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Blended learning: call of the day for medical education in the global South

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ABSTRACT

Blended learning (BL) is an e-learning approach that combines the strengths of both online and face-to-face learning, creating meaningful interactions between students, teachers, and resources. This paper explores students' expectations and satisfaction with, and participation in, a basic science course offered through BL approaches in an undergraduate medical education programme in Pakistan. Developmental anatomy (embryology) was redesigned as a BL course and offered to a hundred first-year students. Both online activities and technology-assisted face-to-face interactive discussions were used in each topic. Students' expectations were gathered at the start of the course and perceptions regarding their satisfaction with the course was collected at the end of the course via questionnaires. A temporal analysis of the website use was conducted to determine any changes in use across the course. The data shows that students were satisfied with their experience in the course. Their expectations regarding technology and pedagogy were met. Online individual learning activities were rated higher than collaborative discussions. Face-to-face discussions received a high rating compared to online learning activities. Students' access to the website varied throughout the course and declined over time. However, some activity was noted before the exams. Students made extensive use of WhatsApp. In basic science subjects, BL has the potential to offer learners some control over content, learning sequence, and pace and time of learning. Unless made part of an assessment scheme, online discussions and other activities are not likely to be seen as useful learning strategies by students. Teachers' skills in designing and facilitating BL courses are critical to the success thereof.

Introduction

Pedagogical advancements in higher education have influenced Medical Education (MedE), as didactic teaching has come under immense criticism across the world (Bruin, Dunlosky & Cavalcanti 2017). In addition, medical curricula have been reformed as new areas of knowledge are continuously integrated into the already overcrowded syllabus (Ruiz, Mintzer & Leipzig 2006). A key pedagogical innovation is a shift to a more competency-based curriculum that emphasises achievement of the stated learning outcomes of an educational experience, irrespective of the process of teaching and learning (Ruiz, Mintzer & Leipzig 2006). To ensure learning outcomes are achieved, self-directed learning opportunities such as e-learning are being adopted (George *et al.* 2014).

Not all areas of MedE have responded in a timely fashion to the available pedagogical innovations. As an example, the effort of professionals to bring about change in the teaching of anatomy through the use of the latest pedagogies has faced significant resistance as cadaveric dissections and preserved human specimens are thought to be the gold standard of teaching in this discipline (Collins 2008). Nonetheless, anatomy is being taught successfully across the world via a combination of didactic lectures, problem-based learning activities and cadaveric dissection/prosection laboratories (Brooks, Woodley, Jackson & Hoesley 2015). In reality, no single strategy has proven itself superior to others in achieving longer retention of knowledge in preclinical subjects, including anatomy (Muller, Jain, Loeser & Irby 2008). For example, the replacement of cadaveric dissection with technology-assisted approaches affords a similar level of learning between the two methods (Wilson *et al.* 2017).

Embryology is one of the sub-disciplines of anatomy that is taught in the preclinical years of undergraduate medical education (UGME). However, to create space for newer areas, such as molecular biology, the learning of developmental anatomy (embryology) has suffered immensely (Skandalakis & Flament 2000). This is concerning as embryology is a cornerstone in gaining in-depth understanding and management of medical and surgical issues (Cassidy 2015). As a result, medical universities have adopted innovative methods of using technology to support teaching and learning. For example, Al-Neklawy (2017) uses a virtual learning environment (VLE), although a lack of face-to-face interaction has posed challenges within this programme. The use of technology has shown promising results in terms of overcoming the limitations of medical curricula and to support engaged learning (Wilson *et al*. 2017). Today's students adapt well to the significant advances in educational technology and appear capable of making the best use of information that is freely available online (Pereira, Pleguezuelos, Merí, Molina-Ros, Molina-Tomás & Masdeu 2007).

Various terminologies define the use of technology in MedE. E-learning is a common term that broadly encompasses all forms of electronically-mediated teaching facilitated by information and communication technology (ICT). Technology-Enhanced Learning (TEL) is defined as learning with technology as a cognitive tool, instead of merely learning through technology (Kim & Reeves 2007). Blended learning (BL) describes a teaching and learning situation in which online and face-to-face (F2F) learning are integrated systematically to support and enhance meaningful interaction between students, teachers and resources (Bonk & Graham 2012). As it blends the strengths of online learning with F2F learning, BL is proving its effectiveness in all fields of higher education, including MedE (Zayapragassarazan & Kumar 2012). Among various models of BL, flipped learning is gaining popularity (Day 2018). Flipped learning involves engaging learners ahead of F2F class time by providing suitable

online material to enhance pre-learning (Chen, Lui & Martinelli 2017). This approach aims to shift the responsibility of learning to the learner as well as to provide them with autonomy to control the pace of their learning. As they are well prepared beforehand, in the F2F component of a flipped classroom, students interact with the teacher and each other to clarify difficult concepts and apply their knowledge in real-life scenarios (Garcia 2018).

Whether we call it TEL, e-learning or BL, the common MedE goal is to prepare future clinicians with in-depth knowledge of basic concepts, psychomotor skills and decision-making skills (Guze 2015). Technology offers learners control over the content, learning sequence, pace of learning and time, providing them opportunities to tailor the course of learning to their personalised needs (Ellaway & Masters 2008). Use of technology allows learning to be individualised (adaptive learning), to enhance learners' interactions with others (collaborative learning) and to transform the role of the teacher (George *et al.* 2014). In exclusive online learning, some of the weaknesses encountered include reduced social interaction, limitations of skill practices, loss of a teacher-student relationship and lack of confidential evaluation methods (Bates 2014). Therefore, in diverse MedE contexts, instead of adoption of completely online learning, the use of BL may seem to complement instructor-led teaching with online learning (Zayapragassarazan & Kumar 2012). Despite a lack of consistency in the adoption of TEL in MedE (McHanwell *et al.* 2014), technology has substituted traditional methodologies especially in pre-clerkship courses (Ruiz, Mintzer & Leipzig 2006). Nonetheless, one of the foremost challenges in incorporating new teaching methods is the development of capable faculty members that are keen to implement diverse teaching methodologies (Hartman, Bann, Barton & Pearce 2016).

Like most UGME programmes in Pakistan, faculty at the university where this project was implemented are faced, during the first two preclinical years, with the challenge of learner engagement. In order to overcome this challenge, the instructor of the course on embryology joined a faculty development programme offered by the Network of Blended and Digital Learning in order to find innovative ways to improve student engagement through the way the course is taught. With substantial evidence supporting the usefulness of BL, the authors worked together to redesign and develop this course to be offered through BL approaches (Naseem & Handley 2015).

In the light of current evidence, the team implemented a BL approach within a medical college in Pakistan with the aim to enhance students' autonomy to interact with the learning material and to create avenues for active student engagement in the classroom with the teacher. The work included three phases: course design and development during a faculty development programme; teaching of the course; and evaluation of the course by students. Specifically, we address the following questions:

1. What were the students' expectations of the BL approach at the beginning of the course?
2. What were students' experiences of the course, as identified through analysis of the course website use?
3. To what extent are the students satisfied with the BL approach as compared to the traditional approach?
4. What are the implications of our findings for designing and teaching basic science courses through blended approaches in an UGME programme?

Methods

Study sampling and duration

The study was conducted at a University in Pakistan between July 2016 and November 2017. Ethical approval was awarded by the Ethics Review Committee of the university. Permission from the UGME curriculum committee was also obtained. One hundred students in a year-1 UGME programme took the compulsory course of developmental anatomy (embryology) in a blended format. The entire class was invited to participate in the study. Seventy-six students consented to be a part of this research project. All 76 students completed the expectations survey. However, only 69 students responded to the question regarding the comparison of blended learning with face-to-face teaching.

Research design, data collection, and analysis

The study had three phases:

1. Course design and development
2. Course teaching
3. Course evaluation

Phase 1: course design

Embryology is a compulsory course taught in the first two years of the five-year UGME programme. Previously, the course had been taught using a large-class teaching format (LCF). Previously, the course spanned a period of eight months with an average of three to four hours of face-to-face didactic lectures conducted during each month.

The process of course redesign began during the faculty development programme on BL in which the course instructor (first author) was a participant. Through a series of activities, which included reflective discussions, analysis of course data from previous years, and students' evaluation of the course, the instructor identified the need and purpose for blending online learning with the F2F teaching of embryology, and redesigned the course. A comparison between the previous course design and the newly designed course has been summarised in Table 1.

Table 1: Comparison of the previous course with the newly designed course:

Item	**Didactic teaching**	**Blended learning**
Facilitator	ZJ (first author)	ZJ
Sections of the course	Eight	Eight
Total span of the course	February to August	February to August
Total face-to-face contact hours	20 hours	16 hours
Total number of students	100 (year-1 UGME)	100 (year-1 UGME)
BOPPPS strategy (explained later in this paper)	Could not be uniformly adopted in all sessions due to time constraints	Practiced throughout the eight sessions
Online reading material	No	Yes
Online learning activities	No	Yes
In-class discussions based on clinical scenario	No	Yes

Online discussions	No	E-learning system made provision, but this was not utilised during the course
In-class quiz	Yes	Yes
Online post-test	No	Yes
Sharing of the material (Ppt) used in the face-to-face session	Yes	Yes
Utilisation of 3D animated videos on development of embryo	Yes	Yes
Real time data on students' performance	No	Yes
Assessment strategy	End of module summative exam	Formative assessments in addition to end of module summative assessment

As this subject comprises complex processes of human development, animated videos along with reading material were identified to be shared with the students prior to the F2F class to provide better three-dimensional visualisation of the concepts. Online learning activities to reinforce students' understanding were also developed. Alongside these, lesson plans for F2F sessions were developed to generate case-based discussions on the applications of knowledge acquired through pre-readings and watching videos, and to address students' shortcomings in the online learning activities. Finally, post-tests were developed as an after-class online activity to ensure in-depth understanding of the learning outcomes. The general flow of the activities for each of the eight sections is schematically represented in Figure 1.

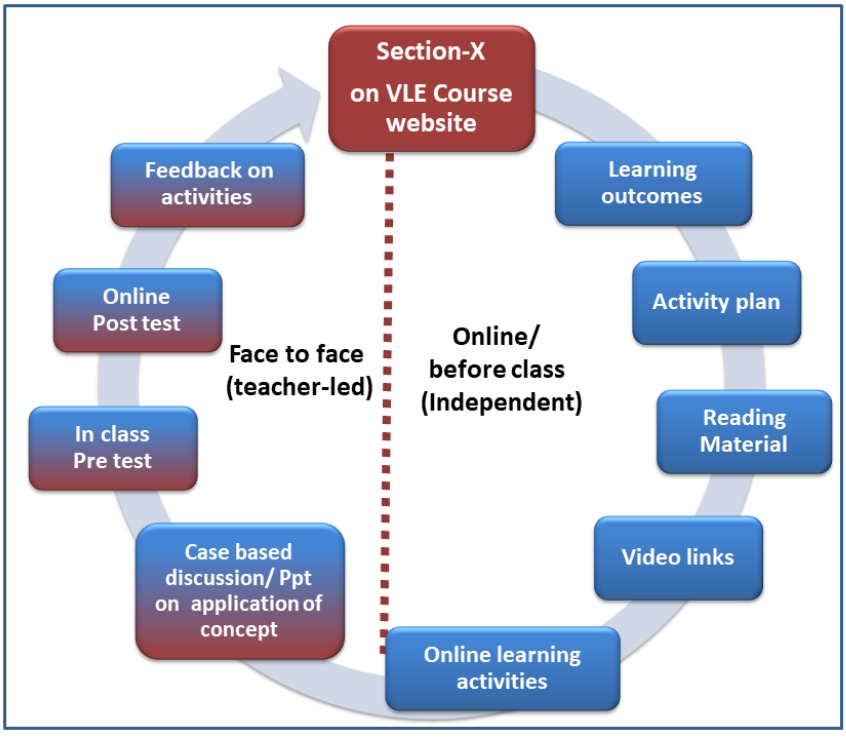

Figure 1: Schematic of the course. Activities placed within blue boxes indicate online tasks while the activities in the shaded maroon-blue boxes indicate in-class, F2F events.

During the redesign of the course, the learning outcomes for each topic were aligned with the teaching strategy. For each section, the following components were designed:

a. Learning outcomes
b. Video links to assist visualisation of the embryological development
c. Supplementary reading material
d. Online learning activities with an expected time required to complete them
e. PowerPoint presentations used during F2F sessions
f. In-class formative assessment and/or case-based discussions
g. Online Post-test

General layout of the course website

The design of the course website was conceived by the anatomy instructor based on the course requirements. The course website was developed by the e-learning developer under the supervision of instructional designers. At each step, feedback was obtained from the course instructor. The virtual learning environment (VLE) for this course was Moodle 2.9, which is an online learning environment that enables teachers to design personalised and collaborative learning environments. Moodle's foundation lies in social constructionist pedagogy; therefore, it offers a collaborative learning environment with learner-centric tools. A quality checklist for designing blended learning course content, developed by the network of Blended Learning at AKU (Chauhan, Naseem & Rashwan 2016), was used to ensure all relevant features were included in the website design. The checklist items were developed based on the seven research-based principles of good teaching practice in colleges and universities suggested by Chickering & Gamson (1989).

The course consisted of eight sections that were accessible from the main page of the course website. Each section was represented by a relevant image to create a visually appealing layout. All eight sections included resources and a series of online activities as shown in Table 2. Resources included materials used to support learning such as readings, video links and PowerPoint presentations. Online activities included 'drag and drop' quizzes, multiple choice questions (MCQs), process mapping and extended matching questions (EMQs) in order to cater to the needs of the diverse content that underpins embryology. These were designed to provide visibility of learning and immediate feedback to students regarding their performance.

Table 2: Details of the sections on the webpage

Sections	No. of online activities	No. of resources
1: Fertilisation to Bilaminar disc formation	3	3
2: Embryogenesis	3	7
3: Foetal Period	1	2
4: Foetal membranes and placenta	2	4
5: Gastrointestinal tract	2	3
6: Cardiovascular system	2	4
7: Respiratory system	1	3
8: Renal system	2	4

Lastly, the main page of the course website contained a video introduction to embryology, developed by the course instructor to highlight the significance of embryonic development in our lives. The course interface contained basic functions that enabled students' easy access to:

- "Course Information", including the course description, outline, and schedule;
- "Flash Cards", including online interactivities;
- "Social Forum", which provided a space for students to communicate and engage in informal group discussions; and
- "Contact Information", which contained the teacher's contact details (email, phone, and contact hours).

Creation of learning activities

Learning activities such as EMQs and MCQs were specifically designed to support the application and analysis of the basic concepts of embryology, as well as foster an understanding of the significance of human development in the clinical context. Quizzes were designed in the format of 'process mapping' that challenged the critical thinking abilities of the learners regarding the complex processes of foetal development. These process mapping activities demonstrated the critical steps and actions required in the formation of an embryo. In other instances, 'drag and drop' labelling activities were utilised to correlate the structure-function relationship. These were set up to allow students to drag labels from a list and drop them into predefined gaps on the image. All these activities included formative assessment aspects; as such, they were designed to provide prompt feedback to the students. These were non-mandatory exercises as special approval from the curriculum committee was required for any mandatory activity, which would have delayed the implementation of this study.

Animated videos on developmental anatomy

Initially, there was a plan to develop video-based lectures for the course. However, we found many relevant videos freely available on the YouTube Education, Khan Academy and other anatomy- and basic science-related websites. The links were shared on the course website, abiding by the relevant copyright laws.

Phase 2: course teaching

For planning and evaluating the teaching strategy, BOPPPS was adopted to actively engage the students. BOPPPS comprises six phases: **B**ridge-In, **O**bjective, **P**re-Assessment, **P**articipatory **L**earning, **P**ost-Assessment, and **S**ummary (Foxe, Frake-Mistak & Popovic 2017). Although BOPPPS was also adopted in the previously offered course, due to time constraints it was challenging to adopt all six phases in each contact session. In the redesigned BL course, provision of a VLE webpage assisted in overcoming this issue, and BOPPPS was implemented throughout the course.

The course began with the sharing of information regarding the BL approach at the beginning of the module. The students were required to go through the resources and attempt the learning activities provided to them via the VLE webpage. This was followed by a F2F session already scheduled in their timetable. As the students had attempted the online activities, the facilitator had prior knowledge regarding their performance and understanding of core concepts. This helped the instructor to design the F2F session in a manner that addressed their weaknesses and enabled the students to reach the learning outcomes. The F2F session was built around the clinical relevance of the core concepts

(bridge-in). This was followed by clinical scenarios to generate discussion on the clinical consequences of abnormal development of an embryo (participatory learning). Next, in-class quizzes were conducted via freely available online tools (www.kahoot.it & www.mentimeter.com) to inculcate critical reasoning and to gain insight into the learning of students. The relevant core concepts were summarised at the end followed by completion of non-mandatory online tasks, mostly based on EMQs.

Phase 3: course evaluation

In this study, data was collected through two methods:

1. Surveys: in total, three questionnaires were administered to students. One of them included a pre-survey that gathered data on students' expectations of learning through the BL approach. This questionnaire was administered at the time of redesigning the course. The second questionnaire included comparison between didactic teaching and BL using Likert scales. This questionnaire acknowledged the five main domains that were considered the key areas of interest while redesigning the course. This questionnaire also comprised one open-ended question regarding the strengths and weakness of the BL course. The third questionnaire (adapted from Wang 2003) assessed the degree of learners' satisfaction with the BL approach in the course. These last two questionnaires were administered at the end of the course. For this paper, analysis of the first two questionnaires is presented.
2. Descriptive analysis of the course website: website analytics were analysed to measure students' participation regarding the number of visits, attempts at each activity and responses at numerous time points. Average scores for each attempt were calculated as well as the total score for each section.

Survey of expectations

Participants' expectations from the course were collected using a paper-based questionnaire. The questionnaire was developed as a part of an earlier study on a previous cohort by the first author of this paper. In that study, students were asked to write down difficulties that they faced in learning embryology. The items were reviewed and a ten-item list of expectations was generated which was converted into a questionnaire consisting of five-point Likert scales where 1 indicated strong disagreement and 5 strong agreement. Students were asked to complete the questionnaire in order to share their expectations of BL approaches. The tool is shown in Table 3.

Table 3: Questionnaire on expectations of students regarding the BL course

	Items	Strongly disagree	Disagree	Uncertain	Agree	Strongly agree
1.	The e-learning system should provide personalised learning support.					
2.	The e-learning system should make it easy for me to find the content I need.					
3.	The comprehensive learning activities provided by the e-learning system will assist in application of knowledge.					

4.	The e-learning system should provide a secure testing environment.					
5.	The e-learning system will make it easy to discuss questions with the teachers and other students.					
6.	The operation of the e-learning system will be technology-stable.					
7.	The e-learning system will enable me to control my learning progress.					
8.	The e-learning system will make it easy to discuss questions with our teachers.					
9.	The e-learning system will make it easy to evaluate my learning performance.					
10.	The e-learning system will provide test results promptly.					

Survey to compare students' satisfaction with BL and Face-to-Face teaching

After completion of the course and the final summative examination, students individually rated the didactic lecture-based teaching and BL pedagogy on Likert scales. Five items were included, which pertained to provision of students' control over their learning, active engagement, visibility of learning, comparison with online learning and alignment of the pedagogy with the students' learning styles (see Table 4). These items were developed by the instructor based on her knowledge of the aspects which are important in a teaching and learning context. T-tests were applied to compare the mean difference between the two groups as the data set met all the assumptions of parametric analysis. A p-value of greater than 0.05 was considered significant. The data was analysed using the software application, SPSS version 21.

Table 4: Five component-based student satisfaction survey, completed for didactic teaching and then for Blended Learning.

Items separately rated for Didactic teaching and BL	
1	I have control over my learning via this methodology.
2	I am actively engaged with learning in this teaching methodology.
3	This methodology provides visibility of learning through formative assessments.
4	I prefer this teaching methodology in comparison to exclusive online-learning.
5	The teaching methodology is aligned to my learning style.
In your opinion what were the strengths of Blended Learning pedagogy?	
In your opinion what were the weaknesses of Blended Learning pedagogy?	

Five-point Likert scale **1:** Strongly disagree **2:** disagree **3:** uncertain **4:** agree **5:** Strongly agree

Descriptive analysis of the course website

Data were gathered from the course website to understand the accessibility and the usage of the site. The average number of attempts for each activity was recorded in addition to the total scores for each

section. The dynamics of access to the website from February 2017 to November 2017 helped in tracking usability on the part of students.

Results

Students' Expectations

Students shared their expectations at the beginning of the course through a questionnaire. The results showed that students rated the stability of technology as the most important aspect of the course. This was followed by easy access to the content and provision of prompt feedback on/results of online activities. On the other hand, peer learning and online discussion with the teacher were given minimum importance (see Figure 2).

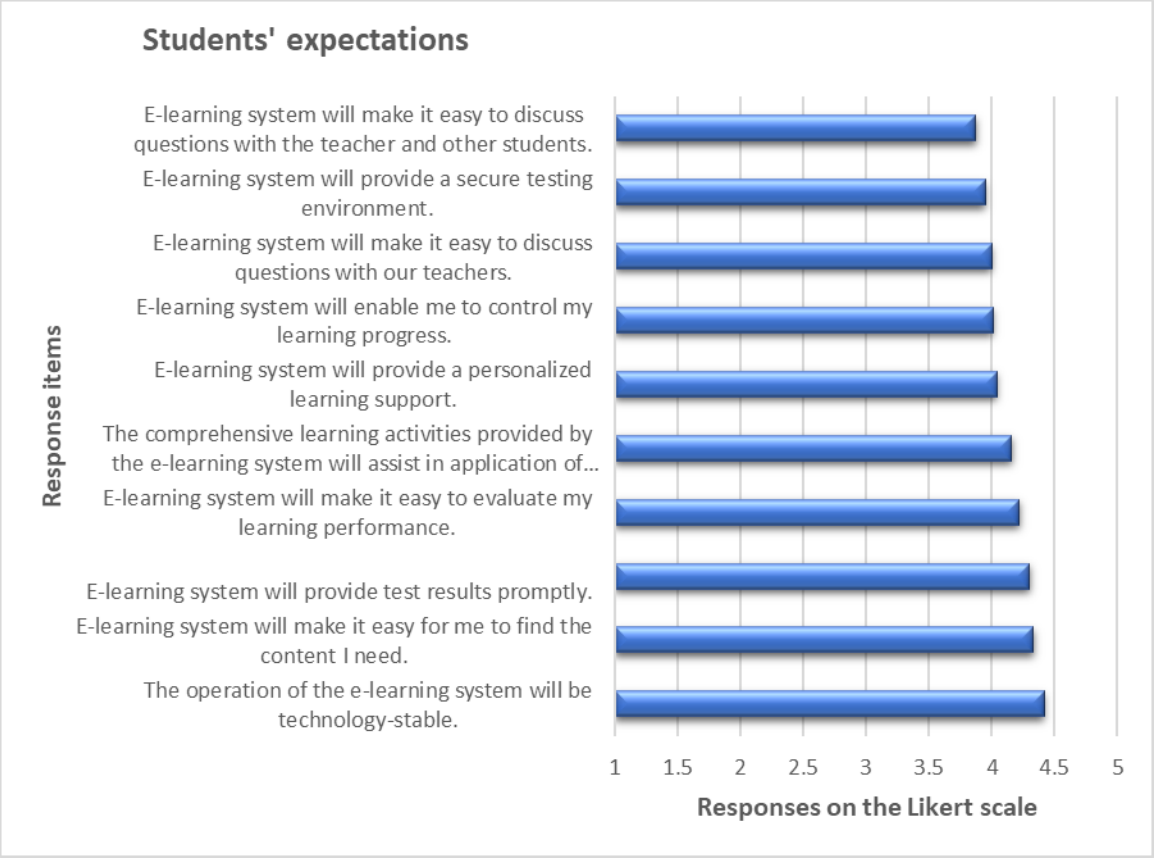

Figure 2: Students' expectations at the beginning of the blended learning course

Students' comparison of BL and Face-to-Face teaching

As the students separately rated the didactic teaching and BL approaches, there was a significant difference in their satisfaction while learning through the BL pedagogy (see Table 5). The majority of the class either agreed or strongly agreed that they preferred BL over exclusive online learning. On the other hand, while comparing didactic teaching with that of online learning they disagreed that didactic delivery was a better mode than exclusive online learning (as seen in the mean Likert score of 1.31). They reported BL as a teaching pedagogy that was aligned to their learning needs. While comparing the visibility of learning, there was a minimal difference between the two pedagogies yet it was still significant ($p<0.001$). This comparison has been summarised in Table 5.

Table 5: Comparison of mean responses on Likert scale for didactic teaching versus Blended learning

Items		**Didactic Learning** Mean ± SD	**Blended Learning** Mean ± SD	p-value
1	Control over learning	1.97 ± 0.91	3.72 ± 0.71	<0.001
2	Actively engaged with learning	1.57 ± 0.53	3.78 ± 0.69	<0.001
3	Visibility of learning	2.21 ± 0.93	3.4 ± 0.77	<0.001
4	Preference over exclusive online-learning	1.31 ± 0.50	4.31 ± 0.74	<0.001
5	Alignment to personal learning style	1.70 ± 0.76	3.42 ± 0.81	<0.001

Groups compared by independent sample t-test, p-value <0.05 was taken as significant
Likert scale 1: Strongly disagree 2: disagree 3: uncertain 4: agree 5: Strongly agree

In addition, regarding the strengths and weaknesses of the BL course, selected comments have been listed below:

- "I could control my progress and study on my own pace"
- "The online material reinforces the concept well"
- "In such sessions, we come with some prior knowledge that is guided well through the website"
- "This methodology is very interactive"
- "You are able to learn from two different sources (online + one-on-one) and this helps clear up misunderstandings if any"
- "Assists construction of long-term memory"
- "You can repeat the activities as many times as you wish"
- "As not everything is understood from the online content, face-to-face sessions are very handing in clarifying the concepts"
- "Good way to revise the concept as different materials are pre-identified by the facilitator"
- "BL makes learning a lot less tedious and even less-time consuming"
- "It's a stage with all the requirement one need to consolidate concepts"
- "It increases our enthusiasm to learn and class engagement. Pre-knowledge and hand full of learning resources are a plus to this methodology"
- "Students automatically become more interested as they see better learning opportunity"
- "Needed to put in effort to access online content due to password issues"
- "VLE page was sometimes non-functional"
- "When all students haven't prepared beforehand, the class behaviour was disturbing"
- "We need to study pre-hand that requires effort"
- "We sometimes get distracted while doing the online activities so I preferred in-class quizzes"
- "I would prefer more online content"
- "Lack of prior study causes difficulty in catching up the clinical cases-based session"

Students' use of the course site

Analysis of the course website statistics shows the average number of times an activity was completed and submitted on the VLE page (see Table 6). These numbers do not include incomplete attempts or those that were not submitted even after completion. As it was non-mandatory, the majority of the attempts were left un-submitted. Some students attempted a single activity up to seven times. Although the study participants included 76 students and the survey questionnaires were completed only by these students, as per the guidelines from the curriculum committee, all one hundred students were allowed to access and learn through the website. Table 7 shows the average scores per activity

in each section, which was very useful in enabling the facilitator to gain insight into students' learning before coming to the F2F session.

Table 6: Summary of total number of students submitting complete attempts. Some activities were attempted more than once by some students as summarised in attempts per activity.

Section	Number of attempts per activity (n)			Total number of students (n)
	Activity 1	**Activity 2**	**Activity 3**	
1	48	37	51	93
2	37	59	31	69
3	36	-	-	27
4	33	33	-	48
5	34	18	-	36
6	8	7	-	12
7	6	-	-	6
8	19	4	-	8

Table 7: Summary of average score per activity

Section	Average Scores/activity (%)			Average score (%)
	Activity 1	**Activity 2**	**Activity 3**	
1	89.6	81.1	66.7	79.13
2	85.4	81.33	92.25	86.33
3	73.33	-	-	73.33
4	81	54	-	67.5
5	82.38	65.25	-	73.81
6	100	76.79	-	88.4
7	75	-	-	75
8	13.68	100	-	56.84

Regarding the accessibility of the webpage, it was also observed that students' use of the website decreased with the passage of time. As shown in Figure 3, the highest student activity was observed during the initial months of the course, and this diminished as the course progressed. There was no activity during June/July, which coincided with the summer break. However, a rise in the number of students revisiting the course site right before the final exam in November was observed. This provides evidence that students used the course materials on the VLE as well as the formative assessments as preparatory learning materials for the final summative examination.

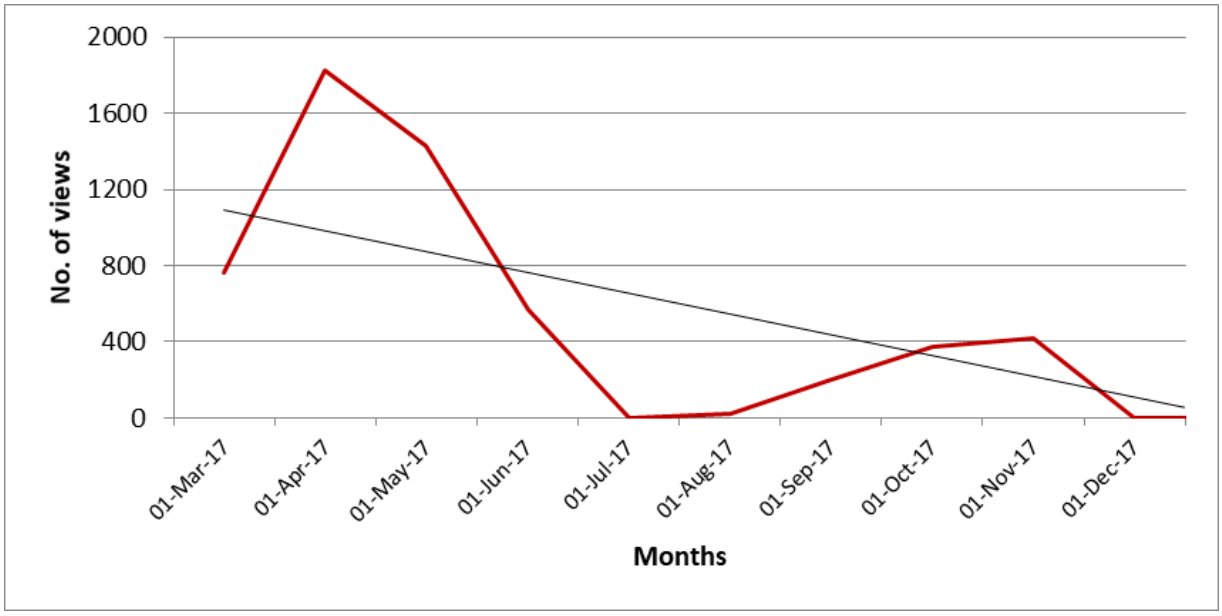

Figure 3: Number of times the website was accessed by students over the duration of the course

It should be noted that, during a F2F discussion, students informed the instructor that they had formed study groups. Instead of accessing and submitting individual responses to online activities, one person downloaded the article and shared it via WhatsApp with the others. Responses to the learning activities were also discussed on WhatsApp and shared by one student on the course website.

Discussion

This study has described the implementation of BL pedagogy in an embryology course offered to first-year MedE students. The authors redesigned the previously offered LCF course as a BL experience by combining online learning through the course website with that of F2F classes. The aim was to enhance students' engagement with their learning and motivate them to overcome the challenges of teaching and learning in this discipline. Before the redesign, this course was taught using LCF lectures where teachers traditionally used PowerPoint to present the basic concepts to a hundred students in a lecture theatre. As a result, students had limited chance to actively engage in the class. Moreover, due to a tightly packed schedule, embryology was often allocated two sessions of 1.5 hours in each module. It was extremely challenging for the facilitator to ensure that all the students were able to build basic concepts while covering the learning outcomes set for each session. As a result, course evaluations by the students often reflected dissatisfaction on the part of students. These shortcomings were also observed during year-end examinations where students performed poorly in questions around embryology. Redesigning this course using blended pedagogy helped the facilitator to address issues such as time constraints, the provision of guided self-study to assist in acquiring basic knowledge, and the addition of numerous formative assessment opportunities to enhance the visibility of students' performance – for both the facilitator and the learner. Case-based discussions in the face-to-face component provided an opportunity for the students to actively apply the knowledge. However, as this paper presents data based on work that is ongoing, a comparative analysis of past and present outcome scores has not been included in this paper.

The students' experience in the newly offered course, as reflected by their feedback (in Table 5), supports the role of this pedagogy in their learning. The course website was accessed during the modules and then revisited at later stages such as summative exams. Some students attempted some online learning activities up to seven times and, likewise, online resources were accessed multiple times by the same student, supporting the role of the VLE in providing a platform where students may learn at their own pace. Moreover, from the perspective of the facilitator, the grade book provided an opportunity to monitor students' progress. Additionally, as personal interaction with the teacher remains significant, F2F sessions ensured one-on-one interaction between the students and the facilitator.

Having said that, there were challenges faced while implementing this pedagogy for the first time. For example, regarding students' expectation from the course, stable technology stood out as the most important aspect. However, issues such as expiry of students' passwords and internet degradation caused problems, for which IT support needed to be sought. These issues were highlighted as weakness of the course in the open-ended questionnaire, and they will need to be addressed in the next iteration of the course by adding a link for technical support related to internet access, course access and other difficulties that students may experience while working independently on the website.

The vision to empower learners to champion their own learning via technologies such as a VLE-based educational resources and interaction with peers is having a significant impact on learning in higher education (Ballard & Butler 2011). Ellaway and Masters (2008) have argued that integration of technology has made MedE more flexible, learner-centred, interactive and collaborative among teachers and learners. Consistent with this literature, in this study, the development and use of the course website helped both the teacher and the students. The faculty member was well informed regarding the prior knowledge of the students as they attempted online activities before coming to the F2F component. This guided the facilitator in tailoring the case-based discussion in the F2F session in order to address the deficiencies of the students. Similarly, students had access to relevant content from the beginning of the course up to their year-end examination. The availability of course material before the F2F classes, the administration of assessment for learning (both as online activities and in-class quizzes) and the interactive F2F discussions were beneficial to the students, leading to overall satisfaction with the course. The usefulness of sharing course material prior to classes, formative assessments administered during the module and interactive class activities has been well documented in the context of medical education (see Pierce & Fox 2012).

The literature shows that online discussions can support learning in MedE (Green, Farchione, Hughes & Chan 2014). Students in our course ranked the significance of online discussion with facilitators and peers as the lowest. This might be explained by the fact that, in MedE, most summative examinations are designed as individual assessments. There is minimal emphasis on group assignments or presentations at pre-clerkship years. As a result, there is minimal focus on digitally based peer learning in MedE at the university level. A few studies support the view that medical students seem to prefer one-on-one discussion within the classroom setting over online group discussions (Thai, De Wever & Valcke 2017). Therefore, in the light of students' opinions as well as our own limitations we did not utilise any online discussion in our study. This was for a number of reasons. Firstly, there were one hundred students in our class and engaging them all together was fruitless if the facilitator could not

keep track of the online discussion. Secondly, in the presence of an already tightly packed curriculum, it was unfair to expect students to engage in an online discussion. Thirdly, the students were already being engaged in one-on-one problem-based learning sessions that covered the content of embryology. Therefore, in this pilot run, we limited one-on-one discussions to the F2F session and decided not to experiment with online discussion activity despite the fact that it may have advantages as highlighted in the literature.

As MedE emphasises developing individuals' clinical competencies, students tend to focus on their individual learning. However, the real-world experiences of doctors show that clinical training goes beyond the acquisition of mere knowledge. F2F discussions with clinical experts could play a critical role in relating the basic understanding of the subject with that of the clinical context in which they will apply their knowledge on patients (Hoy 2014). Interaction with others could significantly add to the development of students' critical reasoning and effective communication abilities. As didactic teaching does not allow avenues for interactive discussion, this course emphasised utilising F2F session for discussion on application of the knowledge and analysis of clinical scenarios. As year-1 students coming into an UGME programme are not trained to work collaboratively, it is necessary to create opportunities for collaborative and constructivist learning in the UGME programme.

In our study, it was observed that students shared links, readings and images of learning activities with each other via their own WhatsApp groups. They attempted quizzes but did not always submit their answers online. A few students reported that they attempted the activities in the form of groups. Therefore, in this situation, the course website report was not an accurate reflection of the performance of individual students. Furthermore, there was a huge difference in the number of students visiting the website and those who attempted the learning activities. However, the facilitator observed that the majority of students were well prepared when they came to the F2F sessions, suggesting appropriate learning beforehand. Although formative assessment is known for its impact on active engagement, in order to enable the course facilitator to track the progress of each student, it is important that these online activities be made compulsory so that each student submits their response individually. In this way, the course website can provide timely feedback to students regarding their performance as well as regular updates to the facilitator. Literature does support the notion that medical students do benefit from guided self-study followed by minimal mandatory activities to groom them as independent learners (Jamil, Fatima & Saeed 2018).

The availability of relevant content and provision of comprehensive learning activities was a leading expectation of this course. Accordingly, content was designed after a well-considered search to provide relevant resources and meaningful learning activities for students. As there is an expanding pool of freely available education resources for MedE, as well as licensed resources with either teachers' subscriptions or university-wide institutional licenses, we utilised these as supplementary learning materials in addition to reading material from textbooks. Our experience shows that instead of developing online teaching resources from scratch, medical schools may benefit from investing in already existing resources to enhance teaching capabilities.

The literature advocates BL as a better pedagogy for engaging students as compared to traditional didactic teaching or fully online learning (Morton *et al.* 2016; Pereira *et al.* 2007). As students' opinions were similar in this study, the findings are consistent with the literature. Adult learning principles

suggest that as the learner actively engages with the content, their motivation, learning experience and, most of all, self-concept improves extensively (Cooper & Richards 2017). In our study, students reported better engagement, higher visibility of learning and better control over their learning via the BL approach. Adopting a BL approach is known for fostering enhanced engagement and motivation (Chen, Lui & Martinelli 2017). As we shared the reading materials and links of animated videos with the students via the course website before the F2F session, students attempted some of the activities multiple times before coming to the F2F session. This provided evidence of the autonomy and control that was gained by the learner in accordance with the individual's need for learning a concept multiple times before gaining a holistic understanding. This autonomy was missing in the traditional lecture setting where all the students were assumed to build their concepts within the limited time frame of the lecture session, irrespective of the fact that each classroom comprises of students with diverse preferred learning styles (Willingham, Hughes & Dobolyi 2015).

Regarding the strengths of the course, students reported the effectiveness of online learning activities and F2F discussions. As per the needs of the curriculum, tailored learning activities were designed in addition to adopting wide range of freely available online educational tools. The F2F sessions were designed to operate at the level of application, as per Bloom's taxonomy (Morton & Colbert-Getz 2017) by including various types of activities such as in-class quizzes, interactive discussions and online post-tests. F2F sessions were dedicated to interactive discussion around concepts to develop and assess students' knowledge of the section. Flipped learning in this course provided insight into student performance in curricular competencies (Manson, Amiel & Gordon 2016). Also, the teacher was able to provide more personalised, self-paced and flexible learning opportunities to the students. The use of assessment and communication tools available on the VLE reflect best practices, as described by Chickering & Gamson (cited in Robb & Fisher 2015).

There is ample evidence in the literature to support the use of assessment for learning in higher education (Deeley 2017). Studies have reported higher learning and retention through reassessing content instead of revisiting it (Augustin 2014). We noticed that, within a single section, there was a major difference in the average scores on MCQs, drag-and-drop activities and process mapping. Students generally scored higher in MCQs perhaps because they were familiar with this question type. On the other hand, a majority of them did not attempt, or left incomplete, the process-mapping activity that required a higher cognitive level, either because it challenged their thinking or it was an unfamiliar activity type. The facilitator addressed these deficiencies during F2F sessions where all challenging sections were revisited, either by generating discussion based on clinical scenarios or reassessing learning in class. Additionally, post-test or summarisation activities included at the end of each section helped the teacher to identify students who had achieved the learning outcomes.

The limitations of this study include an inability to comment on the generalisability of this pedagogy as we offered it in only one subsection of anatomy. The literature suggests that millennials do learn differently (Taylor & van Aswegen 2017), and often engage well with the use of social tools such as WhatsApp for instant communication and other purposes. Therefore, our findings could be further explored by using this pedagogy in other sub-disciplines. Secondly, we could not compare the summative results of the study cohort with the previous batch; hence, the impact of BL on the overall performance of the students cannot be inferred from this study. Lastly, with an already overwhelming curriculum, online discussions were not included in the online part of this course, and F2F sessions

were designed to cater to the need for discussion. Therefore, no evidence can be offered regarding the use of online discussion in medical education.

For further implementation of BL approaches, the motivation of instructors to transform their already established teaching methodology is of primary importance. In addition to providing opportunities for the training of the faculty members, well-equipped technological and pedagogical support seems to be critical for such transitions especially in limited resource settings in the global South. Guided experimentation in adopting newer pedagogies and reflecting upon one's own teaching may assist in the gradual adoption of technology. Sharing of personal experiences of pedagogical innovation and the evidence of the benefits of learning outcomes may provide useful guidance as well as evidence for those who are keen to transform their teaching for the sake of their students' learning (Naseem, Ghias & Sabzwari 2017).

Conclusion

In this study, the effect of a BL approach in a preclinical course at a medical college in Pakistan was examined. The BL approach enables students to engage in learning both online and in face-to-face settings, although challenges were encountered such as declining use of the course website by the students over time. Because the use of online resources and activities was not mandatory, some students did not access the website throughout the course. Adoption of BL in the basic medical sciences appears to be promising for developing core knowledge, which may result in higher competence in clinical interactions. With changes incorporated in the curriculum such as revising assessment strategies, this type of pedagogy could offer greater control over content, learning sequence, and pace of learning and time, thereby enabling students to tailor their learning to their personal needs. Teachers will continue to play a significant role in designing and facilitating students' learning in this approach and there is a need for providing relevant pedagogical training and support to teachers for them to adopt BL pedagogies in medical education. More methodologically rigorous research studies are required to generate evidence in support of the benefits of redesigning preclinical courses through technology integration.

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