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Integrating an open-source course management system (Moodle) into the teaching of a first-year medical physiology course: a case study

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Seluakumaran K, Jusof FF, Ismail R, Husain R. Integrating an open-source course management system (Moodle) into the teaching of a first-year medical physiology course: a case study. *Adv Physiol Educ* 35: 369–377, 2011; doi:10.1152/advan.00008.2011.—Educators in medical schools around the world are presently experimenting with innovative ways of using web-based learning to supplement the existing teaching and learning process. We have recently used a popular open-source course management system (CMS) called the modular object-oriented dynamic learning environment (Moodle) to construct an online site (DPhysiol) to facilitate our face-to-face teaching of physiology to a group of first-year students in the Bachelor of Medicine and Bachelor of Surgery program. The integration of the Moodle site into our teaching was assessed using online log activity, student examination marks, and feedback from students. The freely available Moodle platform was simple to use, helped to effectively deliver course materials, and has features that allowed cooperative learning. Students used the CMS throughout their academic year and commented favorably regarding its use as a complement to the face-to-face classroom sessions. The group of students who used the CMS obtained significantly higher scores in the final examination compared with the previous class that did not use the CMS. In addition, there was a significant correlation between student participation and performance in online quizzes and their final examination marks. However, students' overall online usage of the CMS did not correlate with their examination marks. We recommend Moodle as a useful tool for physiology educators who are interested in integrating web-based learning into their existing teaching curriculum.

e-learning; blended learning; virtual learning environment; web-based teaching

WITH THE ADVENT of a new era in information technology, web-based learning is becoming an important component of today's teaching and learning process in higher educational institutions. Many tertiary institutions have adopted course management systems (CMSs; also called virtual learning environment) to facilitate online teaching activities. CMSs consist of software packages that allow educators to construct online learning sites for uploading content materials, facilitating student-student/student-tutor communication via discussion forums, e-mail, and chat functions, setting up online quizzes and questionnaires, and managing multiple student groups. These features can help educators to organize their course materials, efficiently distribute learning materials, and introduce creative methods of teaching. CMSs can also be used to implement ongoing course evaluation (2), facilitate collaborative learning (1), and enhance student learning (19). A good CMS platform should be easy to use, readily available, stable, flexible, and able to be integrated with other platforms (15). Although commercial CMSs are available for a licensing fee, many institutions are now adopting open-source applications, which carry benefits in terms of cost and functionality (35, 36).

The most widely used open source CMS in the educational setting is the modular object-oriented dynamic learning environment (Moodle). Moodle was created by Martin Dougiamas (Curtin University of Technology, Perth, WA, Australia) (13). It is not only available for free but was also found to be more user friendly and flexible compared with other proprietary CMSs by both educators and students (4, 25, 33). There is a large community of Moodle users worldwide, with >49,000 registered sites in >200 countries (27). Comprehensive reviews regarding the features and development of Moodle online courses are also available (6, 30).

Many educators are presently experimenting with innovative ways of using Moodle either for delivering fully online courses or as a supplement to their face-to-face teaching in a variety of university courses. In terms of undergraduate medical education, several studies have reported on the use of Moodle in the teaching of pharmacology (2, 28), surgery (14), radiology (32), dermatology (24), emergency medicine (31), and some first- and second-year elective subjects (7, 21). These reports suggested that the implementation of Moodle was generally well accepted by the students as a supplement to traditional methods of teaching and has made an effective contribution to the teaching and learning process, including an improvement in student grades (7). Although a number of studies have shared their experiences on using customized web-based learning activities in the teaching of first-year medical physiology course (8, 9, 20), there is still a paucity of literature exploring successful models of how physiology educators can integrate readily available CMSs such as Moodle into their existing curriculum. This issue is pertinent as most medical educators have neither the required funds nor necessary computer skills to design a comprehensive web-based learning system for their students.

Recently, the University of Malaya has adopted Moodle as the main e-learning platform for all courses. Following this decision, we integrated a Moodle e-learning site called DPhysiol into the existing face-to-face teaching of physiology to first-year undergraduate medical students. This approach was taken based on the suggestion that blending e-learning with traditional face-to-face teaching of physiology can promote an active, deeper approach for learning that enhances student learning outcomes (8, 9, 34). In addition, we also wanted to use Moodle to effectively distribute our lesson materials through the online medium. To facilitate these goals, we designed the Moodle site to include features that would promote active learning and enable uploading of relevant course information and lesson materials. In the present study, we evaluated the usage pattern of Moodle and its impact on

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student learning outcomes using online log activity, student exam performance, and student feedback from questionnaires.

MATERIALS AND METHODS

Online Course Setup and Administration

The Bachelor of Medicine and Bachelor of Surgery (MBBS) program offered at the University of Malaya is a 5-yr course, and the student intake is merit based. Physiology is one of the compulsory subjects offered in the first year and is traditionally taught via lectures, tutorials, and practical sessions, all of which involve face-to-face interactions with students. For the entire academic session of 2008/2009 (*term 1*: *weeks 1–22* and *term 2*: *weeks 23–42*), we supplemented the existing teaching modes with an online Moodle site called DPhysiol. We were the first department in the faculty to introduce the Moodle platform for this group of students.

At the beginning of *term 1*, all first-year MBBS students (95 men and 121 women, age: 20.10 ± 0.49 yr, mean ± SD) were requested to self-register at the DPhysiol site using individual user names and e-mail addresses. They were given a short briefing about DPhysiol during their introductory week (all of them were first-time Moodle users). Along with a set of instructions on the registration, students were also provided with an enrollment key, which acted as an access code to the site. When the enrollment key was first entered, students were automatically placed into 10 separate groups based on their tutorial grouping assigned by the faculty. Enrolment to DPhysiol was made available from the beginning of *term 1* until the end of *term 2* and was not made compulsory.

A total of seven lecturers from the Department of Physiology, University of Malaya, were assigned as tutors in DPhysiol. The course content was managed by K. Seluakumaran, who was also one of the tutors. The installation and administration of Moodle (version 1.9) was handled by the Academic Development Center's personnel in our university (http://adec.um.edu.my/code). The site was hosted by the server of the Information Technology Center located on our campus.

Online Course Content

The course content in Moodle is typically organized in topic format (6, 30). A screenshot of DPhysiol is shown in Fig. 1. We designed DPhysiol content using the following topic outlines.

Interactive. This section allowed communication with fellow students and tutors through a discussion forum and an online chat room (DPhysiol also allowed students to send personal messages to each other or to tutors for private discussion). Students were encouraged to post any doubts about the topics being taught, and both the students as well as the tutors could reply to the questions posted. The contents of all posts and replies were sent as e-mails to the corresponding students and tutors. Another forum was created to allow tutors to post announcements either to a specific group or to the entire class.

Course information. Information about the MBBS course structure, contact details of staff and faculty members, and the various facilities available for the students in our faculty were uploaded here. Students were also provided with semester dates, a course timetable, and physiology lecture contents and outcomes for the entire academic year.

Lecture notes. The notes used by the lecturers during their traditional style lectures were made available for download (in .pdf format), usually immediately after the scheduled lectures. Throughout the course, a total of 42 lecture files was uploaded.

Laboratory exercises. Students were involved in a total of 11 laboratory practical sessions. Laboratory exercises for each session were uploaded before the classes so that students would be able to read and prepare for the sessions.

Problem-solving sessions. The physiology teaching also consisted of eight problem-solving sessions in which students were provided with a set of problems that would be discussed with their respective tutors in a tutorial setting. Questions for the problem-solving sessions were uploaded before the scheduled sessions and regular announcements were sent out to the students, requesting them to prepare the answers before attending the sessions.

Audiovisual resources. A total of 24 Audiovisual (AV) resources in the form of animations (.swf format) and videos (.mpeg format) that were deemed relevant to the subjects being taught were uploaded by the tutors. Students were able to either download or view them online. For materials obtained from the internet, the relevant web sources were acknowledged.

Quizzes. Seventeen quizzes, comprising various types of questions (multiple choice, true-false, matching, filling in the blanks), were designed and uploaded by tutors to test the level of understanding of students about the concepts taught. Students were given appropriate

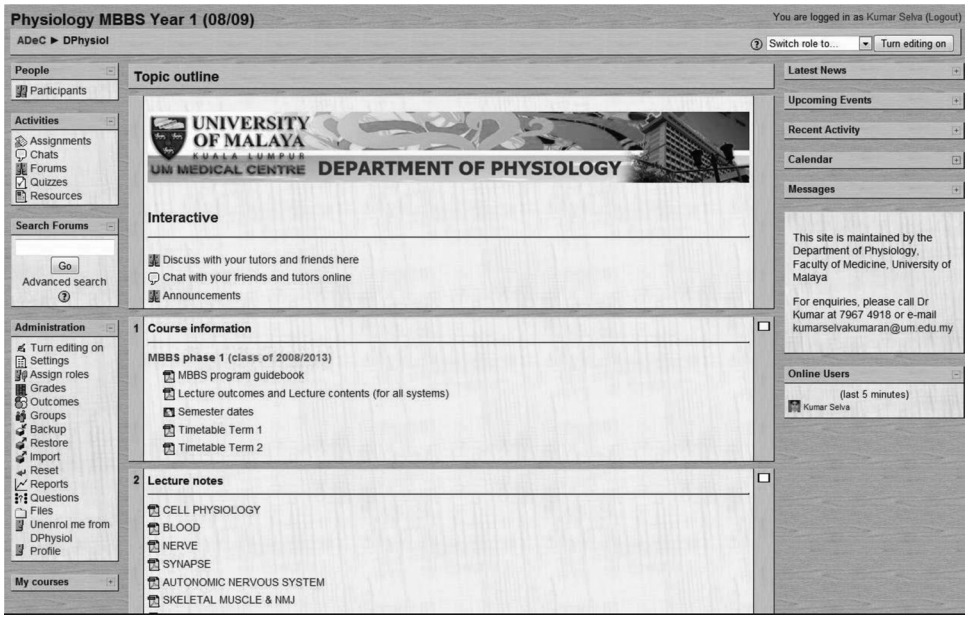

Fig. 1. Screenshot of the DPhysiol webpage. MBBS, Bachelor of Medicine and Bachelor of Surgery.

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time limits to complete each quiz. Only one attempt per quiz was allowed, but students were able to review their attempts throughout the academic year. The quiz settings also allowed students to receive the correct answers, their marks, and feedback for the answers immediately after their attempt. However, quiz marks were not included in the formal assessment.

Useful links. Links to relevant sites such as the webpages of our department, faculty, library, and the university's student e-mail portal were given.

Evaluation Methods

Online activity logs. Data regarding individual student's enrollment and activity logs throughout the academic session were generated by Moodle. These data were downloaded and analyzed offline using a Microsoft Excel worksheet. The online activity of students in DPhysiol was calculated based on their number of visits and hits. "Visits" refers to the number of accesses (log in using username and password) to the site by individual students at one point of time, whereas "hits" refers to the total number of clicks that students perform for accessing the course contents during their visits.

Exam scores. The first year of our MBBS course consists of two major exams: one at the end of *term 1* (*part A* exams) and the other at the end of *term 2* (*part B* exams). All students were required to sit for these exams and obtain a pass to proceed to the second year. These examinations consist of questions from three main subjects taught in the first year (physiology, biochemistry, and anatomy). For the purpose of this study, the physiology component marks in *part A* and *part B* exams were compared with the activity logs of individual students obtained from DPhysiol during *terms 1* and *2*, respectively. To assess the Moodle usage between high and low achievers, we also compared the activity logs of students who were in the top 10% of the overall final physiology results (*part A* and *part B* exams combined) with those of students who were in the bottom 10%.

We also assessed student participation and performance in online quizzes and correlated these with their final exam marks. Quiz participation was determined based on the total number of quizzes attempted by each student during the entire academic session. Student performance in the quizzes was based on the mean score obtained by the students (only students who attempted at least four quizzes were included).

Finally, to evaluate the value of Moodle in improving student exam performance, mean final physiology marks obtained by the students (academic session 2008/2009) were compared with marks obtained by the previous class (academic session 2007/2008), which did not use the CMS. As a comparison, we also included the analysis of the marks obtained in the anatomy component of the final exams for both these cohorts where the CMS was not introduced. The teaching schedule, curriculum, criteria for student intake, and examination style for these two cohorts were similar. There was also no major change in our pool of teaching staff during both academic sessions.

Questionnaire. During the 34th week of their course, a set of questionnaires was handed to each of the students during tutorial sessions to evaluate their feedback on the implementation of DPhysiol. These anonymously answered questionnaires were in paper format to include nonusers as respondents. The questionnaire consisted of three parts. The first part provided the demographic information (age, sex, and DPhysiol usage). The second part enabled students to evaluate various elements of DPhysiol, including its accessibility, ease of use, content, ability to facilitate student-student/student-tutor interactions, and effectiveness in complementing face-to-face teaching using a five-point Likert scale. The third part was a narrative response section with four open-ended questions related to students' overall experience with DPhysiol. Nonusers were requested to respond to the first and third sections of the questionnaire to evaluate their reasons for not using DPhysiol.

Statistical Analysis

Pearson's correlation test was used for all correlation assessments. An unpaired *t*-test was used for all other statistical analysis. The significance level was set at $P < 0.05$.

RESULTS

Study Participants

About 90% ($n = 194$, 86 men and 108 women) of first-year MBBS students registered as DPhysiol users. These users were equipped with sufficient information technology knowledge for using the CMS due to their information technology training in secondary school and during their introductory week at the university. There were a sufficient number of computers at the tutorial rooms, library, computer laboratory, and student residential colleges for students to access the CMS. A total of 178 students (72 men and 106 women) responded to the questionnaire; 97.8% ($n = 174$) of them were DPhysiol users, whereas the remaining 2.2% (2 men and 2 women) were nonusers.

DPhysiol Usage

Of the registered DPhysiol users, 90.7% of the students ($n = 176$) enrolled within the first 2 wk after DPhysiol was made available. The site recorded a total of 6,347 visits and 51,935 hits during the entire academic session (*weeks 1–42*, a total of 291 days). This translates into an average of ~21 visits and 178 hits/day, with a visits-to-hits ratio of ~1:8.

Weekly visits and hits during the entire course are shown in Fig. 2. Students had a total of 6 wk of holidays, and their exams were held on *week 21* and *week 42*. Although there were no significant differences between the average numbers of visits per week for *term 1* (161 ± 57, mean ± SD) and *term 2* (140 ± 55), the average number of hits per week was significantly lower in *term 2* (875 ± 416) compared with *term 1* (1,564 ± 811, $P < 0.05$). This indicates that while students may have been enthusiastic to use the site initially, they probably became more discerning in their learning needs in the later part of the course.

Students tended to use the site more frequently during their study period compared with during the weeks of holiday and exams. The mean number of hits on weekdays (204 ± 160 hits/day) was significantly higher than that of weekends (141 ± 108 hits/day, $P < 0.05$) during the study period. However, the mean numbers of hits on weekdays and weekends during the holidays and exam periods were not significantly different.

When DPhysiol usage was compared by sex, mean hits per day per student for male (0.98 ± 0.81) and female (0.84 ± 0.65) DPhysiol users did not significantly differ.

The total hits for various resources made available in DPhysiol are shown in Fig. 3. The most frequently used content was the interactive functions (8,867 hits), which includes a discussion forum (5,979 hits), announcement forum (2,766 hits), and chat function (122 hits). Other frequently used resources were lecture notes (8,075 hits), quizzes (4,006 hits), and AV resources (2,580 hits). The average access per uploaded lecture note was 192 hits/file, whereas accesses for AV resources were 107 hits/file. Of all the quizzes available to

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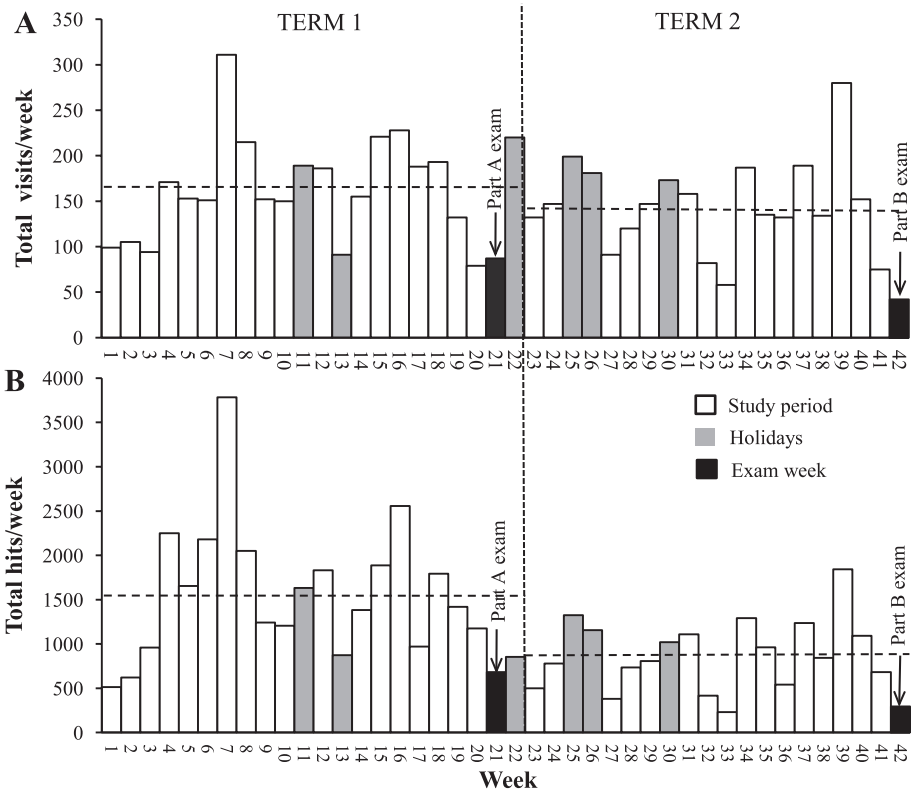

Fig. 2. Total weekly visits (*A*) and hits (*B*) of students to the DPhysiol site for *term 1* and *term 2* of their course. Horizontal lines indicate mean visits and mean hits per term.

students, the most-attempted quiz recorded an attempt rate of 85.6% (166 of 194 users), whereas the least-attempted quiz recorded only a 13.9% attempt rate (27 of 194 users).

The discussion forum had a total of 54 posts (52 by students and 2 by tutors) and 121 replies (105 from students and 16 from tutors). A typical example of a forum discussion involving student-student communication is shown in Fig. 4. For the announcement forum, there were 35 postings by tutors.

Examination Marks and DPhysiol Usage

When individual student exam marks were compared with DPhysiol usage, there was no significant correlation between student examination scores in the physiology component of *part A* and *part B* exams and their corresponding total hits from DPhysiol recorded during *term 1* and *Term 2*. The mean of overall hits as well as hits for the four most popular resources available in DPhysiol for students who ranked in the top 10% of the class was also not significantly different from those who ranked in the bottom 10% (Table 1).

There was a weak but significant correlation between students' participation in the online quizzes and their final physiology exam marks (Fig. 5A). A significant correlation was also found between students' marks obtained from the online quizzes and their final exam marks (Fig. 5*B*).

When mean final physiology marks obtained by students in the year of 2008/2009 were compared with the previous cohort (2007/2008), there was a significant improvement in scores (Table 2). However, no significant difference was detected in the marks of the anatomy component between the two academic years.

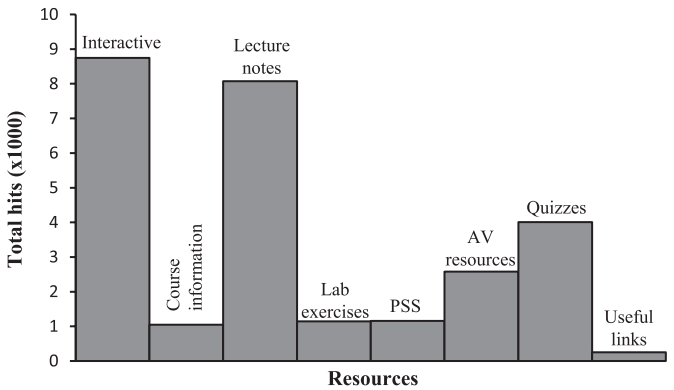

Fig. 3. Total hits of students for the various resources available in DPhysiol. PSS, problem-solving session; AV, audiovisual.

Student Feedback From the Questionnaire

The abbreviated statements that were included in the second part of the questionnaire and the corresponding responses from DPhysiol users are shown in Table 3. Most respondents commented positively (strongly agree/agree) on the convenience of the registration process (71.8%), accessibility (67.8%), and ease of use (78.2%; Table 3, *statements 1–3*). Most of the users (70.1%) were happy and satisfied to use DPhysiol (Table 3, *statement 4*).

According to 85.1% of the respondents, the materials available in DPhysiol were relevant and appropriate, and 88.5% of them agreed that the materials were useful. When asked about the use of DPhysiol as a communication tool, 56.9% of the respondents believed that it allowed interactions with other students (*statement 8*), whereas 55.1% agreed it enabled stu-

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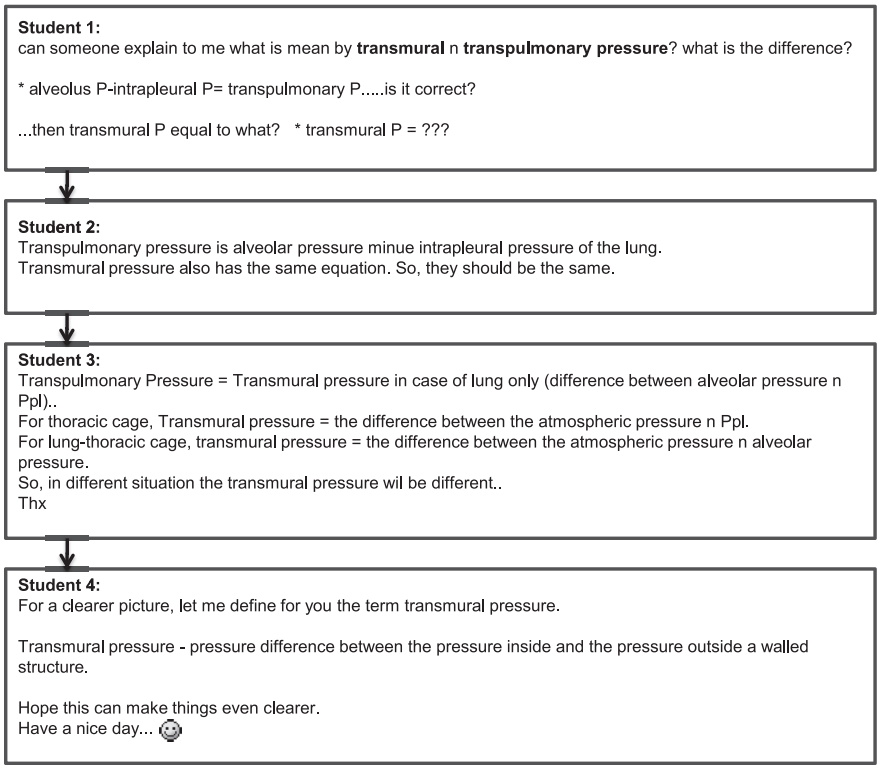

Fig. 4. Example of student-student communication in the discussion forum. P, pressure.

dent-lecturer interactions (*statement 9*). Most respondents expressed neutral (31.4%) to negative (37.7%) opinions on the question regarding the potential of DPhysiol to replace traditional learning (*statement 12*). Despite agreeing that DPhysiol complemented traditional face-to-face learning (59.8%), students still preferred to learn through conventional lessons, which was evident from their responses to *statement 13*. Respondents (78.1%) strongly recommended the continuation of DPhysiol (*statement 14*), and 82.2% of them proposed that a similar e-learning tool be used by other departments in the medical faculty (*statement 15*).

From the narrative response section (Table 4), it was clear that students liked the online lecture notes but preferred to have them uploaded before the lectures. They also liked the quiz feature but requested more exam-based questions (short-answer type, multiple-choice questions, and essays). Although they appreciated the availability of communication with lecturers and peers, some students complained about irrelevant comments in the forum. It also appeared that students experienced problems with the internet connection and speed. Unfortunately, none of the nonusers provided any feedback in the narrative response section, and their reason(s) for not using DPhysiol is not known.

Table 1. *Comparison of overall hits for DPhysiol and hits for the four most popular resources in DPhysiol for high-ranked (students in top 10%) and low-ranked (students in bottom 10%) students*

	Top 10%	Bottom 10%	*P* Value
Overall hits	274 ± 303	242 ± 144	0.6794
Interactive section	61 ± 79	40 ± 30	0.2853
Lecture notes	43 ± 35	57 ± 46	0.2960
Audiovisual resources	14 ± 23	18 ± 17	0.5869
Quizzes	50 ± 45	38 ± 26	0.3273

Values are means ± SD; $n = 19$ students in the the top 10% and 19 students in the bottom 10%.

DISCUSSION

This study describes our initial experience of integrating an open-source CMS (Moodle) to support teaching and learning of physiology to a group of first-year undergraduate medical students. We assessed student usage patterns, performance in final exams, and feedback on the introduction of the DPhysiol Moodle site.

Impact of CMS on Student Performance

The introduction of Moodle significantly improved student final physiology exam marks compared with the previous class that did not use it, suggesting that the implementation of Moodle as a complementary e-learning tool had a positive effect on student learning outcome. The introduction of DPhysiol as a supplement to traditional teaching can be beneficial for students in various ways. The interactive features that promote active learning can assist students to better grasp concepts being taught, resulting in better exam performance. Online quizzes with instant feedback would allow them to better evaluate their understanding of the subject and facilitate exam preparation. Furthermore, the availability of an additional learning tool could increase their motivation to study.

In line with previous studies (8, 17), we noted that students' performance in online quizzes also positively correlated with their performance in final exams. This finding is not surprising as it is natural for good students to do well in online quizzes and subsequently perform better in exams. However, we did

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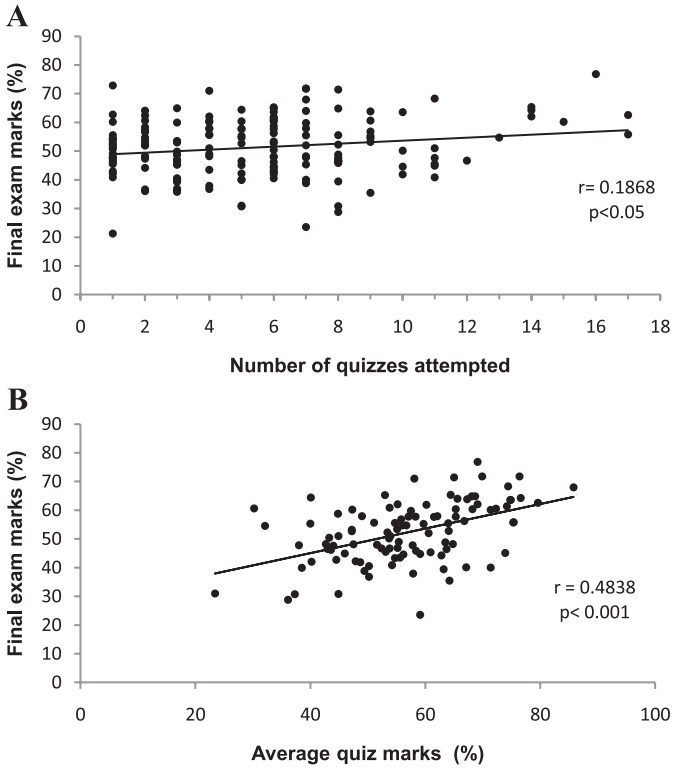

Fig. 5. Correlation between students' final physiology marks with number of online quizzes attempted by the students ($n = 161$; *A*) and average online quiz marks obtained by the students ($n = 104$; *B*).

not find any association between students' total page hits and their final exam marks. In addition, the number of hits for various resources in DPhysiol for high-ranked students did not significantly differ from that of low-ranked students. This finding is interesting as it has been suggested in previous studies (23, 29) that higher CMS usage correlated with better student exam performance. However, our present study indicates that both good and weak students were equally motivated to use the CMS, implying that this tool was well received by both categories of students.

Student Satisfaction

From student feedback, it is clear that students were generally satisfied with this e-learning tool. Students found the Moodle site to be readily accessible, convenient to register, and easy to use. They also agreed that the materials available in DPhysiol were both relevant and useful. This perception is also reflected in their request for the continued usage of the CMS and recommendation for other departments in our faculty to implement a similar online platform. However, only about half of the students agreed that the Moodle site allowed interactions with their peers and tutors.

Factors Affecting Student Interactions

Moodle was originally designed based on the social constructivist learning model (13), which posits that students learn best when they interact with the learning material, their peers, and tutors. Although the most frequently visited resource in DPhysiol was the interactive functions, not all students fully participated in it. For example, although students regularly viewed comments posted in the discussion forum, the total number of posts and replies was low. Students' reluctance to actively participate in the interactive features such as the discussion forum could be due to their busy schedule, unfamiliarity with online forums, and lack of incentives for participation.

Student participation in the interactive activities can be also influenced by tutors' involvement (26). In the present study, we encouraged tutors to play a facilitator's role in the discussion forums, by mainly replying to students' postings when they thought it was necessary. This resulted in only a total of 2 postings and 16 replies by tutors. For effective use of online forums, tutors can actively post questions and comments relevant to the curriculum that lead to critical thinking and deeper learning (22). Incentives can be given to students by grading them based on their participation and content of their postings. Another possible method for improving forum participation is by designating student facilitators, who take turns to lead discussion topics (22).

Limitations of DPhysiol Design and Usage

This was a pioneer project and as such, there were several shortcomings in the design of DPhysiol. First, there was a lack of comprehensive, exam-based questions in the quiz section. Well-designed online quizzes made available for students in physiology courses can help enhance performance in final exams (12, 17). Presumably, due to lack of exam-based questions and incentives for participation, the usage of online quizzes in DPhysiol was only less than half compared with interactive functions. Rewarding students through course credits has been shown to increase student participation rates in online quizzes (17). In addition, various "marketing" strategies such as providing an introductory lecture to emphasize the importance of participating in online quizzes, regular in-class reminders, and subsequent followup discussions can be used (18). The quiz module in Moodle offers a large number of options and tools that are currently underused (6, 30). Presently, efforts are underway to develop a more comprehensive online quiz section and to include it as a part of the formative assessment of our physiology course.

Although the CMS was primarily designed to be used as an interactive learning tool, we also made lesson materials available online for students. This decision was well received by the students (the most liked feature of DPhysiol was the lecture notes) as they were able to access the notes promptly and in color as well. However, we noted that having lecture notes online encouraged some students to use the CMS merely for downloading them rather than using them as a learning tool. Furthermore, the designing of the interactive functions was not

Table 2. *Final physiology and anatomy exam marks for students in academic sessions 2007/2008 and 2008/2009*

	2007/2008 Cohort	2008/2009 Cohort	*P* Value
Physiology	48.8 ± 10.3	50.9 ± 9.9	0.0353†
Anatomy	51.9 ± 11.4	51.6 ± 12.3	0.7663

Values are means ± SD; $n = 211$ students in the 2007/2008 cohort and 216 students in the 2008/2009 cohort. The modular object-oriented dynamic learning environment (Moodle) was introduced to the students at the beginning of the 2008/2009 session. †Significant at the 0.05 level.

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Table 3. *Summary of student responses to 15 statements provided in the questionnaire using a five-point Likert scale*

	Strongly Agree		Agree		Neutral		Disagree		Strongly Disagree		N/A		
	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	Means ± SD
Statement 1. The registration process was simple.	19.5	34	52.3	91	27.0	47	1.2	2	0	0	0	0	3.90 ± 0.8
Statement 2. It was easy to access.	13.8	24	54.0	94	25.9	45	5.2	9	1.2	2	0	0	3.74 ± 0.9
Statement 3. It was easy to navigate and use.	16.7	29	61.5	107	21.3	37	0.6	1	0	0	0	0	3.94 ± 0.7
Statement 4. I was happy and satisfied to use it.	17.8	31	52.3	91	27.0	47	2.9	5	0	0	0	0	3.85 ± 0.8
Statement 5. The materials on it were relevant and appropriate.	23.0	40	62.1	108	14.9	26	0	0	0	0	0	0	4.08 ± 0.7
Statement 6. The uploaded materials were useful.	29.3	51	59.2	103	10.9	19	0.6	1	0	0	0	0	4.17 ± 0.7
Statement 7. The materials could be easily downloaded.	17.8	31	42.5	74	29.3	51	8.6	15	1.7	3	0	0	3.66 ± 1.0
Statement 8. It allowed interactions with other students.	11.5	20	45.4	79	39.1	68	1.7	3	1.2	2	1.2	2	3.65 ± 0.8
Statement 9. It allowed interactions with lecturers/tutors.	8.0	14	47.1	82	39.1	68	4.6	8	0.6	1	0.6	1	3.58 ± 0.7
Statement 10. It helped me to further my understanding about the topic taught in physiology.	10.3	18	50.0	87	35.6	62	4.0	7	0	0	0	0	3.67 ± 0.8
Statement 11. It complemented traditional learning through lectures and tutorials.	9.2	16	50.6	88	37.4	65	2.3	4	0.6	1	0	0	3.66 ± 0.8
Statement 12. Learning through it could replace some lectures and tutorials.	6.3	11	22.4	39	31.6	55	29.3	51	8.6	15	1.7	3	2.88 ± 1.1
Statement 13. I prefer to learn through Moodle e-learning rather than conventional face-to-face lessons.	4.6	8	9.2	16	30.5	53	38.5	67	15.5	27	1.7	3	2.44 ± 1.0
Statement 14. I recommend the Department of Physiology to continue using Moodle e-learning.	42.5	74	37.4	65	18.4	32	0.6	1	1.2	2	0	0	4.20 ± 0.9
Statement 15. I recommend that other departments also use Moodle e-learning.	44.3	77	37.9	66	15.5	27	1.7	3	0.6	1	0	0	4.24 ± 0.9

Statements were scored using a five-point Likert scale, where *5* = strongly agree, *4* = agree; *3* = neutral, *2* = disagree, and *1* = strongly disagree. N/A, not available.

attractive for students as no incentives were offered for their participation. As discussed earlier, we hope to address this issue by coming up with additional strategies to encourage the usage of the CMS for interactive learning.

Throughout the course, tutors only uploaded lecture notes onto DPhysiol after their lectures, mainly due to the assumption that students may decide to access the notes via the CMS and skip lectures. This concern has been shared by other authors (5, 9). However, availability of lecture notes online before the lecture would enable students to read the notes beforehand and have printed notes with them during lectures. This can help them concentrate in understanding lecture contents without being burdened with the task of taking notes as well (10). In the year after this report, we encouraged lecturers to upload their notes into the CMS before lectures, and this did not appreciably affect student attendance at lectures.

Table 4. *Key points of the students' opinions about DPhysiol provided in the narrative response section of the questionnaire*

Key Points	Number of Responses
Question 1. What did you like about DPhysiol?	
Lecture notes	77
Quizzes	48
Videos	32
Communication with tutors and peers	12
New way of learning	6
Question 2. What did you not like about it?	
Lecture notes uploaded after lecture	49
Poor internet connection	20
Slow download	12
Irrelevant comments in the forum	16
Question 3. How could it be improved?	
Uploading of lecture notes before lecture	57
Better internet connection	19
More exam-oriented quizzes	10
Question 4. Further comments.	
Internet accessibility is poor in campus	8
Other departments should implement Moodle	7
Very good	9

Finally, students also voiced concern over the poor internet connection and download speed in the campus. Students using CMSs are likely to be dissatisfied if network resources to support online learning are limited (16). Presently, the wired internet network in the University of Malaya uses an Ethernet broadband line with a data transmission rate of 100-Mbits/s, which, from our experience, is satisfactory. However, during the duration of this study, the Wifi-based wireless access in our university was still in its infancy, and coverage was limited. From our observations, many of our students use personal laptops and are likely to access the CMS using them. The ongoing efforts from our university to expand and improve the wireless network access should offer solutions to this issue in the future.

Educational Benefits and Implications of the Study

Using the CMS to supplement traditional classroom teaching provides many benefits. As discussed earlier, the CMS provides an opportunity for cooperative learning. The features

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available in the CMS promote interactions with learning resources that can enhance student interest and motivation. In addition, it also increases flexibility in the teaching and learning process. The CMS allows students to decide where and when they want to engage in learning, and it can have the effect of bringing educators and students closer together (3). It was found that students were willing to use DPhysiol outside formal teaching hours, including on weekends and holidays. This is a great advantage in courses such as medicine, where students and educators are equally busy and have limited physical interactions with one another.

If the CMS offers greater rewards in teaching, is it then acceptable to replace the traditional method of teaching with web-based learning? The feedback from our students indicates that despite being strongly supportive of DPhysiol usage as an adjunct to the traditional style of teaching, they were largely apprehensive of its potential as a substitute to face-to-face teaching. This finding concurs with the findings from another study (11) that compared student feedback of web-based physiology teaching with traditionally conducted lectures. The unwillingness of students to adopt the online method completely may be caused by lack of familiarity with web-based teaching. After years of learning in conventional styles and environments, the perceived indispensability of face-to-face learning may have been ingrained in their minds. Thus, educators should be aware that any effort to replace conventional teaching with an online method should be carried out in carefully planned stages rather than as an abrupt shift of teaching medium.

Conclusions

Based on our initial evaluation, the integration of the freely available Moodle platform into our first-year medical physiology teaching clearly provided many advantages. The Moodle platform was user friendly, had many interactive features that could enhance the students' learning experience, and allowed more flexibility in teaching. The introduction of Moodle also improved student performance in their final summative exams, suggesting that it had a positive impact on student learning outcomes. We recommend Moodle as an option for physiology educators who are interested in incorporating CMS in their teaching domain.

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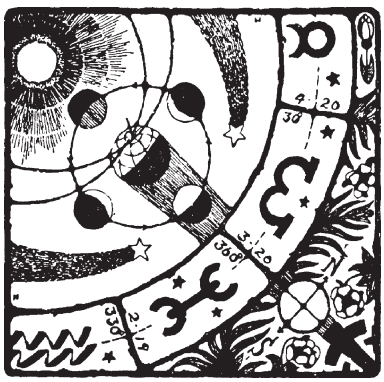

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