

Effectiveness of using blended learning strategies for teaching and learning human anatomy

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OBJECTIVES This study aimed to implement innovative teaching methods – blended learning strategies – that include the use of new information technologies in the teaching of human anatomy and to analyse both the impact of these strategies on academic performance, and the degree of user satisfaction.

METHODS The study was carried out among students in Year 1 of the biology degree curriculum (human biology profile) at Pompeu Fabra University, Barcelona. Two groups of students were tested on knowledge of the anatomy of the locomotor system and results compared between groups. Blended learning strategies were employed in 1 group (BL group, $n = 69$); the other (TT group; $n = 65$) received traditional teaching aided by complementary material that could be accessed on the Internet. Both groups were evaluated using the same types of examination.

RESULTS The average marks presented statistically significant differences (BL 6.3 versus TT 5.0; $P < 0.0001$). The percentage pass rate for the subject in the first call was higher in the BL group (87.9% versus 71.4%; $P = 0.02$), reflecting a lower incidence of students who failed to sit the examination (BL 4.3% versus TT 13.8%; $P = 0.05$). There were no differences regarding overall satisfaction with the teaching received.

CONCLUSIONS Blended learning was more effective than traditional teaching for teaching human anatomy.

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INTRODUCTION

Times are changing and university teaching is not exempt from the repercussions on society that occur as a result of the development and utilisation of new technologies. In fact, the application of computer tools in teaching is among the prevailing themes in the current literature on medical education.¹

Today, despite various efforts, there is still no clear proof that computer-assisted learning is better than the methods used in traditional teaching.^{2–7} Most of the changes introduced so far have concentrated on the development of computer tools as complements to traditional teaching methods, both for consultation purposes and as study material for students,⁸ as well as on their application by teachers as support materials for attendance-based teaching.⁹

In any case, the use of computing in teaching has been imposed on teaching practice, thanks to the ease with which teaching materials can be developed with modern computer programs, which have transformed the simple personal computer into a high-quality, multimedia creative instrument. Moreover, students have evolved in parallel with computers and are not only more demanding of the materials with which they are presented, but are usually highly capable in terms of searching for information and learning materials on the Internet.^{9–11}

Overview

What is already known on this subject

No clear proof exists to demonstrate that computer-assisted learning is more effective than traditional teaching methods in the teaching of human anatomy.

What this study adds

The application of blended learning strategies achieves improved academic performance, an increase in the percentage of students who pass the examination and a decrease in the number of students who fail to sit the examination.

Suggestions for further research

Future research should evaluate the impact of blended learning as a replacement for the whole of a traditional course and assess its impact on long-term learning.

New computer technology applied to teaching has forced various changes on the methods classically used in the teaching of human anatomy.^{12–14} These changes have initially involved the incorporation of computerised materials presented in a variety of formats and used to complement the traditional delivery of the subject^{2,10,15,16} and as an aid with which the lecturer can improve classic teaching.^{17,18} In very few cases have computerised tools fully replaced traditional teaching^{19,20} and in practically none have they led to substantial changes, either to syllabi, or to the number of hours of attendance students must devote to a subject.^{10,21–23}

The comparison between traditional teaching and computer-assisted learning, both in human anatomy and other areas of study, has generated discordant results^{2–6,10,21,24,25} and has highlighted the presence of a number of problems similar to those detected in the application of e-learning strategies in distance learning courses.²⁶ These include difficulties in comprehension and orientation of materials, student doubts as to the most relevant points, and difficulties in ensuring that the teacher is able to control the development of the course and retain the attention of a student who is not physically present in the classroom.^{3,10,20} After all, the student is just a click away from dropping out of class.

In order to avoid such problems, a strategy that may prove useful is semi-attendance-based learning, known as ‘blended learning’.²⁷ This teaching modality is based on the synergic combination of traditional teaching methods with tactics that are characteristic of non-attendance-based distance teaching or e-learning, with the aims of:

- facilitating active learning;
- decreasing the number of hours of attendance-based classes;
- improving or maintaining academic performance and longterm knowledge, while
- avoiding problems that may arise as a result of exclusively non-attendance-based teaching.²⁸

The benefits that can be derived from the use of blended learning in the teaching of human anatomy are listed in Table 1.

At Pompeu Fabra University, a variety of computer-based materials (summary of lessons with linked images in html format, instructions for and key points of practical lessons, examples of tests) have been used since 1998 in the teaching of human anatomy in the long degree in biology (human biology profile), integrated within the classic structure of an attendance-based course on anatomy, which includes theoretical and practical lessons. The materials are diffused through a virtual campus (‘Campus Global’) for use, fundamentally, as complementary study material and to follow up the lessons and practical activities involved in the course. In addition, specific components have been designed (PowerPoint presentations, videos and animations) to help lecturers deliver classes.^{29,30}

However, over the years, there has been a lack of correlation between the effort put into designing the

Table 1 Potential benefits of blended learning in human anatomy

- It makes use of the potential of the subject to render it more attractive
- It modernises teaching methods that have traditionally been used in the teaching of human anatomy
- It develops transversal competencies
- It provides students with solid, reliable, continuously accessible and updateable materials
- It helps to maintain a suitable level of knowledge for the profession
- It improves academic performance
- It increases lecturer?–pupil, pupil–?pupil and lecturer–?lecturer communication flow
- It facilitates adaptation to the Bologna Declaration directives (in the European framework)

teaching materials that make up the subject 'web' and the degree of improvement in assessment results. In addition, students have been observed to put the materials to uses other than those foreseen at the time of drafting, and the results of satisfaction surveys show that students have not been especially satisfied with this type of learning compared with that in other subjects, where this type of complementary tool has not been used.^{29,30}

These limitations prompted us to redesign the teaching materials in order to:

- 1 adapt them to students' needs;
- 2 increase the frequency and effectiveness of their use, and
- 3 get them to play a fundamental role in achieving the subject's teaching aims.

The objective of this study was to analyse the impact of the use of semi-attendance-based teaching strategies on academic performance and satisfaction with the teaching of the anatomy of the human locomotor system.

METHODS

Two groups of students from 2 consecutive years took part in the study. All of them had registered on a course entitled 'Descriptive Anatomy I', in Year 1 of the long degree in biology at Pompeu Fabra University in Barcelona. The characteristics of the groups are shown in Table 2. Students repeating a class were excluded from results analysis.

Both groups had similar characteristics. They comprised students who had achieved fairly high scores in the university admissions examination and of whom similar performances were expected in subsequent tests. In Spain, each university admits a limited number of students according to scores obtained in

the national admissions examination. Our university's cut-off score is consistently among the highest in the country.

The subject comprises a total of 45 class hours devoted to the basic concepts of human anatomy and embryology and the anatomy of the locomotor apparatus. Students in the first group (traditional teaching [TT]) received a total of 30 hours of theoretical (6 hours of embryology, 2 hours of basic concepts of anatomy, 6 hours of arthrology, 13 hours of miology and 3 hours of vascularisation and nerves of the locomotor system) and 15 hours of practical classes (9 hours of osteology and 6 hours in the dissection room studying prosected specimens). In the second group (blended learning [BL]), 13 hours of theory, devoted to study of the muscles, were replaced by non-attendance-based hours using purpose-designed computerised materials with relevant supervision, both online as well as at 3 seminars which students had to attend for support and problem solving activities (Table 3). This part of the course was replaced by the blended learning approach due to difficulties in learning detected in previous years.

Throughout the teaching period, students in the TT group had access via the virtual campus to printable support materials (lecture notes) as study guides. They were also able to view related images via hyperlinks. These materials were designed in html format (1 document per lesson) and connected via hyperlinks with the associated explanatory images.

By contrast, the BL group had access to a surfable web structure designed to allow students to:

- obtain information on the course, its organisation, syllabus, teaching and evaluation methods, and examples thereof;
- gain access to the contents of the whole subject broken down into sections (1 page per section of each lesson), associated with specially designed images and animations for each of them;

Table 2 Characteristics of the groups

	Traditional teaching	Blended learning
Students	65	69
Sex (male : female)	9 : 56	9 : 60
Average previous mark*(SD)	8.34 (0.47)	8.21 (0.56)
Cut-off mark†	7.7	7.3

* Scale 0–10 points

† Cut-off score for university entrance year

SD = standard deviation

Table 3 Characteristics of the course

	Traditional teaching	Blended learning
Total credits	4.5	4.5
Masterclasses	30	17
Practical lessons	15	15
Non-attendance-based lessons	0	13
Seminars	0	3

- print pdf documents for each of the lessons;
- perform specific activities and exercises to participate in lessons where attendance was not necessary, such as interactive multiple-choice, short-answer, jumbled-sentence, crossword, matching/ordering and gap-filling exercises;
- evaluate the knowledge acquired by means of a self-assessment test, which incorporated a mock-up of a multiple-choice test similar in design and composition to those used in the final examination;
- connect with teaching staff by e-mail, and
- discuss issues related to the teaching material with other classmates online in a virtual forum.

Both groups had free, unrestricted access to their respective teaching materials via the virtual campus (<http://campusglobal.upf.es/>).

The programs used to create these tools were: Macromedia Dreamweaver (MACR, San Francisco, CA, USA) for the creation of web pages; Hot Potatoes (Half Baked Software Inc., Victoria, BC, Canada) for the activities and exercises; programs using JAVASCRIPT for setting up self-assessment questionnaires; Adobe Photoshop (Adobe Systems Inc., San Jose, CA, USA) for processing images, and Adobe Acrobat (Adobe Systems Inc.) for creating pdf documents.

Both groups were evaluated at the end of the teaching period through 3 tests: a 30-question, 5-answer multiple-choice test (MCT); a 15-question, short-answer written examination (WE) and a 10-question practical examination (PE) based on recognition of structures. The final mark for the TT group was calculated by applying the following percentages: MCT 60%, AT 25%, PE 15%. During the study period of the non-attendance-based lessons, students in the BL group took 3 MCTs (10 questions, 5 answers, only 1 correct, for each test) as continuous assessment (CA) of the specific knowledge that they had acquired about muscles. The final mark for this group was calculated as follows: CA 30%, MCT 35%, WE 20%, PE 15%. The examination questions, especially in the non-attendance-based section, were designed to evaluate the same items according to different principles. We tried to avoid repetition of questions and to maintain similar levels of difficulty and discrimination in both groups.

Students in the BL group received specific surveys as to the development of their learning, the number of hours dedicated to studying and the uses made of the different types of materials. At the end of the teaching and prior to the final evaluation, both

groups were administered with a standardised survey to assess their level of satisfaction with the teaching they had received. The results of surveys, examinations and final marks were evaluated using a numeric scale (0–10 points).

The results were analysed statistically using Statview Version 5.0 (SAS Institute Inc., Mountain View, CA, USA). The quantitative variables were expressed as means \pm standard deviations (SDs), and the qualitative as proportions and percentages. Student's *t* and Mann–Whitney *U*-tests were used to compare the means of quantitative variables. Chi-square contingency tables were used to investigate the differences between qualitative variables. Significance was established at $P < 0.05$.

RESULTS

Of the 69 students registered on the blended learning course, 65 participated in CA; results can be seen in Table 4. All participating students passed the CA tests, obtaining an average score of 8 points (scale 0–10). Specific satisfaction surveys of the BL group on non-attendance lessons showed a high degree of satisfaction with their learning (mean 7.6 points) and with the teaching materials (mean 7.7). The mean total studying time in order to carry out all the activities involved in the 13 non-attendance-based lessons (including class attendance) was 51 hours (3.9 hours per lesson), most of which was devoted to individual work or study (28.7 hours, 56.3% of total time). When BL students were asked about the subjective importance of the materials provided, the scores given to printed documents and online materials were similar (7.74 versus 7.80; NS; scale 0–10).

Use of the materials available via the web, evaluated by assessing the number of times the subject was accessed, was clearly greater in the semi-attendance-based teaching group, in which 88% increased access (BL 1043 versus TT 555) was detected. This increase in the use of teaching materials was among the aims of this study.

Table 4 Results of the blended learning group

Continuous assessment average mark	8
Participating students	94.2%
Continuous assessment pass rate	100%
Evaluation of overall learning*	7.6
Quality of materials*	7.7

* Scale 0–10 points

When comparing the results obtained in the final evaluation by both groups in the study (Table 5), significant differences favouring the group receiving semi-attendance-based teaching were observed, regarding both quantitative qualifications (TT 5.0 versus BL 6.3; $P < 0.0001$) and the percentage of students who passed the examinations at the first attempt (BL 87.9% versus TT 71.4%; $P = 0.02$); the TT group tended to equalise at the second examination attempt. Likewise, we saw that a higher percentage of students from the BL group sat the first call to evaluation.

When we compared both groups taking into account only the marks obtained at the final test stage, and excluding scores obtained in CA by students in the BL group, the differences maintained their significance, both quantitatively (TT 5.0 [SD 1.7] versus BL 6.1 [SD 1.7]; $P < 0.001$) and as a percentage of passing the subject (TT 71.4% versus BL 85%; $P < 0.01$).

The surveys on satisfaction (Table 6) carried out in both groups of students showed a high level of participation. Regarding overall satisfaction with the teaching received, higher scores were awarded by the

students in the non-attendance group (BL), although the differences were not statistically significant (BL 7.6 versus TT 7.1). The teaching materials obtained high scores in both groups, with differences that significantly favoured the materials used by the BL group. Scores for how interesting the students found the subject were higher in the BL group, but not to the level of significance.

DISCUSSION

Recent years have witnessed the creation of numerous multimedia tools applied to modernise the teaching of human anatomy.^{13,16,17} Fundamentally, in human anatomy, new technologies have meant 3 changes. The first of these concerns the change from the attendance-based masterclass employing drawings on the blackboard or low-quality transparencies to the use of slides accompanied by high-quality images, which has in turn led to greater agility in the realisation of masterclasses and necessary time savings in the theoretical teaching of anatomy.^{19,23,31} The second change involves the emergence of multimedia material complementary to teaching for study, self-assessment and/or use as a communication vehicle between teachers and students.^{2,7,8,15,16,32} The final change refers to the use of computerised tools for the practical teaching of human anatomy, which reflects an attempt to replace, either totally or partially, the use of cadavers in hands-on teaching.^{3,8-10,24,33}

All of the above have coincided with a certain state of crisis in the teaching of human anatomy, to a great extent due to the use of teaching methods that are considered obsolete, the abuse of rote learning and the diminishing importance of the morphological sciences in health science syllabi in favour of a supposedly more biological approach to the medical disciplines. This situation demands alternatives and adaptation to current practices.^{10,12,13,17,34-37}

The use of semi-attendance-based strategies, together with practical teaching on the cadaver in human anatomy, could help towards adapting anatomy teaching fit in with modern times and syllabi, and might serve to unify programmes, criteria and objectives between different universities that teach similar subjects, even in different countries (as is the aim of the European Higher Education Area as set out in the Bologna Declaration).³⁸ It might also improve students' adaptation to the learning of anatomy with tools that are far more familiar to and enjoyable for them than classic

Table 5 Comparison of the academic results of the 2 groups

	Traditional teaching	Blended learning	P
Average mark (SD)*	5.0 (1.6)	6.3 (1.3)	< 0.0001
Subject pass	71.4%	87.9%	0.02
Students not sitting the examination	13.8%	4.3%	0.05
Subject pass (second examination)†	94.3%	95.4%	NS

* Scale 0–10 points

† Students who failed the first examination in June had a second opportunity to sit it in September

SD = standard deviation; NS = not significant

Table 6 Results of the satisfaction surveys in both groups

	Traditional teaching	Blended learning	P
Participation	63%	71%	
Overall satisfaction (SD)*	7.1 (1.8)	7.6 (1.7)	NS
Study materials (SD)*	7.8 (2.0)	8.6 (1.6)	0.03
Interest in the subject (SD)*	6.0 (2.1)	6.8 (2.2)	NS

* Scale 0–10 points

SD = standard deviation; NS = not significant

masterclasses accompanied by blackboard drawings and diagrams.¹¹

This study revealed a clear improvement in the academic performance of students who were taught the anatomy of the locomotor apparatus via blended learning, both in terms of their marks and the number of students who passed the assessment at the first attempt. This effect is maintained when we exclude, in the comparison, the results of the CA carried out in the BL group. A potential limitation of our study that arises from the fact that the examinations administered to the 2 groups contained different questions was overcome by the evaluation of identical concepts. For example, the TT group was asked: 'Which of the following muscles is a shoulder abductor?' and the BL group was asked: 'What is the main action of the deltoid muscle?'

Students who failed the first examination in June were given a second opportunity to take it in September, after a holiday period without any teaching. The percentage of students who passed the subject at the second examination was similar in both groups. We believe that the lack of difference in results at a timepoint when differential teaching methods were no longer being applied reinforces our hypothesis of the positive effect of blended learning.

Likewise, there were fewer dropouts in the BL group than in the TT group. This is regarded as due to the effect of continuous follow-up of students, rather than the fact that the BL group followed a semi-attendance-based regime.

It is interesting to note that, despite this improved performance, student opinions of the subject, level of interest in it and satisfaction with the teaching did not improve, although they did acknowledge the quality of the teaching materials provided. The students continued to show a clear predilection for written material over computerised media, but both were used similarly in preparation for examinations.

The implementation of blended learning is extremely demanding of teaching staff, especially in terms of organisation of the course²⁸ and clear definition of its rules. These require prior reflection that takes into account the students' status as learners, the nature of course content, and the course objectives. Thus, materials can be designed to respond to student expectations, increase student motivation, allow for participation, anticipate problems that may arise during the course, and sufficiently emphasise the subject's key points. At the same time, the materials

must offer tools for the realisation of exercises and activities, for self-assessment and for allowing teaching staff to follow up students' individual and collective progress as the course evolves. Equally, implementation requires institutional IT infrastructure (hardware and software). Recent initiatives using free software and the development of computer networks shared by several universities may be of great interest in this sense.

The results of this paper require corroboration in future studies in which semi-attendance-based teaching totally replaces traditional teaching. Semi-attendance-based teaching must also prove its effectiveness in long-term learning.

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