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Blended Learning in Anatomy Teaching for Non-Medical Students: An Innovative Approach to the Health Professions Education

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Abstract

Purpose: Anatomy is a basic science for health professions curricula. Recent research suggests that the innovative blended learning approach (classroom learning plus use of online learning) outperforms conventional didactic teaching by facilitating effective learning. This study explores the feasibility of adopting blended learning in anatomy teaching and evaluates the learning experiences of students.

Method: Courseware called electronic Professional Study (ePS) was developed and used for teaching anatomy of the cardiovascular system for non-medical students. ePS composed of three condensed, recorded course lectures, revision guides, and gamified quizzes. These were placed on the Web platform for students to watch before didactic lecture. Scheduled class periods were dedicated to participating in active-learning exercises. By the end of the academic semester, the courseware evaluation was implemented using a set of 5-point Likert scale questions. The e-questionnaire was distributed to a convenience sample of Year-2 full-time undergraduate students majoring in pharmacy enrolled in an introductory course in anatomy and physiology. Multiple linear regression was conducted to examine the relationship between courseware usage and examination results.

Results: All enrolled students ($n = 53$) completed and returned the questionnaire. About 38% used the courseware less than ten times during the semester, and 7.5% never used it. e-Questionnaire shows that a majority agreed that the courseware content was clearly presented and easy to navigate. Multiple regression shows that courseware usage did not contribute significantly to the performance.

Conclusions: Blended learning was perceived positively by most students. However, no effect on learning could be established.

Keywords: Anatomy; Health profession education; Micro-module; Medical education; e-learning Courseware; Gamification; Hong Kong

1. Introduction

Anatomy is a fundamental curriculum in health professions education during freshman and sophomore requiring students to acquire an understanding of the structure and

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function of human body systems. Cadaver dissection is a major activity in the process of learning anatomy, where students can gain an accurate perspective of the size and location of an organ and understanding the context of surrounding organs and tissue that could not be taught via textbook.[1–3] Despite its advantage, cadaver dissection is not a mandatory curriculum for health professions students who are expected to understand the gross structures and functions of various human body systems. They are taught by using plastinated specimens which demonstrate the realistic anatomical structures for the anatomy study.[4] There are several existing commercial platforms support anatomy learning, such as Visible Body,[5] Anatomy.TV,[6] and Zygote Body.[7] The design of the contents follows medicine curriculum covering extensive breadth and depth of technical information and not explicitly addressing non-medical students' (i.e., pharmacy, nursing) need. For example, nursing students although recognized the importance of autonomy to the clinical development, they not only found bioscience subjects more demanding than nursing subjects but also were anxious about the difficulty of what they are learning and the depth of knowledge required to deliver safe, competent nursing care.[8]

In the teaching of histology, virtual microscopy becomes the major scientific instrument to teach cells and tissue sections using one or more microscope objectives at different focal planes.[9] The hands-on histological course allows students lie in the manual practice without handling glass slides and a microscope, such that they still gain an impression of how the tissue is organized to function.[10] Difficulty in studying histology was commonly reported among students, mainly because of limited resources access and time allocated for this subject. Histology thus was often regarded as 'abstract' because they found specific tissues looked similarly and had difficulty differentiating a variety of tissues type.[11] There is a freely available platform called HistoViewer providing a central database for cytology and histology courses.[12] The pictures do not include labeling such that students at the beginner learning level may not be benefited from the extensive database.

Non-medical students may not be rewarded as much as medical students from existing resources that are designed explicitly for medicine curriculum. These limitations prompted us to develop an innovative learning tool that meets the specific needs of non-medical students.

1.1. Blended learning

There has been growing interest among healthcare educators to move away from classroom teaching followed by examination assessment and engage students in active learning.[13,14] The conventional teaching approach involved didactic lecture only is noted to be ineffective since the learning environment is passive that students are spoon-fed with knowledge without critical thinking. It has been shown that knowledge obtained through passive learning style might not be sustained all over the time.[15] The unprecedented growth of digital technology such as computer and mobile application has provided a complementary alternative to the teacher-centric teaching approach.

Blended learning is a type of modern teaching that integrates didactic teaching pedagogy with media-rich technology. This approach is flexible in presenting content, where students can gain access to additional learning mediums in supplementary to the formal classroom teaching, tutorials or practicals. Blending e-learning materials with didactic lectures are now increasingly popular in the university teaching practices, especially for health professions education,[16–18] majorly because of the observed learning benefits through verbal, visual, and auditory stimulations.[19,20] Most common advantages include enhanced motivation in self-regulatory learning, increased the level of engagement between students and teachers both inside and outside of the classroom,[21–23] improved long-term retention of information for better cognitive learning outcome.[24]

1.2. Gamification in health professions education

Educators always seek an approach to help students achieve better learning outcome. An educational psychology study reported that students are often more motivated and successful when e-learning activities involve competitive elements.[25] The concept of gamification advocating 'the use of game design elements in non-game contexts to engage learners for critical connection,' is progressively adopted in health professions education to facilitate knowledge acquisition.[26,27] In particular, the scoring system enables students to track self-learning progress and receive a positive social-comparative feedback among peers. There were various types of gamified platforms available for medical education, such as electronic instructional games, medical mobile applications, and virtual patient simulations. Incorporation of gamified pedagogy in health professions education provides several advantages, including motivating students to learn in the way of problem-solving and critical thinking in clinical decision making,and expediting learning outcomes, enhancing students' engagement in learning.[28]

1.3. Integrating blended learning in anatomy and histology teaching: ePS courseware

The study aims to evaluate the feasibility of adopting blended learning approach with interactive animation plastinated specimens and gamification elements in anatomy teaching in health professions education and evaluate learning experience from the students' perspective. An e-learning platform called electronic Professional Study (ePS) was developed. In particular, we selected a topic of the cardiovascular system as a pilot module because it is related to the world's most common non-communicable diseases – cardiovascular diseases, including heart and blood vessels disease. In worldwide, about 17.5 million people die each year, which accounts for an estimated 31% of all deaths, the world's top cause of fatalities.[29] In respect to its high incidence and clinical importance, the topic of the cardiovascular system is chosen in the development of the courseware.

The paper describes a courseware developed and have been employed for teaching anatomy for students from non-medical programs, in combination with conventional teaching methods in a blended learning approach. The significance of the study is two-folded. Firstly, we showed an inexpensive and effective way in the development of an interactive courseware by using plastinated specimens rather than animated illustrations to demonstrate realistic anatomical structures. Secondly, we analyzed the impact of the use of blended learning approach on academic performance and satisfaction with courseware.

2. Methodology

The cross-sectional quantitative evaluation aims to 1) describe pharmacy students' perception about courseware by using e-questionnaire and 2) assess the effectiveness of blended learning pedagogy by examining the relationship between courseware usage and examination performance. This study was approved by the University Ethics Committee.

2.1. Study population

A convenience sample of Year-2 full-time undergraduate students majoring in Pharmacy enrolled in an introductory course in anatomy and physiology were recruited in the study.

Table 1
The objective of each micro-modules.

ePS Courseware **Pilot Module: Cardiovascular System**
Micro-module 1: Heart Structure Investigation
– To understand core knowledge of both macroscopic and microscopic structures and functions of the heart
– To illustrate clinical implications related to gross anatomy of the heart
Micro-module 2: Coronary circulation
– To understand blood circulation through the ascending aorta to the heart muscle
– To illustrate clinical implication related to coronary circulation
Micro-module 3: Histology of blood vessels
– To understand the histological structures of blood vessels, the exchange of material between the blood capillaries and surrounding tissues
– To illustrate the clinical implication related to microscopic anatomy of blood vessel

2.2. Materials

The courseware ePS composed of three micro-modules, including (1) Heart Structure Investigation, (2) Coronary Circulation, and (3) Histology of Blood Vessels, which highlights the anatomical structures of the cardiovascular system, histology of the blood vessels, and related clinical implications. Table 1 shows the study objectives of each micro-module.

With the storyline driven background, each micro-module embeds three elements, including narrative animation, interactive revision guide, and gamified quiz. The following provides a thick description.

2.2.1. Narrative animation

Narrative animation builds on the concepts presenting an introductory understanding of cell and tissues specific to the cardiovascular system.[30,31] Each narrative animation was selected from SMART image base (Nucleus Medical Media Inc., USA) and lasts about five minutes. Articulate Storyline 2 software (Articulate Global, Inc., USA) was adopted to integrate learning contents in a storytelling style. In this regard, ePS adopted the theme of "Future Space City", linking with the content among each micro-module (Fig. 1a). The main character, Mrs. Jackson (Fig. 1b), visits different departments to conduct cardiovascular health risk assessment. The robots, CaMed007 (Fig. 1c) and Micro-bee injector (Fig. 1d) are artificial intelligence to screen health status and diagnose blood vessel disorders, respectively.

Fig. 1. The Features of ePS Narrative Animation. (a) Courseware Theme: Future Space City; (b) The main character, Mrs. Jackson, who lives in the space city and go to the cardiovascular tower for body checkup; (c) A door robot named CaMed007 scans Mrs Jackson's health status; (d) The Micro-bee injector of the blood vessel robot helps diagnose blood vessel disorders.

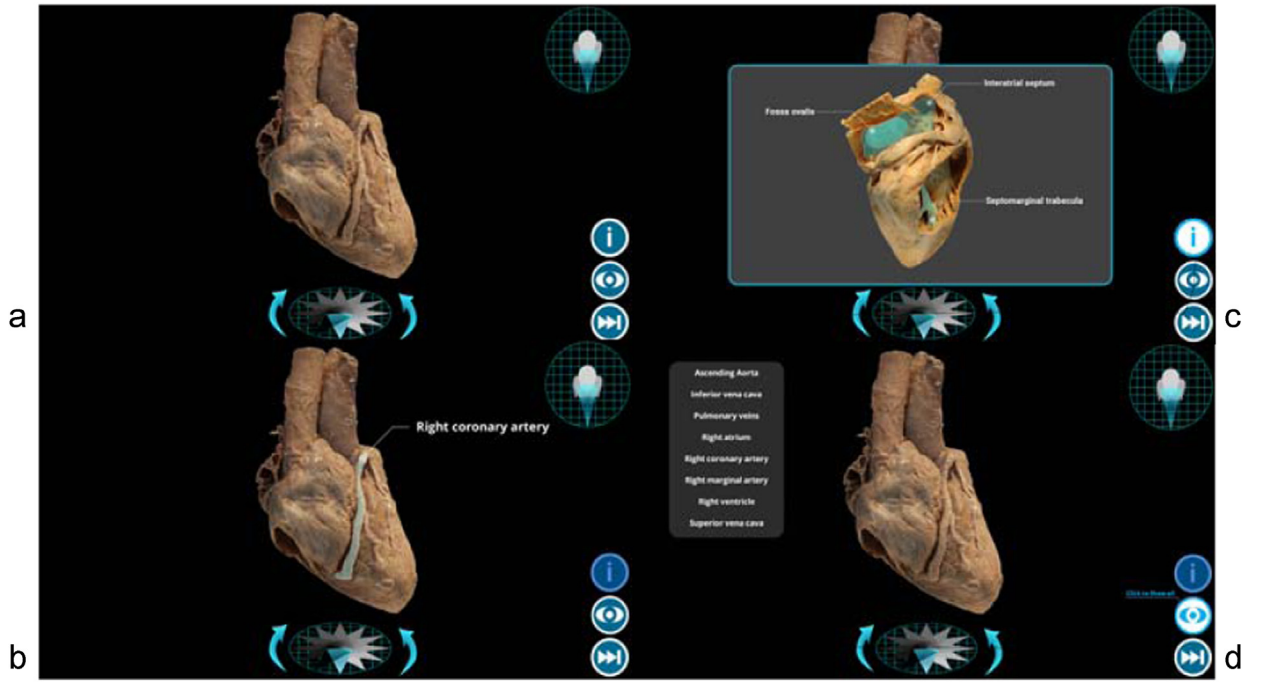

Fig. 2. Samples of the 360 Simulation Viewer. (a) The cursor located under the heart navigates the heart at the different direction; (b) The name of the structure will pop out when the pointer is placed on the structure; (c) The internal structures of the heart in in-situ view could be examined when the top "information icon" is clicked; (d) All the names of the structures at in-situ view can be shown when the middle "zoom icon" is clicked.

2.2.2. Interactive revision guide

2.2.2.1. 360-degree Spatial Simulation. The spatial simulation, using a plastinated heart, aims to create immersive experiences to facilitate cognitive understanding in the relationship of anatomical structures with the heart by providing realistic perception at different angles. Fig. 2 shows the anatomic atlases revision guide of the heart structure.

2.2.2.2. Blood vessel histological illustrations. The histological illustrations are presented in the form of color photographs, where accompanying text outlines

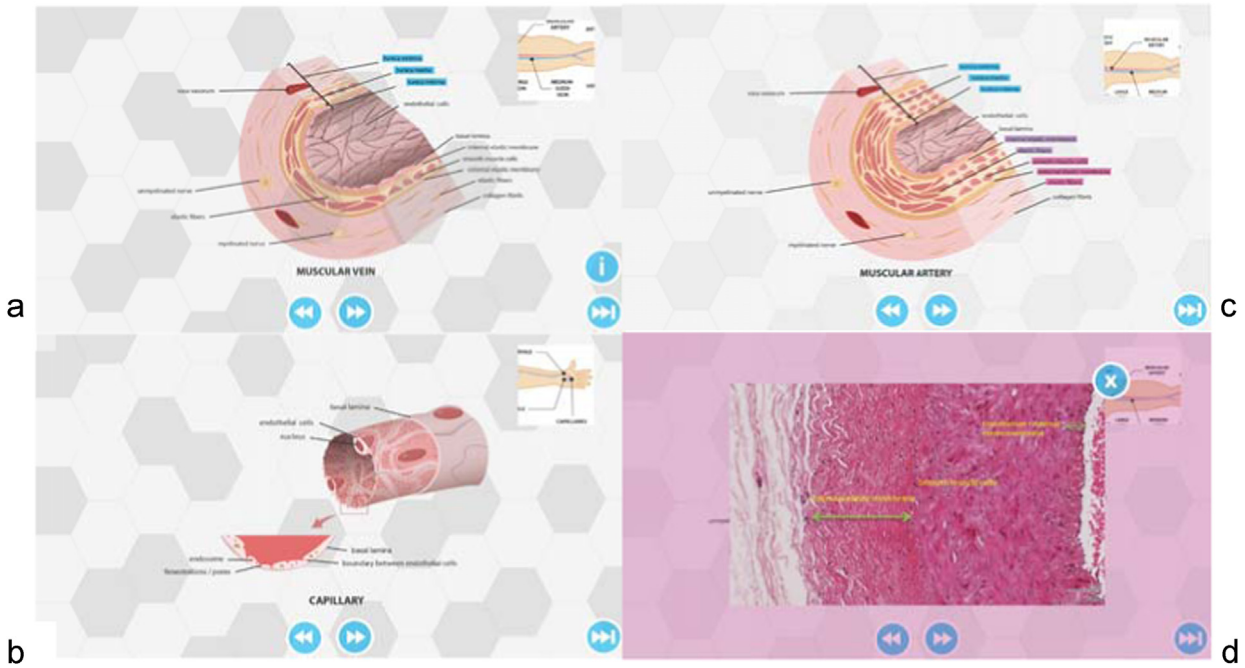

Fig. 3. Examples of Histological Illustrations. The arrangement of the layers of the wall of the (a) muscular vein; (b) capillary; (c) muscular artery; (d) the histological slide will pop out when the pointer is placed on the name of the structure.

the functional aspect. It aims to give a clear, lucid depiction to facilitate understanding. Fig. 3 shows sample illustrations that introduce different types of blood cells in the blood vessels and demonstrate the histological arrangement of the layers in blood vessels.

2.2.3. *The design of gamified quiz*

Competitive interventions were incorporated in the design of quiz to increase students' engagement in the revision. Students were instructed to find out the problems during the transmission of the health data for Mrs. Jackson. Our team designed quiz questions in line with the course objectives. Three difficulty levels were set up to address varying students' need: *Basic level* requires memorization of fundamental knowledge related to the cardiovascular system; *Advanced level* requires an understanding of the correlation with functions of the cardiovascular system; *Challenging level* requires a comprehensive understanding and application of pathological changes of the cardiovascular system. Students would be notified whether they answer the question correctly or incorrectly. We did not provide the answer to incorrect attempts to encourage students to revisit the courseware and solve the questions by themselves.

Table 2 shows the scoring mechanism in the quiz. Each question score 5, 6, and 9 points at the level of basic, advanced, and challenging, respectively. In each attempt, students could try five questions in each level at a time, and the total possible points are 100 if all questions are answered correctly. Students have unlimited attempts throughout the semester and, in each attempt, questions will be randomly selected from the question bank. The system would record the latest score only. Three book coupon awards were given to students who achieved the top three in the quiz by the end of the academic term.

Table 2
Scoring mechanism in the quiz.

Level	Number of questions in the bank	Points for each question	Total points at the level
Basic	> 100	5	25
Advanced	> 30	6	30
Challenging	> 20	9	45
Total Points in each attempt:			100

2.3. *Procedures*

The ePS courseware was launched on the university-wide learning platform, Blackboard Learn, starting from 15th September to 12th December 2016. By the

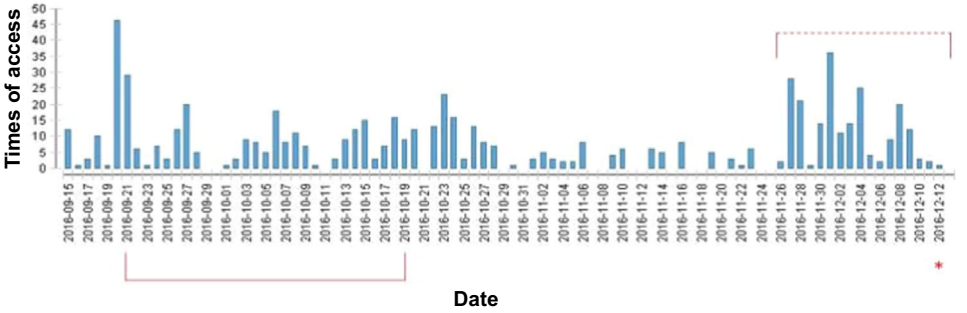

Fig. 4. Temporal Accesses to the Courseware. *Indicates formative assessment date, which was on 12th December, 2016. The solid-lined parenthesis indicates the teaching period of the cardiovascular system module. The first usage peak was noted in the first week of the module; the dotted-lined parenthesis indicates the second usage peak, which was on 30th November, 2016, which was two weeks before the formative assessment.

end of the semester, an anonymous e-questionnaire was distributed to pharmacy students enrolled in the course.

2.4. Instruments

The e-questionnaire with nine statements assesses attitudes towards courseware design, content presentation, features as well as the perception of a learning environment where technology is used. Students were asked to rate the statement using a 5-point Likert scales ranging from 1 (strongly disagree) to 5 (strongly agree). A short answer question (SAQ) related to cardiovascular system was used as an outcome indicator to assess the effectiveness of the courseware. Full mark of the SAQ is 10 points. Final course grade, average GPA, courseware usage, such as the number of times a student logged into the courseware, were also collected from the platform system.

2.5. Data analysis

Descriptive analyses were used to describe participants' perceived attitude of the courseware. Because of the small sample size, nonparametric Spearman rank order correlation analysis and Kruskal–Wallis test were used to examine the relationship and difference in SAQ performance and courseware usage, and overall course grade. Course grade of the course were collapsed into five categories: A and A− were combined as A range; B+, B, and B− were combined as B range; C+, C, and C− were combined as C range; D+, D, and D− were combined as D range; and F for students who failed the course. Multiple linear regression was used to examine as to whether SAQ performance can be predicted based on a number of courseware access, controlling for course grade and average GPA. The Predictive Analytics Software Statistics SPSS program version 24.0 was used to analyze all data.

3. Results

3.1. Study pattern for the ePS

All enrolled students (n = 53) completed and returned the questionnaire. Prior to this course, 45% students had ever been exposed to an e-learning courseware. About 38% used the courseware less than 10 times during the semester, 41.5% used it 10–20 times, 13% utilized more than 20 times, and 7.5% never used the ePS.

Fig. 4 shows periodic access to the courseware throughout the semester. Regular teaching lectures, practicals, and tutorials covered physiology and anatomy components of the cardiovascular system during 21st September to 19th October 2016. By the end of the course, the total hit of the ePS courseware was 669, and the average hit for each student was about 12.1. Two access peaks were noted: first were the teaching period of the cardiovascular system modules at the early term; second frequent access was observed two weeks before the summative examination date held on 12th December 2016.

3.2. Attitudes towards the design and content of ePS

Fig. 5 shows attitudes towards the content of ePS. The majority of 83% and 78% agreed that the courseware content was clearly presented and easy to navigate. About three-fifth (66%) found the content helpful in addressing their revision need. Regarding the courseware features, gamified quizz was valued the most where about 85% find it constructive in monitoring study progress towards the overall course expectation, followed by histology illustration (78%), and 3D simulation (74%). Two-third respondents (66%) found narration video helpful to the learning and one-third (32%) was uncertain about the effectiveness of having a storyline component in the courseware. In

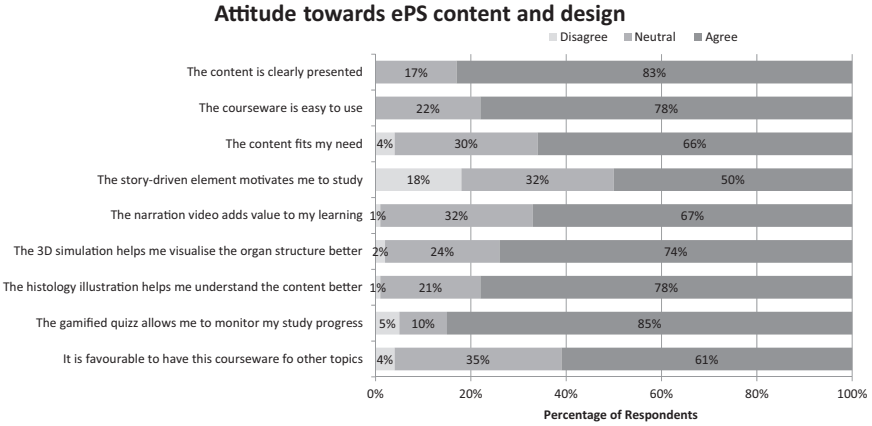

Fig. 5. Attitude towards ePS content and design.

Table 3
Descriptive and correlation statistic of data.

Inclusion of Outliers	**Total (n = 53) Mean (SD, Range)**	**1**	**2**	**3**	**Course Grade**					H^a	***p*-Value**
					A (n = 18)	**B (n = 17)**	**C (n = 12)**	**D (n = 3)**	**F (n = 3)**		
1. Courseware Access	12.1 (10.8, 0-55)	1.00	0.127	.382**	15.8 (14.4)	9.59 (4.53)	11.9 (10.8)	8.00 (1.73)	9.33 (15.3)	2.77	0.598
2. SAQ	5.69 (2.19, 0-10)		1.00	.677***	7.36 (1.42)	5.97 (1.49)	3.67 (2.07)	3.17 (1.44)	4.67 (1.52)	25.5	< 0.001
3. Average GPA	3.11 (0.52, 1.66-3.91)			1.00	3.58 (0.18)	3.15 (0.34)	2.65 (0.42)	2.73 (0.1)	2.29 (0.56)	39.3	< 0.001
Exclusion of Outliers	**Total (n = 48) Mean (SD, Range)**	**1**	**2**	**3**	**A (n = 16)**	**B (n = 17)**	**C (n = 10)**	**D (n = 3)**	**F (n = 2)**	H^a	***p*-Value**
1. Courseware Access	9.40 (5.91, 0-23)	1.00	0.165	.444**	11.5 (7.16)	9.59 (4.53)	7.90 (5.59)	8.00 (1.73)	0.50 (0.71)	6.47	0.167
2. SAQ	5.571 (2.22, 0-10)		1.00	.699***	7.41 (1.45)	5.97 (1.49)	3.65 (2.21)	3.17 (1.44)	4.00 (1.41)	22.9	< 0.001
3. Average GPA	3.10 (0.53, 1.66–3.91)			1.00	3.58 (0.18)	3.15 (0.34)	2.57 (0.40)	2.73 (0.12)	2.07 (0.57)	35.8	< 0.001

[a]Kruskal–Wallis H test

general, students favored expansion of e-learning courseware access for other topics in future (61%).

3.3. Courseware usage and final examination result

Table 3 shows descriptive and correlation statistic of SAQ performance and courseware usage by overall course grade. Overall, the average courseware log-in rate was about 12 times per students. Students from A range accessed ePS more often than other grade ranges, although the difference was not statistically significant ($p = 0.598$). Further analysis identified five students attempted the ePS more than 20 times that far exceeded the class average (outliers); of which two students from A range attempted 46 and 55 times, two from C ranges who attempted 28 and 36 times, and one from F range who attempted 27 times. The outliers were then excluded in further analysis.

In the analysis excluding the outliers, the courseware usage by exam performances remained statistically insignificant ($p = 0.167$). Average GPA is statistically moderately correlated with courseware usage ($r_s = 0.444$, $p = 0.002$) and SAQ performance ($r_s = 0.699$, $p < 0.001$). Multiple regression models in Table 4 show that courseware usage did not contribute significantly to the SAQ performance and its effect is moderately modified by student's average GPA performances ($p < 0.001$).

Table 4
Multiple regression table of factors related to SAQ performance.

	B	Std. Error	*t*	95% CI	*p*-Value
Inclusion of Outliers					
Intercept	−2.70	1.50	−1.81	(−5.71, .298)	.076
Courseware Access	−.032	.024	−1.35	(−.080, .016)	.183
Average GPA	2.83	.500	5.65	(1.82, 3.83)	.000
Exclusion of Outliers					
Intercept	−3.25	1.52	−2.14	(−6.30, −.194)	.038
Courseware Access	−.090	.049	−1.85	(−.188, .008)	.071
Average GPA	3.16	.540	5.85	(2.07, 4.25)	.000

*Outcome variable: SAQ performance

4. Discussion

This study contributes to the literature by introducing an innovative courseware that is exclusively oriented for non-medical students and exploring attitude and blended learning experience from students' perspective. The findings indicated that using the applications help promote active learning and suggest wider dissemination of blended learning pedagogy in health professions education.

Study findings reported that slightly more than half were first exposed to e-learning courseware in learning anatomy, meaning blended pedagogical approach deploying multiple modes and technologies in Hong Kong, however, remained in its infancy in tertiary education. The active access of the ePS courseware suggest that students ascertained its educational value and utility in supporting active learning, as they keened to revisit ePS periodically, especially before the summative examination. This innovative courseware may benefit learners who otherwise would not have been able to access to learning resources other than lectures notes of in this case. The positive feedback received from learners indicates a favorable inclination towards the use of multimedia, implying its advantage to complement the didactic teaching.

The study findings reported spatial simulation as one of the most appreciated features in the courseware suggesting impediments in learning anatomy and histology. This view could also be explained by the mainstream students who learned anatomy in the form of pure memorization instead of strategic learning felt that the amount to learn was daunting and stressful.[32] In the current program curriculums for health professions training, the plastinated specimens are used as teaching resource to illustrate anatomic structures in the human body systems. Students are only allowed to view specimens within the assigned office hours and could only view the atlas of the anatomy in self-revision after office hours. The illustrations in the textbooks are found to be difficult and challenging to conceptualize human body. This paper suggests e-resources may be a preferred mode of study to overcome existing institutional barriers accessing to resources, especially plastinated specimens rather than animated illustration was used to build up the spatial simulation. It is expected to help student contextualize materials and build up a deep conceptual understanding of the subject.[4,33,34]

A gamified element in health professions education has gained wide attention as an active learning strategy, especially when there is ample evidence that passive delivery provides the lowest level of knowledge retention and cognition.[35] Unlike current active learning strategies that advocate team-based learning[36] or case-study learning,[37] this study incorporates an intervention at the individual level. We found a motivational influence in mastery learning when the quiz is designed in a game format. In particular, questions come in varying levels of basic drills and practice to intelligent adaptive systems. This feature is practically useful providing students with an indicator of what topics they have not yet mastered and should concentrate on. Compared to other game structures,[38,39] our ePS courseware lacked a feedback mechanism that did not provide guidance correcting wrong concepts which, are of students' favor.[40,41] In response to the shortcoming, we will modify the quiz and provide real-time feedback with descriptions as to why each answer is correct or incorrect after the submission.

Study findings showed that student's average GPA performance rather than the courseware usage had accounted considerable effect on the SAQ performance. Within our expectation, high-performing students tended to use the courseware more frequently than the poor-performers just as they use any other learning material. Although courseware usage was found not significant in the model, students reported positive reinforcement in using the courseware for revision. It could be explained by the courseware features aid the learning process. In education, provided that examination score is not a quality indicator for academic success, designing a course oriented to students' need is rather imperative. The

outliers in C and F grade who frequently utilized the courseware yet scored a low course grade range calls for particular attention to address inadequacy in helping low-achieving students and reconsideration what goals and benefits of e-learning technology should be emphasized.

This study provides an example of adopting blended learning in anatomy teaching to facilitate active learning among students. The active access and favorable attitude towards courseware features in addressing the existing learning barrier, although no inference could be drawn on the influence of the courseware on learning due to the limited sample size. The researchers believe that similar courseware should be developed to add value to practical-based courses.

4.1. Study limitation

This study is limited in several ways. Firstly, most data are self-reported feedback and limited to a small sample size in that may prevent the findings from being extrapolated. Population biases are possible because of the smaller size and homogenous characteristic. Results cannot be seen as being representative of students in other disciplines, but many similarities are evident. Further studies with larger sample size are crucial before making further inference. Secondly, the final examination grade covers a topic other than a cardiovascular system such that it does not fully reflect the effectiveness of the courseware; thus, a high or low number of accesses of ePS do not directly predict examination performance considering other variables, such as students learning difficulties. Thirdly, the security of the weblog is limited to accessing the number of attempts students made to log into the courseware yet failed to factor in the duration of the courseware. Future researchers may consider these parameters in the pedagogical studies.

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Disclosure

Ethical approval: Ethical approval has been obtained from the institutional review board for research involving human subjects.

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