction on learning using CAI and traditional handouts consisted of 1 questions assessing satisfaction on content (2 questions), integration of content and multimedia (5 questions), learning skill enhancement (2 questions), and overall satisfaction (1 question). The response was 5-point Likert-type rating scale ranging from 5-the most satisfied, 4-highly satisfied, 3-moderately satisfied, and 2-less satisfied, and 1-the least satisfied. This questionnaire was developed by modifying the works of Chisholm and colleagues¹⁵ and Phimarn et al.¹⁶ In this study, internal consistency reliability of the questionnaire was found high with a Cronbach's alpha coefficient of 0.853.

This study was granted the exemption review by the Ethics Committee on Human Study, Faculty of Pharmacy, Mahasarakham University (Approval number: 01 0 / 2560; approval date: January 4, 2018).

Statistical analysis

Demographic characteristics were presented by descriptive statistics including mean with standard deviation and frequency with percentage. Differences between the two groups were tested, where categorical variables (e.g., gender) were tested with Chi-square test and continuous variables (e.g., age, accumulated grade point average or GPAX) were tested with independent t-test if normally distributed and Mann-Whitney U test if not. Statistical significance was set at a *P*-value of < 0.05.

Since the distribution of knowledge scores was not normally distributed, within-group differences before self-study, after self-study and 15 days after self-study were tested with Friedman test with Wilcoxon signed rank test for individual pairwise comparisons. For between-group differences on the knowledge scores at each time point, Mann-Whitney U test was used.

The scores of satisfaction were also not normally distributed. The difference between the two groups was tested with Mann-Whitney U test. All statistical analysis was performed using SPSS for window version 16.

Results

Of the total of 91 students (46 and 45 students in the control and test groups, respectively), no differences regarding age, gender, and GPAX were found (Table 1).

Table 1 Demographic characteristics of the participants (N = 91).

Characteristics	Control group (n = 46)	Test group (n = 45)	P-value
Gender			
Male	11	11	0.573 ^a
Female	35	34	
Age*	20.87 ± 0.66	20.82 ± 0.54	0.666 ^b
Cumulative grade point average (GPAX)*	3.49 ± 0.29	3.53 ± 0.28	0.573 ^b

^a by Chi-square test.

^b by Mann-Whitney U test.

* presented as mean ± SD.

Learning effectiveness before and after self-study

Scores of knowledge before self-study (PreInt) of the two groups were not statistically different indicating comparable basic knowledge of the two groups. In each of the two groups, the score after the two self-study sessions (PostInt2) was significantly higher than that at pre-intervention (or before self-study sessions or PreInt) (P -value < 0.001 for both groups). However, difference between groups at PostInt2 was not found (Figure 2). In terms of effectiveness index (E.I.), an E.I. of 0.69 in the test group was comparable to that in control group (0.70) (Table 2).

Learning retention after the self-study

Learning retention was reflected by scores at 15 days after the two self-study session or the 15-day retention (or Ret15). It was found that each of the two groups had a score at Ret15 higher than that before self-study session (PreInt) with statistical significance (P -value < 0.001 for both groups) (Figure 2). However, score at Ret15 in each of the two groups was not significantly different from that after the two self-study sessions (or PostInt2). No differences between the two group either at PostInt2 or Ret15 (Figure 2). These finding indicated that CAI and traditional handout offer comparable learning retention.

In terms of the midterm examination, the scores of the two groups were comparable with $92.83 \pm 8.86\%$ and $92.22 \pm 8.83\%$ in control and test groups, respectively. Again, no significant difference was found.

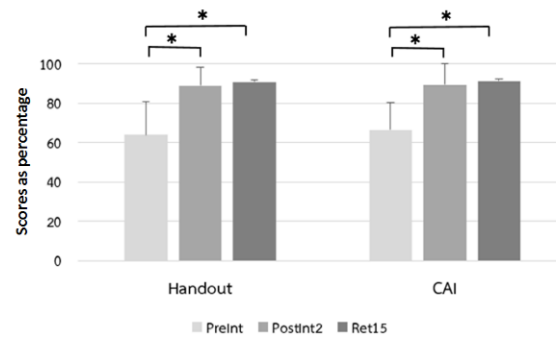


Figure 2 Learning effectiveness (i.e., scores at PreInt and PostInt2) and learning retention (i.e., at Ret15) between control group (handout) and test group (CAI).

* P -value < 0.001

Note: PreInt = assessment on learning effectiveness at pre-intervention (or before self-study sessions); PostInt2 = assessment on learning effectiveness after the two self-study sessions; Ret15 = assessment on learning retention at 15 days after the two self-study session or the 15-day retention.

Table 2 Effectiveness index (E.I.) of the two groups.

Number of participants	Assessment	Total scores	E.I.
Control group (n = 46)	PreInt	588	0.70
	PostInt2	819	
Test group (n = 45)	PreInt	598	0.69
	PostInt2	805	

Note: PreInt = assessment on learning effectiveness at pre-intervention (or before self-study sessions); PostInt2 = assessment on learning effectiveness after the two self-study sessions.

Satisfaction on learning

Among students in the test group, the learning with CAI was rated as highest satisfied in 7 of 10 questions; while those in control group using handout reported highest satisfaction with no questions. Scores of satisfaction in the test group were significantly higher than those in control group (P -value < 0.05) in the questions of (1) appropriate, clear and readable font size, (2) concise, understandable and meaningful language, (3) pictures relevant and complimentary to the content, and (4) attractive imagery; while scores of the questions of (1) content understanding, (2) learning skill promotion, and (3) overall satisfaction were not different between groups (Table 3).

Discussions and Conclusion

Self-study using traditional handout and CAI resulted in a relatively comparable outcomes. Both self-study modalities improved knowledge scores at two sessions significantly from pre-

Table 3 Satisfaction towards learning materials, handout in control group and CAI in test group.

Satisfactions	Average scores (mean ± SD)		P-value ^a
	Control	Test	
	group (n = 46)	group (n = 45)	
Content understanding			
1. Content clearly directed and easily understood	4.41 ± 0.65	4.64 ± 0.48	0.098
2. Content layout and continuity (handout) or clear and systematic section of content (CAI)	4.48 ± 0.66	4.58 ± 0.54	0.571
Multimedia and content			
3. Clear and readable font with appropriate size	4.35 ± 0.77	4.67 ± 0.56	0.025
4. Concise, understandable and meaningful language	4.17 ± 0.88	4.62 ± 0.65	0.007
5. Graphics relevant to the content	4.30 ± 0.70	4.64 ± 0.57	0.012
6. Attractive graphics	4.04 ± 0.76	4.56 ± 0.62	0.001
7. Communicative graphics and tables (handout) or clear sound and animation (CAI)	4.35 ± 0.76	4.36 ± 0.71	0.193
Learning skill promotion			
8. Appropriate learning time	4.17 ± 0.64	4.40 ± 0.62	0.089
9. Test questions relevant to the content	4.46 ± 0.62	4.58 ± 0.62	0.282
10. Overall satisfaction	4.41 ± 0.58	4.56 ± 0.62	0.174

^a Mann-Whitney U test.

learning (P -value < 0.001 for both groups). This suggested that self-study using either traditional handout or CAI could improve the knowledge acquisition. This was consistent with the work of Yingkaew and colleagues where both handout and CAI improved the knowledge score on phenytoin pharmacokinetics among 4th year pharmacy students after taking the lecture on the topic (P -value < 0.001 for both groups).⁹ A study by Phimarn and colleagues also found that handout and CAI improved knowledge score on pharmacology of antiepileptic drugs among 5th year pharmacy students taking the lecture class on the topic 2 years before (P -value < 0.001 for both groups).¹⁶

In terms of the differences between groups, we found no significant differences of the scores after self-study sessions. This finding was also consistent with the works of Yingkaew et al⁹ and Phimarn et al.¹⁶ In our study, students attained two self-study sessions; while in these two previous researches^{9,16}, only one session was provided. A long period of time from the lecture and self-study session was found in these two studies.^{9,16} On the other hand, only 3 days interval was applied in our study to imitate the actual learning process and application.

No difference on scores post self-study between handout and CAI could be in part due to identical test questions with shuffled orders. Pre-exposure to the test questions could have led students in both groups to be more determined to find the answers for the post-test. Hence, the scores after self-study improved significantly from pre-test in both groups with no significant difference between the groups.

In terms of effectiveness index (E.I.) of the learning materials, an E.I. of 0.5 or higher is desirable.¹⁴ We found that with E.I. values of 0.69 in test group and 0.70 in control group, handout and CAI were comparably effective learning materials for self-study post lecture. However, with an E.I. close to that of the handout, CAI could have been more effective if the narrative voices was more poised rather than low as found later in the study. The narration could be more energetic and stimulating for the learners as opposed to being rather less energetic. In addition, if correction on the answers before submission was allowed, the effectiveness of learning by CAI could be higher. The program of CAI needed to be improved to allow such modification on answering the questions in CAI package.

For learning retention, the knowledge score at 15 days after the two self-study session (or the 15-day retention) in each of the two groups was significantly higher than that before the self-study sessions (P -value < 0.001 for both groups). Moreover, such scores at 15 days after the two self-study sessions was not different from that right after the two self-study sessions within each of the two groups. This suggested the retention of the learning 15 days after the two self-study sessions. Since no difference in the scores at 15 days after the two self-study sessions between the two groups, the retention was comparable regardless of the learning materials.

The comparable learning effectiveness and retention between handout and CAI could be seen in the satisfaction towards the two learning materials. Students in the two groups showed similar satisfaction towards the aspects of (1) content understanding, (2) learning skill promotion, and (3) overall satisfaction (Table 3). These aspects of satisfaction also reflected the effectiveness of learning through the similarity of the content and the order of the presentation of the two materials but with different presentation platform. CAI module was built with various multimedia such as text, still pictures, moving pictures, and sound narration. For interactive parts, the interaction was embedded within the quiz and matching game of drug names and their related pharmacological actions. The feedbacks from CAI could attract and stimulate the learning and memorizing. On the other hand, handout offered content and learning only through text and still pictures.

Our findings were consistent with various studies. In a study of Kunawaradisai and colleagues, they tested the effectiveness of traditional lecture by the expert (n = 46) with the CAI (n = 47) for the topic of pharmacotherapy of smoking

cessation among 3rd year pharmacy students of Ubonratchathani University.⁷ There were no differences in the knowledge scores both right after and 14 days after the class between the two groups.⁷ In 2010, Bloomfield and colleagues compared knowledge scores on the topic of hand-wash by the expert's lecture (n = 133) and self-learning using CAI (n = 118) for 1st year nursing students in various colleges in London.¹⁷ They found no significant differences in knowledge scores either right after or 14 days after the class; however, in terms of within-group changes, scores at these two assessments were significantly higher than those at pre-learning in each group. The findings in these two studies were similar to our present study where more than 85% of scores right after and 15 days after the self-study sessions were higher than that before self-study sessions. This indicated an adequate learning retention with CAI even though such retention could also be found in the handout group.

Based on the midterm examination which was held 25 days after the self-study sessions with the questions different from those previous assessments, both groups had scores of 90% or higher. This indicated that the two learning methods, both by traditional handout and CAI, could offer an adequate learning retention. Our finding was consistent with the work of Basturk where graduate students of Carnegie Research University, USA, were tested with lecture-based learning and (n = 140) and the mixed learning (lecture followed by CAI) (n = 65).¹⁸ It was found that the mixed learning group had significantly higher scores than the lecture-based group, both at midterm and final examinations (*P*-value < 0.05, for both examinations).¹⁸ This suggested that CAI after lecture-based learning could improve learning effectiveness than lecture-based learning alone.

In terms of satisfaction, students using CAI reported significantly more satisfaction than those using handout with respect to font size, language for communication, pictures and graphics accompanying the content, and attractiveness of pictures and graphics. On the other hand, the aspects of content understanding, meaningful graphics, duration of learning, tests questions corresponding to the content, and overall satisfaction were comparable between the two learning materials. It was found that most students were positively satisfied with the two materials for self-study. Students using CAI were satisfied with the method because of interactive feedback right away after the test on each subtopic, and summary of each group of drugs. CAI also offered students

the opportunity for review, analytic thinking, and post self-learning tests readily available for each sub-topic. These advantages of CAI could allow students to memorize and recall the content more easily. Students self-learning with handout, on the other hand, were less attracted to this still learning material. All findings could benefit us in improving the CAI materials.

This study had certain limitations. Since the knowledge test questions were identical for each of the assessments with shuffled order. This could allow for familiarity with and learning on the questions. Students could focus mainly on finding the answers from the learning materials. However, our study was trying to prove that learning retention at 25 days after the self-study sessions, nor merely memorizing the test questions and answers, was possible. This was proved by at least 90% of correct answers by the students.

The findings and conduct in our study could suggest future research. To better prove effectiveness of CAI, different sets of questions should be created for various assessments to avoid the memorizing effect of the students. However, these tests should be equivalent or parallel in difficulties specifically the structure and content of the tests. Means with standard deviations of these different sets of questions should be comparable when tested and re-tested in a given group of students. The test-retest reliability, or specifically equivalent forms reliability¹⁹, should be acceptable with a correlation coefficient of 0.7 or higher.

In conclusion, the two self-study sessions 3 days apart using either handout or CAI, 3 days after the traditional lecture class lecture, could comparably improve learning effectiveness (15 days after the self-study sessions) and retention (25 days after the self-study sessions). Such retention could advance into a long-term memory. Even though we found no significant differences between learning with handout and CAI materials, more satisfaction on learning was observed in the CAI-using students especially on the aspect of integrative multimedia, timely feedback and interaction, tailor-made feedback for individual students, inviting atmosphere for self-study, and as needed repeatability. CAI on pharmacology of cancers developed in this study was somewhat appropriate and effective for student-centered self-study learning.

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