Introducing an Open-Source Course Management System (Moodle) for Infectious Diseases and Microbiology blended learning, third year of medical study.

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Introducing an Open-Source Course Management System (Moodle) for Infectious Diseases and Microbiology blended learning, third year of medical study.

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Key-words: course management systems, Moodle, feedback, interactivity

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ABSTRACT

Objectives. After the first year of medical school in France, attendance to face-to-face courses is low in the 2nd and 3rd years, mostly because of a lack of interactivity. We used Moodle (an open-source course management system) to introduce blended learning of Infectious Diseases and Microbiology through interactive quizzes and sessions of online continuous assessment. Our primary objective was to assess the effect of Moodle on students’ attendance, satisfaction and performance with a pre-post observational study design.

Methods. Infectious Diseases and Microbiology (UE14) are compulsory subjects taught in third year of Medical school (DFGSM3) at Paris Descartes University (France). During 2017-2018 academic session, we included interactive quizzes during face-to-face courses, through Moodle. Students used their own devices to answer multiple/single choice questions online, in real-time. After twenty seconds, the teacher displayed a global result of these anonymous votes, thus providing a direct feedback regarding students’ answers. We also organized five sessions of continuous assessment using Moodle during which students had twenty minutes to answer ten quizzes on their own devices. A global feedback was provided to all attending students. Their results to continuous assessment sessions accounted for 10% of their final mark.

Results. Mean (±SD) attendance over the 63 UE14 courses was 33.4 (±9.3) and 47.3 (±25.9) students in 2016-2017 and 2017-2018, respectively (p<0.001). Interactive courses were more frequently considered to improve teaching in 2018 than in 2017 (81.9% vs. 73.8%, p=0.01). Students more frequently recommended next-year students to attend UE14 courses in 2017-2018 than in 2016-2017 (96.1% vs. 42.1%, p<0.001). When restricted to students attending ≥25% of courses, courses quality was considered excellent or good. Interactive quizzes were more frequently considered beneficial, as compared to continuous assessment sessions. Among the eleven teachers who gave at least one course using interactive quizzes on Moodle, most of them considered that it helped them teaching and all planned to continue using Moodle next year. Due to a technical issue, we could not compare students’ performance between 2016-2017 and 2017-2018 academic sessions.

Conclusion. Using Moodle for blended learning of Infectious Diseases and Microbiology improved students’ attendance to face-to-face courses and improved their level of satisfaction.
INTRODUCTION

After the first year of medical school in France, attendance to face-to-face courses is low in the 2nd and 3rd years. This observation may mainly result from both the lack of interactivity during the courses and the availability of online learning resources including student-driven summary of each course that is distributed to all classmates. The combination of these two factors leads to a perceived lack of pedagogical benefits for students who physically attend face-to-face lectures.

Several course management systems (CMS) have been adopted by tertiary institutions in order to improve online teaching activities. One of the most frequently used open-source CMS is the modular object-oriented dynamic learning environment (Moodle), created by Martin Dougiamas in 2002 and available for free on the Web (http://www.moodle.org) (1). Moodle allows the construction of online teaching environments with teaching materials (2) and the creation of online activities such as quizzes to improve interactivity during a lecture or tests for continuous assessment (1, 3). Several reports described the use of Moodle for online teaching of medical disciplines such as Urology, Thoracic Surgery, Physiology, Epidemiology and Medical Statistics, among others (3-9). Beyond the fact that Moodle is frequently well-accepted by students, some studies also reported that the use of Moodle may improve student knowledge and grades, as compared to face-to-face courses (10, 11). More recently, Moodle has been reported as a tool to enrich face-to-face courses, leading to the emerging concept of blended learning (8, 12).

Infectious Diseases and Microbiology are taught during the third year of medical school at Paris Descartes University and we observed that less than 10% of the class attended our face-to-face courses in 2017. Furthermore, through satisfaction surveys, students repeatedly requested more interactivity and the use of online platform. Thus, we decided to use Moodle to introduce blended learning of Infectious Diseases and Microbiology through interactive quizzes during face-to-face courses and sessions of online continuous assessment. Our primary objective was to assess the effect of Moodle on students’ attendance, satisfaction and performance with a pre-post observational study design.
METHODS

Description of French medical studies and Infectious Diseases/Microbiology courses at Paris Descartes University.

French medical undergraduate 6-year curriculum includes a first cycle of three years (starting with PACES, a competitive exam, followed by two years of DFGSM for “Diplôme de formation générale en sciences médicales”) and a 3-year second cycle (DFASM for “Diplôme de formation approfondie en sciences médicales”). Following these six years, students pass a national competitive exam (“ECN” for examen national classant) allowing to choose internship specialty and location. After the first-year competitive exam (PACES), the average class size is about 400 students at Paris Descartes University.

Infectious Diseases and Microbiology (i.e. UE14 for “Unité d’Enseignement 14”) are among the compulsory subjects that are taught in third year of Medical school (DFGSM3) at Paris Descartes University (France) and include the following disciplines: Infectious Diseases, Bacteriology, Virology, Myco-Parasitology, Nosocomial Infections and Infection Control. UE14 includes 88 teaching hours composed of 63 face-to-face courses (between January and March). Half of these courses (31/63) are performed by two concomitant teachers (one physician and one biologist). During these 31 “clinical case-based” courses, questions are asked to students, using vote by show of hands.

Pre-intervention assessment

During the 2016-2017 academic session, we quantified the number of students attending each course and we recorded their marks at the end-of-session exam. Afterwards, we used an online satisfaction questionnaire using closed and open-ended questions in order to assess their perception of UE14 teaching. In 2016-2017, Paris Descartes University already used Moodle (version 2.7) for other teaching activities but none of the UE14 disciplines were using it.

Intervention

Preliminary steps. At the end of 2016-2017 academic session, this teaching project was validated and authorized by Paris Descartes University teaching board. Ten UE14 teachers were trained to Moodle by EJ and BP. Online teaching environments for all UE14 disciplines were constructed (Supplementary Figure 1) with
teaching materials including links to national syllabus and videos for all the 63 courses performed in 2016-2017. In June 2017, crash-test courses were performed with DFASM3 students. During summer 2017, Moodle version was upgraded to 3.3.

*Information to students.* During the first UE14 course of the 2017-2018 academic session, a brief description of Moodle, its options and functions was made to students. This material was left available on the UE14 teaching environment on Moodle, associated with course structure and timetable. We also used Moodle to post weekly announcements to all DFGSM3 students regarding the Moodle-based interactive courses. In this message, we recommended students to read the dedicated chapter from national syllabus but also to bring their own devices (see below).

*Interactive quizzes.* Interactive quizzes (using the “questionnaire” function of Moodle) were included in 14/63 (22.2%) face-to-face courses and their use relied on the “bring your own device (BYOD)” system. Touchpad could also be borrowed for free at the Paris Descartes University Library. Most of these “Moodle courses” were “clinical case-based” courses (13/14, 93%). The number (usually between 5 and 10) and composition of each quiz were left to the teacher discretion. Teachers could scatter quizzes throughout the lecture or decide to gather them at the end of the talk. Quizzes could consist of multiple/single choice questions. Their goal was to assess the level of knowledge and understanding of students before or after explaining a concept. No time limit was specified but teachers could end a vote when a sufficient number of students answered (usually after 20 seconds). Only one try per quiz was allowed. These quizzes were anonymous and none of the students’ answers were included in their final mark. Right after students finished to answer a quiz, the teacher displayed a global result of the vote with the percentage of answers for each item (*Supplementary Figure 2*). Teachers were encouraged to discuss each of the students’ answers (either wrong or right).

*Continuous assessment.* We also organized sessions of continuous assessment using Moodle (using the “test” function) and BYOD system. Five sessions were planed between January and March 2018. They all took place on Tuesday afternoon. Students were recalled the session date and time via Moodle and were informed about which previous courses could be part of the exam. Each session was composed of ten quizzes and students had 20 minutes to complete the test. Each quiz was prepared by the teachers of the courses from the previous
week and had to highlight the most important message of each course. One teacher (DL) was present at the beginning of all continuous assessment sessions in order to initiate the activity on Moodle. After 20 minutes, the test ended and students could not modify their answers any longer. Their results were stored and used for their final mark. Apart from the first session, which was used as a final crash-test session, addition of the students’ results at the four other sessions accounted for 10% of their final mark. After each session of continuous assessment test, one teacher (DL) commented on each question/answer. The pdf version of these annotated questions/answers was left available on Moodle.

**Outcomes and evaluation.**

To assess the effect of our intervention, the following outcomes were measured:

*Student attendance.* Each teacher was asked to quantify the number of student attending the course.

*Student satisfaction questionnaire.* In 2017-2018, we used the same questionnaire as in 2016-2017. In addition, several questions were added to assess the students’ perception of the use of Moodle using Likert-like scales (from strongly disagree to strongly agree), closed and open-ended questions. Students were also encouraged to include free comments as a feedback regarding interactive quizzes and continuous assessment sessions.

*Teacher satisfaction questionnaire.* All teachers who had given at least one course using interactive quizzes with Moodle were asked to answer a satisfaction questionnaire regarding the perceived impact, benefits and limits of the use of Moodle.

*Student performance.* UE14 exam occurs two weeks after the last course. It is performed on touchpads and includes two clinical cases in Infectious Diseases (with 15 questions for each case), one clinical case in Mycology or Parasitology and standalone quizzes of Bacteriology, Virology, Nosocomial Infections and Infection Control (20 multiple or single-choice questions for each discipline). After finishing the exam, these subjects are transferred to a national database (SiDES: http://side-sante.org/) that is used for students’ training to the ECN. No paper version of this exam is available. To compare students’ performance in 2016-2017 and 2017-2018, we planned to use the same clinical cases in Infectious Diseases for both exams. Teachers and students were not informed and we asked SiDES administrative staff to remove these cases from SiDES database before the start of 2017-2018 UE14 academic session.
**Statistical Analysis**

Continuous data are presented as medians (ranges) or means (SD), and categorical data are presented as numbers (proportions). Bivariable analyses were performed using the Fisher exact or chi-square tests to compare categorical variables, and Student t-tests or Wilcoxon Mann-Whitney tests were performed to compare continuous variables, depending on the number of subjects in each group. A p-value of < 0.05 was considered statistically significant.
RESULTS

Description of the classes and student attendance. 2016-2017 and 2017-2018 DFGSM3 classes were composed of 444 and 405 students, respectively. Among these classes, the proportion of female students was higher in 2017-2018 than in 2016-2017 (259/405, 63.9% and 235/444, 52.9%, $\chi^2$ p<0.001). Considering that 24 and 29 students went abroad during the entire academic session for international exchange with other faculties (Erasmus program), actual classes were composed of 420 and 376 students in 2016-2017 and 2017-2018, respectively. The mean (±SD) attendance over the 63 UE14 courses was 33.4 (±9.3) and 47.3 (±25.9) students in 2016-2017 and 2017-2018, respectively (student t-test, p<0.001). In 2017-2018, an unusually high number of attending students was observed during five courses that correspond to the continuous assessment sessions (Figure 1A and B). However, the mean rate of attendance over the 58 other UE14 courses was also higher in 2017-2018 compared with 2016-2017 (40.8 (±12) versus 34.2 (±9), student t-test, p<0.001).

Students satisfaction questionnaire. Questionnaire was completed by 248/420 (59%) and 166/376 (44%) of the students in 2016-2017 and 2017-2018, respectively (Table 1). In 2017-2018, number and duration of clinical case-based courses were more frequently considered as adequate than in 2016-2018 (81.9% vs. 69.8%, $\chi^2$, p<0.001). Clinical case-based courses were also more frequently considered to improve UE14 teaching and learning (81.9% vs. 73.8%, $\chi^2$, p=0.01). Students more frequently recommended next-year students to attend UE14 courses in 2017-2018 than in 2016-2017 (96.1% vs. 42.1%, $\chi^2$, p<0.001). When restricted to students attending ≥25% of courses, courses quality was considered excellent or good (Figure 2).

When focusing on the students’ perception of the educational benefit for each Moodle activity, interactive quizzes were more frequently considered beneficial, as compared to continuous assessment sessions (Figure 3). Most of free comments regarding interactive quizzes were positive (Table 2). Most frequent suggestion from students is the importance of a dedicated feedback from teachers to all questions. Regarding continuous assessment sessions, the main criticism was that questions were considered too difficult by 39.3% of the students (35/89) who made free comments (Table 2).

Teacher satisfaction. Among the eleven teachers who gave at least one course using interactive quizzes on Moodle, most of them considered that it helped them teaching (mean answer=3.3/4, Figure 4). All teachers
planned to continue using Moodle next year. Main limitations of the tool include the time spent for question preparation and upload on Moodle and the loss of time because of technical aspects during the course.

**Student performance.** Both infectious diseases clinical cases that were used during 2016-2017 exam were removed from national database a week before the beginning of UE14 courses. Unfortunately, due to a technical issue, both of them reappeared a week before the 2017-2018 exam. As a consequence, most of students used these clinical cases as training before passing the exam. Unsurprisingly, their grades were better in 2017-2018, as compared to 2016-2017 *(Supplementary Figure 3).* Among 2017-2018 class, grades were better among those who trained, as compared to those who did not.
DISCUSSION

Our study aimed to assess with a pre-post observational design the effect of using Moodle to introduce blended learning of Infectious Diseases and Microbiology on students’ attendance, satisfaction and performance. Compared to 2016-2017, we observed a higher student attendance to face-to-face courses and an improved level of student satisfaction in 2017-2018.

Over the last decade, CMS (including Moodle) gained more attention, because of the wide range of teaching possibilities they could bring, including the use of interactive activities or the diffusion of teaching materials. In this context, we used Moodle to maintain continuity between face-to-face lectures and interactive quizzes. The main benefit of performing embedded and real-time quizzes was to take advantage of students correct or wrong answers. As acknowledged by students in the satisfaction questionnaire, the quizzes teaching benefit is correlated to the time spent by the teacher for debriefing, right after the students’ answers are shown. Moodle quizzes can be used as a pre-test (before explaining a concept, to assess the level of knowledge and adapt the content of the course accordingly) or as a post-test (to check students understanding of the concept).

Even if students’ attendance was higher, as compared to previous academic session, one can also observe that only a minority of them came to face-to-face lectures. Several reasons may explain this observation, including the fact that less than a quarter of courses included interactive quizzes or the fact that some students may have been unaware of this innovation. It is also likely that several students do not need to attend face-to-face courses and are able to understand and learn a discipline using only online resources and textbooks. As a consequence, expecting full attendance does not seem to make sense.

We also introduced five sessions of continuous assessments, occurring every one or two weeks. Our aim was to help students to identify and focus on cornerstone items of each disciplines. The other theoretical benefit of this activity was to incite them to progressively absorb knowledge content and to avoid “binge-learning” few days before the exam. The Moodle function “test” fits these goals and allows to restrict the capacity to answer to identified students during a specific duration, with the use of a countdown initiated by the student’s click. After the end of the session, students’ grade can easily be integrated in their final score. An immediate feedback regarding correct or wrong answers was provided to those who were present in the classroom (usually about 100 students). Through the satisfaction questionnaire, students provided valuable and
constructive feedback regarding technical or educational aspects that we did not anticipated. For instance, they propose to reduce the time left to answer questions in order to reduce the risk of fraud but also to increase the duration of feedbacks. They also requested a 1-week delay between a lecture and the question related to it. These upgrades will be included in the 2018-2019 academic session.

Beyond the overall positive feedbacks from students and teachers, one of the main limitation of our study is our inability to assess the benefits of introducing Moodle on students’ performance during the final exam. We first planned to compared the grades of 2016-2017 and 2017-2018 classes at two identical Infectious Diseases clinical cases. To do so, these cases were removed from national and local databases, in order to prevent students from training with them. Unfortunately, these two cases were reinstated in the database one week before the UE14 exam. Thus, the significant improvement of the students’ grade is likely related to their training. The lack of a robust assessment of the effect of e- or blended learning on knowledge retention among our students might indeed constitute a barrier to the introduction of CMS in medical teaching based on evidence (5). Most of studies demonstrated that the high-volume users of Moodle tended to have a greater score improvement but the obvious motivation bias prevent from drawing any definitive conclusions from these studies (4). Another study reported a significant improvement in students’ knowledge and performance using Moodle in unrandomized students group (11). However, the optimal assessment method would be to perform a randomized controlled trial (RCT) during which half of a class receives “classic” face-to-face courses (with no connection to Moodle resources or activities) whereas the other half receives blended learning.

Another limitation of our study is the fact that only 22% of courses included interactive quizzes. Ten additional teachers agreed to receive a training dedicated to Moodle whereas our goal was to expand its use to a majority of courses. A possible retarder to this spread is the not-so-infrequent teacher reluctance regarding online and informatic tools. One possibility to overcome these hesitations is the creation of teaching duos, including a junior and a senior teacher.

In conclusion, using Moodle for blended learning of Infectious Diseases and Microbiology improved students attendance to face-to-face courses and improved their level of satisfaction.
ACKNOWLEDGEMENTS

The authors would like to thank all the administrative staff from Paris Descartes University, for their critical and invaluable help (Zoubida Sayah, Jane Brégier, Aurore Cartier and Lucille Gay), Antoine Tesnières, for support and constructive comments and also all the teachers who agreed to include Moodle activities in their teaching: Jade Ghosn, Hervé Lecuyer, Najiby Kassis, Hélène Père, Philippe Morand, Emmanuelle Bille, Véronique Avettand-Fenoel, Amélie Duréault, Caroline Charlier and Dominique Salmon.

We also thank students who helped performing crash-test courses (Alexandre Meunier et Steven Defarge) and Nadia Bahi-Buisson and Frédéric Lene on behalf of the GT commission d'évaluation des enseignements.
REFERENCES


Table 1. Students’ answers to the satisfaction questionnaire after passing the UE14 exam, academic sessions 2016-2017 and 2017-2018. In 2016-2017, the number of responders to the last question was different as it was asked during a second round of questionnaire.

<table>
<thead>
<tr>
<th>Questions</th>
<th>2016-2017</th>
<th>2017-2018</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teaching organization and structure are adequate? Yes, n (%)</td>
<td>199 (80.2)</td>
<td>142 (85.5)</td>
</tr>
<tr>
<td>Number and duration of face-to-face lectures are adequate? Yes, n (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Not enough hours</td>
<td>23 (9.3)</td>
<td>8 (4.8)</td>
</tr>
<tr>
<td>Adequate</td>
<td>199 (80.2)</td>
<td>143 (86.1)</td>
</tr>
<tr>
<td>Too many hours</td>
<td>26 (10.5)</td>
<td>15 (9.0)</td>
</tr>
<tr>
<td>Number and duration of clinical case-based courses are adequate? Yes, n (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Not enough hours</td>
<td>35 (14.1)</td>
<td>12 (7.2)</td>
</tr>
<tr>
<td>Adequate</td>
<td>173 (69.8)</td>
<td>136 (81.9)</td>
</tr>
<tr>
<td>Too many hours</td>
<td>40 (16.1)</td>
<td>18 (10.8)</td>
</tr>
<tr>
<td>Clinical case-based courses improve UE14 teaching and learning? Yes, n (%)</td>
<td>183 (73.8)</td>
<td>136 (81.9)</td>
</tr>
<tr>
<td>Exam difficulty is consistent with courses content? Yes, n (%)</td>
<td>156 (62.9)</td>
<td>134 (80.7)</td>
</tr>
<tr>
<td>Would you recommend next year students to attend UE14 courses? Yes, n (%)</td>
<td>24 (42.1)</td>
<td>160 (96.4)</td>
</tr>
</tbody>
</table>

(responders: n=57 in 2017 and n=166 in 2018)

Table AND FIGURES

NOTE: except for the last question, responders: n=248/420 (59%) in 2017 and n=166/376 (44%) in 2018
Table 2. Students free comments regarding Moodle activities, UE14, academic session 2017-2018

<table>
<thead>
<tr>
<th>Free comments</th>
<th>n (%)</th>
</tr>
</thead>
</table>

**Comments regarding interactive quizzes (n=49)**

| Positive comments | 35 (71.4) |
| Neutral comments/technical suggestions | 11 (22.4) |
| Negative comments | 3 (6.1) |

Examples of free comments:
- "Interactive quizzes are fantastic and should be generalized"
- "Interactive quizzes should be used for all courses"
- "It helped me staying focused during courses"
- "It allows testing our knowledge and understanding in real-time"
- "Feedback from teachers to all quizzes should be more detailed"
- "Frequent loss of time because of technical difficulties"
- "No significant benefits as compared to vote by show of hands"

**Comments regarding continuous assessment sessions (n=89)**

| Positive comments | 21 (23.6) |
| Technical or educational aspects that need to be improved | 33 (37.1) |
| Too difficult | 35 (39.3) |

Examples of free comments:
- "It helps working regularly"
- "It allows the identification of important messages or items"
- "The contribution of the continuous assessment sessions to the final mark should be increased"
- "Performing all sessions at the same moment is unfair to students who have a job outside the University"
- "Reduce the time left to answer the quizzes to reduce the risk of fraud"
- "Increase the face-to-face feedback duration after the session"
- "Respect a 1-week embargo between the course and the question asked on this course"
Figure 1. Number (A) and percentage (B) of students attending each of the 63 UE14 courses in 2016-2017 and 2017-2018 academic sessions. Each dot represents a course. The period between courses n°40 and 60 corresponds to the 2-week winter school vacations. For B panel, actual number of students for each academic session was used (420 in 2016-2017 and 376 in 2017-2018).
Figure 2. Students’ perception of global teaching quality of each discipline in 2016-2017 and 2017-2018 academic sessions (A. Bacteriology and Virology, B. Mycology and Parasitology, C. Infectious Diseases, D. Nosocomial infections and infection control). This part of the questionnaire was restricted to students who attended ≥ 25% of courses (n=51 in 2017 and n=42 in 2018).
Figure 3. Students’ perception of teaching benefit of interactive quizzes and continuous assessment sessions, academic session 2017-2018. Students were asked to answer the following question: “this Moodle activity helped me learning or understanding Infectious Diseases and Microbiology”, through a Likert-like scale. Total number of responders = 166.
Figure 4. Teachers’ perception of educational benefit of interactive quizzes, academic session 2017-2018. The 11 teachers who gave at least one course using interactive quizzes with Moodle were asked to answer the following question: “interactive quizzes helped me teaching Infectious Diseases and Microbiology”, through a Likert-like scale from “strongly disagree (0)” to “strongly agree (4)”. Dark bar indicates mean value (3.36).
**SUPPLEMENTARY DATA**

*Supplementary Figure 1.* Example of Moodle teaching environment for one course in Infectious Diseases (urinary tract infection).
**Supplementary Figure 2.** Example of one interactive quiz answer panel. During this face-to-face course, 125 students were present. After asking the question: “which antibiotic would you recommend for the treatment of uncomplicated pyelonephritis”, students had 20 seconds to answer the question on Moodle. In real-time, students’ answers appear on the quiz answer panel, allowing the teacher to comment their answers.

<table>
<thead>
<tr>
<th>Urinary tract infections</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Question 5</strong></td>
<td>Participants: 125</td>
</tr>
<tr>
<td>Which antibiotic treatment would you recommend (multiple choice question)?</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Answers</td>
</tr>
<tr>
<td>Ceftriaxone IV</td>
<td>104</td>
</tr>
<tr>
<td>Nitrofurantoine orally</td>
<td>25</td>
</tr>
<tr>
<td>Amox + clavulanic acid orally</td>
<td>7</td>
</tr>
<tr>
<td>Amoxicillin orally</td>
<td>3</td>
</tr>
<tr>
<td>Levofloxacin orally</td>
<td>96</td>
</tr>
</tbody>
</table>
Supplementary Figure 3. Students’ grades at two clinical cases in infectious diseases, 2016-2017 and 2017-2018 academic sessions. Solid lines represent the median grade of each group.