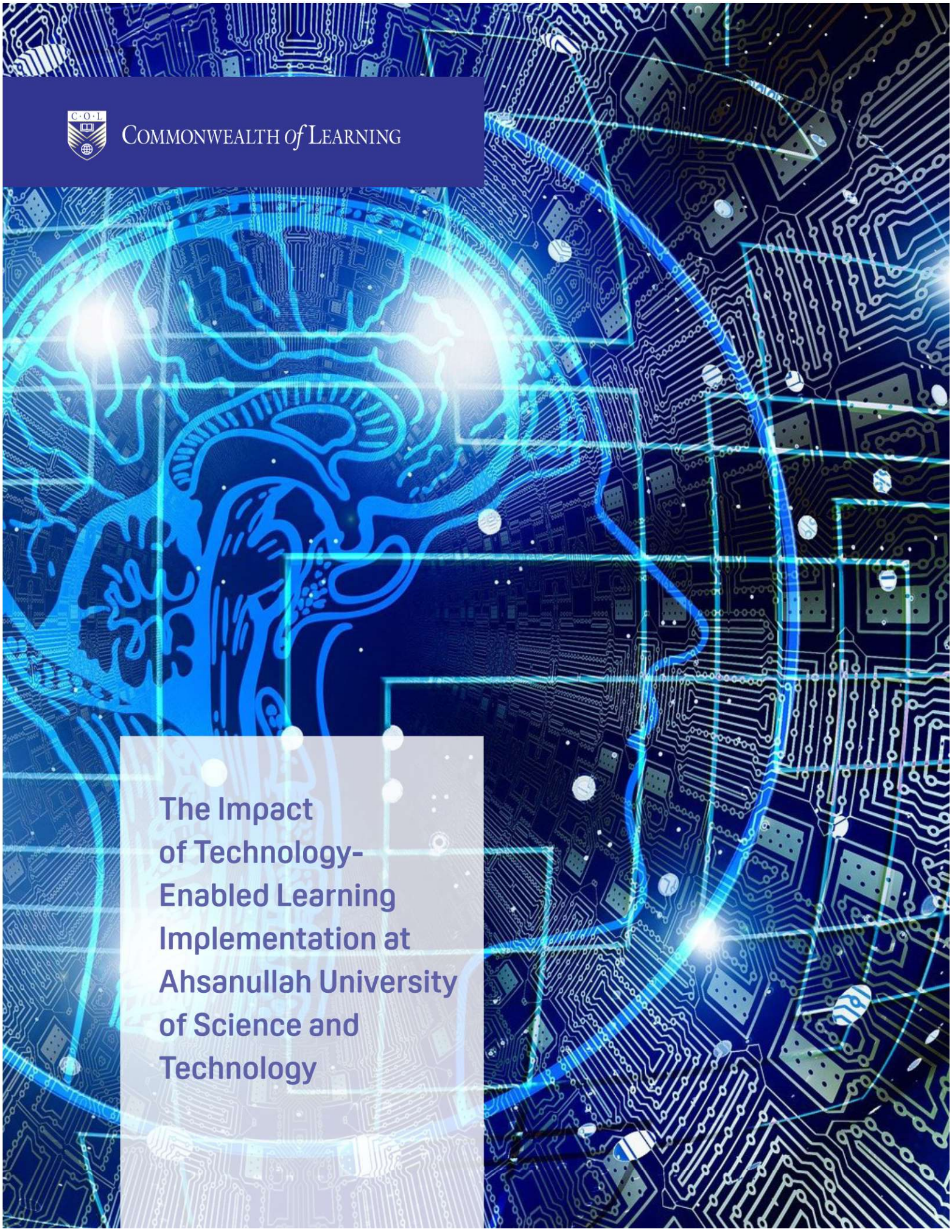
COMMONWEALTH of LEARNING
The Impact of Technology-Enabled Learning Implementation at Ahsanullah University of Science and Technology

The Impact of Technology-Enabled Learning Implementation at Ahsanullah University of Science and Technology

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COMMONWEALTH of LEARNING

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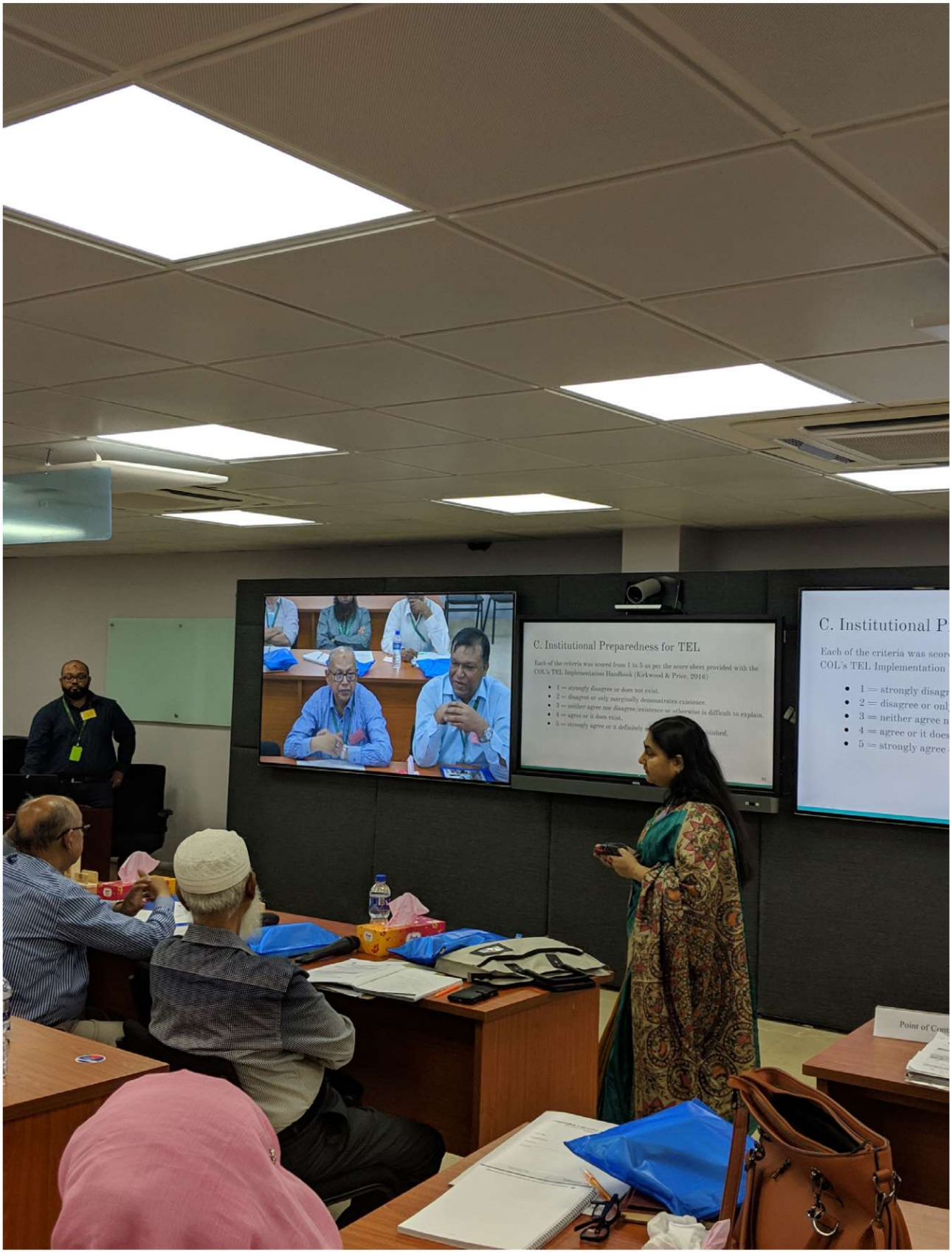
Executive Summary

This report evaluates blended learning implementation at Ahsanullah University of Science and Technology (AUST), Dhaka, Bangladesh. The current investigation reports the impact of blended learning implementation on various courses offered during the COVID-19 pandemic, from 2 February to 13 December 2020. The impact was assessed based on survey data collected from the participants of the blended courses. In addition, the final grades of the students taking part in the blended courses were collected from the Integrated University Management System (IUMS) at AUST. These results were compared with the outcomes of students in similar courses offered in a non-blended mode in a previous semester, to assess whether there was any significant improvement in students' academic performance. The report also assesses participants' responses to a survey containing carefully formulated questions organised in various categories. Detailed analyses and observations are presented.

Students' online activities were tracked using Moodle, AUST's learning management system.[1] Their activities were mapped against their results to discern any significant relationships between final grades and the students' self-regulated learning behaviours. Four variables were identified: login frequency, forum access, file access and course view. The data sample for this investigation included 20 faculty members and 2,220 students enrolled in 18 blended courses during a semester in February 2020. A total of 309 students participated in the survey. We have used various strategies for data analysis. For example, an independent sample *t*-test was carried out to compare the results of the blended and non-blended groups. Similar *t*-tests were performed for each course as well. In addition, students were grouped based on achievement level into high-, average- and low-achiever groups. The final results were compared to determine whether blended learning impacted any achiever group over the others. Statistical data analysis was performed to calculate Pearson correlation coefficients, likelihood-ratio tests and stepwise regression analyses.

The survey included an open-ended question that allowed students to write comments. Aspect-based sentiment analysis was applied to these data. We also interviewed teachers, then analysed their answers using the Activity Theory Framework (Engeström, 1987). Overall, the investigation showed that students had a positive attitude toward blended learning and achieved good results in the blended courses. Teachers were sufficiently trained to conduct the blended courses and expressed their overall satisfaction, confirming the positive impact of blended learning implementation at AUST.

[1] http://moodle.aust.edu/


C. Institutional Preparedness for TEL
Each of the criteria was scored from 1 to 5 as per the score sheet provided with the COL's TEL Implementation Handbook (Kirkwood & Price, 2016)
1 = strongly disagree or does not exist.
2 = disagree or only marginally demonstrates existence.
3 = neither agree nor disagree/existence or otherwise is difficult to explain.
4 = agree or it does exist.
C. Institutional P
Each of the criteria was scor
COL's TEL Implementation
1 = strongly disagr
2 = disagree or onl
3 = neither agree n
4 = agree or it does
5 = strongly agree

1. Introduction

Technology-enabled learning (TEL) is the use of some form of digital technology to support teaching and learning. Blended learning (BL), a variant of TEL, is a combination of face-to-face instruction and online learning. BL enables both teachers and students to engage in ways that would not normally be available in a traditional face-to-face classroom. Moreover, the teaching–learning resources are available for them to access anywhere and anytime.

AUST has been collaborating with the Commonwealth of Learning (COL) since 2019, and a baseline study on TEL at AUST is already available (Kalpoma et al., 2019). Using a systematic approach, a TEL policy was developed and several capacity-building activities on TEL were also organised. An outcome of Phase 1 was clarity on the institution's TEL infrastructure and capacity. This study is part of Phase 2 activities to institutionalise the TEL policy by developing some blended courses and offering these to students. COL's *Guide to Blended Learning* (Cleveland-Innes & Wilton, 2018) assisted with the development of these courses, and various templates in the guide were used to assure the quality of the developed courses. By the end of Phase 2, a group of teachers had become experienced in developing and delivering BL courses, which aimed to improve student learning experiences and outcomes by providing them with flexible and interactive learning opportunities. This phase also focused on evaluating TEL implementation by measuring student learning outcomes in concurrent blended courses.

As noted above, BL is a style of education whereby students learn partly through traditional face-to-face classroom methods and partly online using different digital technologies. In a BL course, students attend a class taught by a teacher in a traditional classroom setting, while also independently completing online components of the course outside of the classroom. The online and in-person learning experiences run in parallel and complement one another.

The Moodle learning management system (LMS) can enhance existing learning environments. As an eLearning tool, Moodle has a wide range of standard and innovative features, such as a calendar and a gradebook. COL provided support for a consultant to join the AUST team to demonstrate the different functionalities of Moodle in BL course development that can help enhance students' learning experience; in addition, the consultant assisted with designing effective course plans, writing SMART learning outcomes using Bloom's Taxonomy, and helping teachers understand the core functions of e-assessment and Moodle's assessment modules. The training also covered the use of open educational resources (OER) in blended courses.

From January 2020, AUST offered 20 Moodle-based blended courses in eight different departments: two courses from Architecture, two from the Bachelor of Business Administration programme, two from Civil Engineering, three from Computer Science and Engineering, two from Electrical and Electronic Engineering, one from Mechanical Engineering, one from Industrial and Production Engineering, one from Mechanical and Production Engineering, two from Textile Engineering, one Chemistry course, one Physics course, one Math course and one English course. This research report is a systematic inquiry into students' and teachers' experiences of blended learning in these courses at AUST.

2. Research Questions

The present study is both exploratory and evaluative. As noted above, it was conducted with COL's support as part of Phase 2 of TEL implementation at AUST, to answer the following questions:

- Is there any significant difference between students' learning performance in blended and non-blended courses?
- Are there any significant differences in learning performance for students of different achievement levels?
- Is there any significant relationship between learners' perceptions, motivations, digital literacy, attitude towards learning and final grade in a blended course?
- How do learners describe the effectiveness of the blended learning environment in their course of study?
- What impact does a training and mentoring programme have on teachers' experience of designing and teaching in a blended learning environment?
- Is there any significant relationship between self-regulated learning behaviour indicators (e.g., total login time) and students' learning performance?

3. Methodology

The study reported here was conducted based on 18 courses offered from February to December 2020 (called the Fall 2019 semester) in a blended learning form. A total of 2,220 students were enrolled in the courses offered. A few students were enrolled in multiple blended courses, which resulted in a total sample size of 2,682 students participating in the blended courses. The survey questions used tools developed by COL in previous studies (Bhagat, 2019). Survey respondents (a total of 309 students) voluntarily provided their opinions. The demographic distribution of the respondents is presented in Table 1, which shows the total number of students in various age groups and their gender distribution.

Table 2 shows the distribution of respondents in the various BL courses. The students' pre-CGPA values (i.e., the CGPA — cumulative grade point average — up to the Spring 2019 semester) and grade points earned in the Fall 2019 BL courses were obtained from AUST's Integrated University Management System.

The same 18 course had been offered in the previous semester in a non-blended mode, and we obtained the students' final grades for that semester from the IUMS as well to compare the impact of blended teaching and learning methods in terms of grades obtained. We also categorised the students who participated in the blended mode into three different achiever groups: high achiever (pre-CGPA of 3.081–4.00), average achiever (2.648–3.078) and low achiever (2.00–2.647).

The students in the non-blended teaching and learning mode were also categorised into similar groups based on their pre-CGPA values (Fall 2018). The CGPA ranges for the achiever groups were selected based on a fair distribution of students, with similar numbers of students in each category. The BL and non-BL results of these groups were compared to assess the impact of blended learning among the various types of achievers.

Table 1. Demographic data distribution for the student participants

Item	Category	Number	(%)
Gender	Male	215	69.6
	Female	94	30.4
	Total	309	
Age groups	**Age**	**Number**	**(%)**
	18	3	0.97
	19	14	4.53
	20	47	15.21
	21	86	27.83
	22	87	28.16
	23	49	15.86
	24	23	7.44
	Total	**309**	

We sifted through around half a million student records extracted from the Moodle LMS at AUST. This mammoth amount of information was divided into various categories, including students' course view, file access (download/upload), forum access (participation in the discussion forum), and a student's total number of logins to the system during the course study period. These numbers were progressively matched with the students' earned CGPA in the BL courses to assess whether the students' self-regulatory learning behaviours had any impact on their performance in the courses.

The teachers of the BL courses also participated in a detailed interview using questions modified from a study by Mishra (2017). A total of 20 teachers participated in the interview process.

Table 2. Distribution of survey participants in various blended learning courses

Course name	Number of students	(%)	Course name	Number of students	(%)
Biomedical Instrumentation	2	0.8	Environmental Engineering III	1	0.4
Chemistry	1	0.4	Export-Import Management	8	3.4
Computer Graphics	18	7.6	Geology and Geomorphology	26	11
Cost and Management Accounting	5	2.1	Internal Combustion Engine	13	5.5
English	1	0.4	Landscape Design	1	0.4
Mathematical Analysis for Computer Science	6	2.5	Numerical Methods	8	3.4
Mathematics II	42	17.8	Physics	21	8.9
Multimedia Communication	16	6.8	Wet Processing-I	32	13.6
Numerical Analysis	29	12.3	Yarn Manufacturing-I	6	2.5

4. Results

The survey employed a five-point Likert scale, but for simplicity, we have collapsed five response categories into three: *strongly agree* and *agree* were collapsed into ***agree***, *neither agree nor disagree* is designated ***neutral***, and *strongly disagree* and *disagree* were collapsed into ***disagree***. Table 3 presents the group-wise aggregated results on the respondents' digital literacy and technology use. We also employed the likelihood-ratio chi-squared test, which compared the participants' actual responses to the questions during the survey and assessed the statistical significance of the responses. The test allowed us to check whether there was a significant difference between the proportions of responses. A higher chi-square value usually points to a greater difference.

Table 3. Digital literacy and access to technology (n = 309)

SL	Digital literacy and access to technology	Agree	Neutral	Disagree	x^2
1	My digital literacy (use of MS Office, browse the Web and navigate through the virtual learning environment) skills are excellent.	258	40	11	
2	My access to and use of digital tools (laptop, smartphone) are excellent.	262	33	14	
3	My ability to access and use the AUST learning management system was excellent.	250	40	19	**345.3***
	Combined score for items	**257**	**38**	**15**	
	In %	**83**	**12**	**5**	

For the "course interest" portion of the survey (Table 4), the "attention" group of questions achieved a higher proportion of respondents agreeing (54%) than disagreeing (28%), with a moderate number of participants (18%) remaining neutral. Similarly, the "relevance" group had a significantly higher proportion of respondents agreeing (68%) than disagreeing (14%), with a handful (18%) staying neutral. The "satisfaction" group had agree, disagree and neutral values of 66%, 20% and 14%, respectively, indicating the participants were satisfied with the BL methodology.

With respect to the "attitudes towards thinking and learning" scale (Table 5), the overall score showed a significantly higher proportion of participants agreeing (65%) than disagreeing (7%), but a substantial portion of students (28.4%) preferred to stay neutral.

In the BL "course experience" portion of the survey (Table 6), questions were grouped in three areas: course design, personal factors and learning experience. The results indicated that apart from personal factors, more participants agreed than disagreed. With respect to personal factors, participants seemed to be more confused, and many preferred to stay neutral (36%), though the percentage in agreement (35%) was still more than those in disagreement (29%). Notably, 71% of student participants agreed that BL improved their performance in mid-semester tests and end-semester exams, with 20% remaining neutral on this.

The *p*-values for all the categories were below 0.001, indicating a strong and significant difference in participants' opinions regarding their experience of and interest in the BL courses.

Table 4. Course interest portion of the survey

SL	Attention	Agree	Neutral	Disagree	x^2
1	The professor knows how to make us feel enthusiastic about the subject matter of this course.	252	42	15	
2	This course has very little in it that captures my attention.	78	99	132	
3	The professor creates suspense when building up to a point.	140	107	62	
4	The students in this course seem curious about the subject matter.	209	74	26	
5	The professor does unusual or surprising things that are interesting.	164	102	43	**63.5***
6	The professor uses an interesting variety of teaching techniques.	229	53	27	
7	I often daydream while in this course.	68	104	137	
8	My curiosity is often stimulated by the questions asked or the problems given on the subject matter in this course.	193	99	17	
	Combined score for items	**167**	**85**	**57**	
	In %	**54**	**28**	**18**	

SL	Relevance	Agree	Neutral	Disagree	x^2
1	The things I am learning in this course will be useful to me.	273	26	10	
2	The professor makes the subject matter of this module seem important.	270	30	9	
3	I do not see how the content of this course relates to anything I already know.	74	85	150	
4	In this course, I try to set and achieve high standards of excellence.	240	59	10	
5	The content of this course relates to my expectations and goals.	210	82	17	
6	The students actively participate in this course.	211	72	26	**167.3***
7	To accomplish my goals, it is important that I do well in this course.	265	37	7	
8	I do not think I will benefit much from this course.	57	49	203	
9	The personal benefits of this course are clear to me.	240	53	16	
10	I have to work very hard to succeed in this course.	255	43	11	
11	I feel that this course gives me a lot of satisfaction.	218	65	26	
	Combined score for items	**210**	**55**	**44**	
	In %	**68**	**18**	**14**	
SL	**Confidence**	**Agree**	**Neutral**	**Disagree**	**x^2**
1	I feel confident that I will do well in this course.	243	51	15	
2	You have to be lucky to get good grades in this course.	140	78	91	
3	Whether or not I succeed in this course is up to me.	233	63	13	
4	The subject matter of this course is just too difficult for me.	78	99	132	
5	It is difficult to predict what grade the professor will give my assignments.	150	107	52	
6	As I am taking this course, I believe that I can succeed if I try hard enough.	274	29	6	**122.3***
7	I find the challenge level in this module to be about right: neither too easy nor too hard.	225	75	9	
8	I get enough feedback to know how well I am doing.	203	80	26	
	Combined score for items	**193**	**73**	**43**	
	In %	**62**	**24**	**14**	

SL	Satisfaction	Agree	Neutral	Disagree	x^2
1	I feel that the grades or other recognition I receive are fair compared to other students.	222	65	22	
2	I enjoy working for this course.	239	48	22	
3	I am pleased with the professor's evaluations of my work compared to how well I think I have done.	247	43	19	
4	I feel satisfied with what I am getting from this course.	244	49	16	
5	I feel rather disappointed with this course.	56	62	191	**150.3***
6	I feel that I get enough recognition of my work in this course by means of grades, comments, or other feedback.	195	97	17	
7	The amount of work I have to do is appropriate for this type of course.	225	67	17	
	Combined score for items	**204**	**62**	**43**	
	In %	**66**	**20**	**14**	

Table 5. Attitudes towards thinking and learning

SL	Attitudes towards thinking and learning	Agree	Neutral	Disagree	x^2
1	I like to understand where other people are "coming from," what experiences have led them to feel the way they do.	219	85	5	
2	The most important part of my education has been learning to understand people who are very different to me.	206	90	13	
3	I feel that the best way for me to achieve my own identity is to interact with a variety of other people.	248	51	10	
4	I enjoy hearing the opinions of people who come from backgrounds different to mine — it helps me to understand how the same things can be seen in such different ways.	254	46	9	
5	I am always interested in knowing why people say and believe the things they do.	251	51	7	
6	I try to think with people instead of against them.	216	82	11	
7	I'm more likely to try to understand someone else's opinion than to try to evaluate it.	236	64	9	
8	I tend to put myself in other people's shoes when discussing controversial issues, to see why they think the way they do.	183	97	29	
9	Through empathy, I can obtain insight into opinions that differ from mine.	193	106	10	
10	When I encounter people whose opinions seem alien to me, I make a deliberate effort to "extend" myself into that person, to try to see how they could have those opinions.	168	121	20	**156.3***
11	In evaluating what someone says, I focus on the quality of their argument, not on the person who's presenting it.	224	75	10	
12	I like playing devil's advocate — arguing the opposite of what someone is saying.	82	115	112	
13	I find that I can strengthen my own position through arguing with someone who disagrees with me.	123	96	90	
14	I often find myself arguing, in my head, with the authors of books that I read, trying to logically figure out why they're wrong.	154	114	41	
15	It's important for me to remain as objective as possible when I analyse something.	228	76	5	
16	I have certain criteria I use in evaluating arguments.	208	90	11	
17	I try to point out weaknesses in other people's thinking to help them clarify their arguments.	178	100	31	
18	One could call my way of analysing things "putting them on trial" because I am careful to consider all the evidence.	194	103	12	
19	I value the use of logic and reason over the incorporation of my own concerns when solving problems.	242	61	6	
20	I spend time figuring out what's "wrong" with things. For example, I'll look for something in a literary interpretation that isn't argued well enough.	188	103	18	
	Combined score for items	**200**	**86**	**23**	
	In %	**65**	**28**	**7**	

Table 6. Blended learning course experience portion of the survey

SL	Course design	Agree	Neutral	Disagree	x^2
1	Description of module objectives, learning activities and assignments in the online module was excellent.	227	50	32	
2	Expression of expectations for performance (e.g., online forums and assignments) in the module was excellent.	203	67	39	
3	The professor's overall organisation of the course was great.	275	25	9	
4	Continuity between face-to-face class and online learning was good.	209	63	37	
5	The pace of the module was user friendly.	208	60	41	
6	The professor's interest in your learning was good.	281	19	9	**275.9***
7	The professor's feedback on your performance in assignments and participation in the forums was very helpful.	254	42	13	
8	The professor-provided orientation on use of the online resources, activities and AUST learning management system was very helpful.	268	30	11	
9	Overall, the course experience was excellent.	235	54	20	
	Combined score for items	**240**	**46**	**23**	
	In %	**78**	**15**	**7**	

SL	Learning experience	Agree	Neutral	Disagree	x^2
1	Multimedia resources on AUST's learning management system enriched my learning experience.	223	58	28	
2	Communicating online with students and the professor improved my learning.	209	74	26	
3	Blended learning improved my time-management skills.	212	68	29	
4	Blended learning improved my digital literacy.	231	61	17	
5	Blended learning improved my performance in mid-semester tests and end-semester exams.	212	70	27	**206***
6	Blended learning enabled me to learn at any time, any pace, from anywhere, using any device.	251	42	16	
7	Use of Moodle Classic mobile app for viewing / reading learning resources; interacting with faculty and peers in forums; and submitting assignments was satisfactory.	200	70	39	
	Combined score for items	**220**	**63**	**26**	
	In %	**71**	**20**	**9**	

SL	Personal factor	Agree	Neutral	Disagree	x^2
1	I feel more anxious in this course.	94	87	128	
2	I have trouble using the technologies in this course.	78	48	183	
3	This course required more time and effort.	151	83	75	**15.5***
	Combined score for items	**108**	**73**	**129**	
	In %	**35**	**36**	**29**	

*$p < 0.01$

4.1. Is there a significant difference in performance between students in blended and non-blended courses?

In this section, we investigate the students' performance in terms of final grades achieved in the BL courses offered in the Fall 2019 semester. We compare these grades to those for the same courses offered in the Spring 2019 semester in a non-blended method.

The results of the blended and non-blended groups were compared using an independent sample *t*-test. The comparison methodology was carefully chosen to assess whether the students in the BL courses had an edge over those in the non-blended ones.

To calculate the *t*-value among the groups of students, we collected the results of the blended and non-blended groups from the IUMS. The students' letter grades were converted to equivalent grade points as follows: A+ = 4.00, A = 3.75, A– = 3.5, B+ = 3.25, B = 3.00, B– = 2.75, C+ = 2.5, C = 2.25, D = 2.0 and F = 0.0. The mean and standard deviation (*SD*) were calculated from the grade point data. We had a total sample size of 2,682 students in the BL group and 3,020 in the non-blended group. An independent sample *t*-test was conducted to compare the performance of the students in both groups. Table 7 shows the means and *SD*s of the groups. There was a significant difference between the mean scores of the non-blended group ($M = 2.26$) compared to the blended group ($M = 2.96$). The calculated effect size (Cohen's *d*) is 0.271, which is considered a medium effect (Cohen, 1988).

Table 7. Independent sample *t*-test for the final scores

Group	Mean	*SD*	*N*	*df*	*p*-value	*t*-value
Non-blended	2.25	1.320	3,020	5,700	$p < 0.001$	**11.88**
Blended	2.96	1.321	2,682			

SD = standard deviation, df = degree of freedom (N1-1) + (N2-1)

Table 7 also shows the *t*-value to be 11.88 among the blended and non-blended groups, with a *p*-value < 0.001, which clearly indicates there was a highly significant effect (improved performance) in the blended learning group in terms of results compared to the other group. This to a great extent establishes the impact of blended learning.

Table 8. Independent sample *t*-test for the final scores for different courses

Course name	Non-blended	Blended	*t*-value
	M(SD)	*M(SD)*	
Biomedical Instrumentation	3.63(0.55)	3.49(0.87)	0.71
Chemistry	2.06(1.27)	3.29(0.8)	17.05*
Computer Graphics	2.9(1.09)	3.55(0.67)	5.73*
Cost and Management Accounting	1.66(1.68))	2.98(0.92)	8.06*
English Language	2.47(1.13)	3.14(1.39)	4.38*
Environmental Engineering III	2.25(1.17)	3.74(0.72)	11.03*
Export-Import Management	2.3(1.18)	2.54(0.68)	1.39
Geology and Geomorphology	2.59(1)	3.38(0.66)	7.67*
Internal Combustion Engine	1.92(1.28)	2.98(0.83)	4.94*
Landscape Design	3.06(0.98)	2.91(0.63)	0.76
Mathematical Analysis for Computer Science	2.99(0.97)	3.66(0.72)	5.35*
Mathematics-II	1.75(1.53)	3.33(0.87)	11.73*
Multimedia Communications	3.58(0.63)	3.92(0.51)	4.83*
Numerical Analysis and Statistics	2.22(1.19)	3.52(0.76))	12.95*
Numerical Methods	2.55(1.06)	3.38(0.67)	7.41*
Physics	1.91(1.32)	3.27(0.83)	19.2*
Wet Processing-I	1.71(1.27)	3.29(0.86)	13.11*
Yarn Manufacturing-I	2.57(1.13)	3.21(0.9)	5.09*

** $p < 0.001$, SD = standard deviation, M = mean*

Table 8 shows the course-by-course significance of the blended learning approach over the non-blended mode. We can see that in 15 out of 18 blended courses, significant performance improvement was observed in terms of the students' grades. Table 8 presents a detailed comparison in terms of *t*-value. For the Biomedical Instrumentation course, the non-blended learning group performed slightly better than the blended learning group in terms of mean grade points earned. A similar result was observed for the Landscape Design course in the Department of Architecture. However, the significance in both cases was very low (the *t*-value and *p*-value were insignificant). In the case of the Export-Import Management course in the Business Administration department, the blended and non-blended groups could not be significantly differentiated. It is worth noting

that around 50% of the total classes in the Fall 2019 semester were conducted over the Zoom platform due to the COVID-19 pandemic. Students were thus significantly immersed in the technological environment compared to in previous semesters. We think the combination of blended learning and increased technological use contributed to the massive improvement in performance observed in the BL-based courses, evident from the results in Table 8.

4.2. Comparing students' performance versus achievement levels

In this section, our objective was to investigate whether BL affects any specific group(s) of students. For example, we wanted to observe the impact of blended learning compared to non-blended learning among the high, average and low CGPA achiever groups of students. To do so, we categorised the students who had participated in the blended and non-blended forms of the courses in three different groups based on their pre-CGPA.

Table 9. Independent sample *t*-test for the groups' final grades, based on achievement level

Achievement level	Course type	Mean	*SD*	*t*-value
High achievers	Blended	3.75	0.38	9.16*
	Non-blended	3.42	0.74	
Average achievers	Blended	3.48	0.71	18.40*
	Non-blended	2.38	1.16	
Low achievers	Blended	3.00	0.97	23.73*
	Non-blended	1.39	1.22	

** $p < 0.001$, SD = standard deviation*

Table 9 summarises the performance of the different achievement level groups in the blended and non-blended courses. We can see from the summary that the high achievers of the blended group had $M = 3.75$ and $SD = 0.38$, compared to $M = 3.42$ and $SD = 0.74$ for the non-blended group. The results were found to be significantly different (at $p < 0.001$).

A similar result was observed for the average achievers; the blended group had $M = 3.48$ and $SD = 0.71$, compared to $M = 2.38$ and SD = 1.16 for the non-blended group. For the low achievers, the blended group had $M = 3.00$ and $SD = 0.97$, compared to M = 1.39 and $SD =$ 1.22 for the non-blended group.

From the overall results we can conclude that the students showed better performance in the blended courses, irrespective of their achievement levels.

4.3. Relationship between learners' perceptions, motivations, digital literacy, attitude towards learning and final score in a blended course

We were interested in comparing students' perceptions with their achieved grades to see whether there was any correlation. We similarly looked for any correlation among other factors, such as attention, confidence, satisfaction and relevance.

To assess correlations, we employed Pearson's correlation with 11 variables: final grade, digital literacy, course design, learning experience, personal factors, attention, relevance, confidence, satisfaction, connected knower and separate knower. The last two variables were isolated from the "Attitude towards thinking and learning" portion of the survey (Galotti et al., 1999). Connected knowers are flexible, adaptable, and love to go with the flow of a class, whereas separate knowers are more critical and argumentative in their attitude towards learning. We have included those two factors as variables to see whether learners' attitude mattered for their final achievement in the course.

The results (Table 10) suggest there is a significant relationship between learning experience and course design, with $r = 0.77$ and $p < 0.01$, which also indicates that course design strongly impacted participants' learning experience. Satisfaction was strongly correlated with almost all the remaining variables, with $p < 0.01$.

The results also indicate that connected knowers had good learning experiences and better satisfaction levels than separate knowers.

The results further show that personal factors were negatively related to most of the variables. We think this might be because while participants talked positively about the survey, their results, learning experience, confidence, etc. were not necessarily satisfactory.

From Table 10 we can also see a correlation between the variables digital literacy and final grade earned, with $r = 0.12$ and $p < 0.05$.

Similarly, there was a correlation between final grade and satisfaction, with $r = 0.11$ and $p < 0.05$. The rest of the variables could be significantly correlated with the students' final grades. Our data also show that being confident did not necessarily guarantee a good result ($r[confidence, final\ grade] = -0.4$), though this could not be strongly verified.

Table 10. Correlations between learners' perceptions, motivations, digital literacy, attitudes and final grades

	1	2	3	4	5	6	7	8	9	10	11
Final grade (1)	1										
Digital literacy (2)	.12*	1									
Course design (3)	.07	.52**	1								
Learning experience (4)	.03	.52**	.77**	1							
Personal factors (5)	–.02	–.46**	–.52**	–.48**	1						
Attention (6)	–.02	.24**	.49**	.42**	–.04	1					
Relevance (7)	.09	.44**	.59**	.59**	–.30**	.51**	1				
Confidence (8)	–.04	.30**	.36**	.46**	–0.01	.41**	.55**	1			
Satisfaction (9)	.11*	.44**	.66**	.65**	–.28**	.54**	.65**	.60**	1		
CK (10)	–.04	.30**	.29**	.32**	–.11*	.24**	.47**	.51**	.38**	1	
SK (11)	–.05	.15**	.24**	.25**	.01	.34**	.42**	.52**	.33**	.63**	1

* Correlation is significant at the 0.05 level. ** Correlation is significant at the 0.01 level.

4.4. Relationship between self-regulated learning behaviour and students' learning performance

Table 11 shows the stepwise regression model summary of the students' self-regulated learning behaviour indicators for their final scores. The data were collected from the AUST Moodle LMS platform.

Four independent variables — forum access, login frequency, course view and file access — were entered in the regression analysis. Among these, two variables were less significant predictors, namely forum access

and login frequency. Model 2 was the better fit, explaining 3% of the variance in the final scores, $F(2,974) = 15.958$, $p < .05$. This result indicated that two predictor variables had no effects and two had very low positive effects on students' final scores.

Table 11. Model summary for stepwise regression analysis

Dependent variable	Predictor	Model 1	Model 2
		β	β
Final scores	Forum access	.079*	.239*
	Login frequency		–.226*
Adjusted R^2		.005	.030
F change		6.059	15.958
Sig. *F* change		.014	.000

*$p < .05$

4.5. Analysis of learners' personal opinions on the effectiveness of the BL environment for their course of study

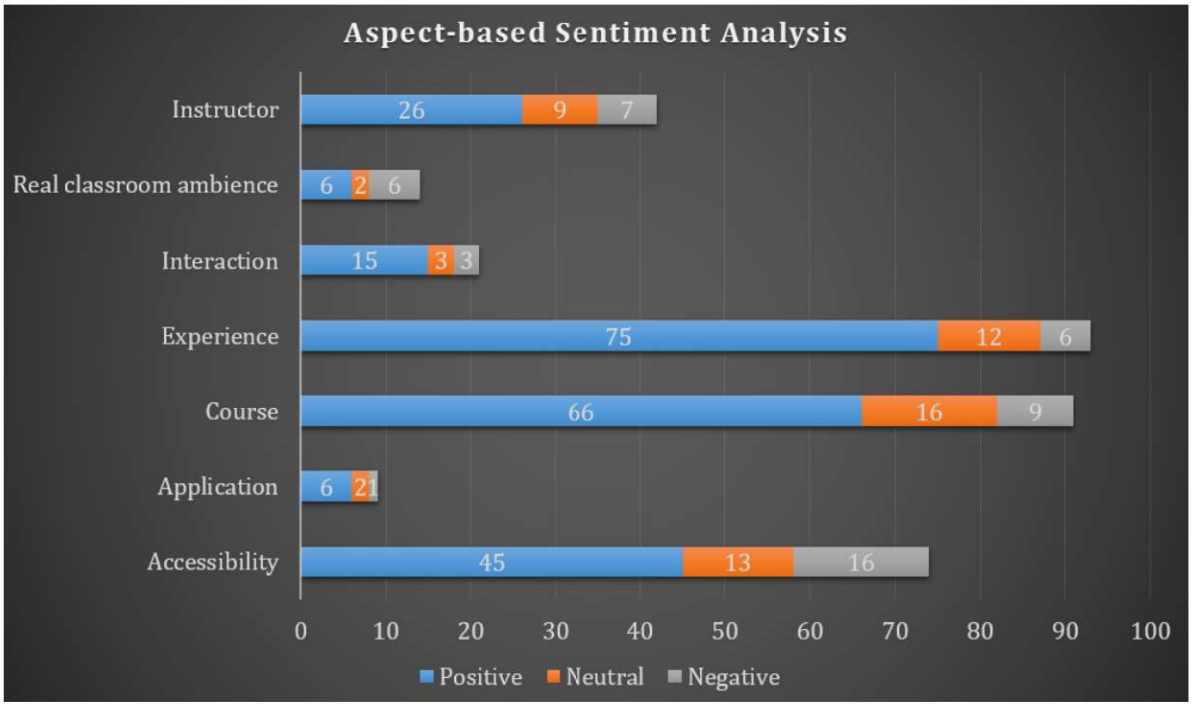


Figure 1. Aspect-based sentiment analysis of the students' feedback

The survey included one open-ended question, where respondents were free to write their opinions regarding the blended learning course. We then performed aspect-based sentiment analysis on the collected data. In essence, we trained a model with 50% personal comments data (30% pre-labelled and 20% labelled using active learning). The remaining 50% of the data were kept separated as a test set. The data were labelled with seven predefined classes: instructor, real classroom ambience, interaction, experience, course, application and accessibility. Our trained model received the test set and provided an output of the test dataset, labelled with an F1 score of 0.62. Once we had the labelled data, we applied group-wise sentiment analysis using the Microsoft Azure data analysis platform in Microsoft Excel 2013 and received

the positive, negative and neutral polarity values of all the comments. A summary of the polarity values is shown in Figure 1.

From the figure we can see that the responses containing instructor-related remarks included 26 positive comments, nine neutral comments and seven negative comments. For the aspect "real classroom ambience," the positives and negatives were equal (six in both cases). The figure shows the results for all seven aspect-based classes, and we can see that the respondents wrote mostly about their experience (primarily positive) and least about the real classroom ambience (also primarily positive). Most of the students commented that they appreciated seeing all the lectures for their course on the LMS, as well as what each lecture covered. They also liked being able to find lectures or updates they had missed, and professors' notifications about the lectures. They were impressed with the availability of resources for their course. Additional study materials helped them to understand the topics better. On the downside, they commented that Moodle had a complex layout and was not user-friendly. They suggested improving the Moodle website, especially in terms of communication methods, such as introducing file sharing among teachers and students. A few also pointed out that email notifications regarding classes arrived hours late due to connectivity issues, which caused a few students to miss classes occasionally. A few students found the BL system complex and were not satisfied with their grades. They thought the BL system presented numerous irrelevant topics not related to the examination, and they felt overburdened.

The following are some of the student comments:

Real classroom ambience: Here, the participants talk about the class environment.

Positive: "Blended course is beneficial as we can interact with the course teacher and course mates easily through this platform in this pandemic."

Neutral: "The environment should be designed more user-friendly."

Negative: "Even though I achieved a good grade in the previous blended learning course, I still wouldn't prefer to do it again because it's an extra hassle for me. I'd rather prefer the normal way. There is a possibility that I feel this way because the previous course had such a big content that it required a lot of time to finish in comparison to all other courses."

Accessibility: Here, the participants talk about application use, network issues, etc.

Positive: "It's informative and user-friendly."

Neutral: "Getting an email for the notifications would be nice."

Negative: "The layout of this application is complex. Sometimes it is difficult to submit our work."

Instructor: Participants offer their views on the course instructor.

Positive: "The course was excellent. The Professor had put so much effort & that was very helpful for us to understand this course."

Neutral: "I think the course was good enough but every chapter we have studied should have more elaborated examples where we can understand what's happening and why."

Negative: "I think it is new for both teachers and students so before starting this course, a proper training session should be arranged."

Course: Here, the participants talk about their views on course design and related issues.

Positive: "I am quite satisfied with this course and have nothing additional to comment on."

Neutral: "Course content needs to be more detailed so we can have a clear idea of the course from the start of the semester."

Negative: "Blended course is not enough user-friendly."

Experience: Here, the participants talk about their overall experience of the blended learning course.

Positive: "It was a good experience."

Neutral: "Course can be made more interesting by gaining field experience."

Interaction: Here, the participants express their views about interactions with the instructor regarding the course materials.

Positive: "The course was excellent. The Professor had put so much effort & that was very helpful for us to understand this course."

Neutral: "Because of the pandemic situation, we couldn't get the chance to be familiar with the blended course properly. The full course was done online since the pandemic started. But we believe we could do good if this course was done properly. We think blended courses will be helpful for us to understand any topic thoroughly and also make us good at modern technologies."

Application: Here, the participants talk about the applied knowledge gained.

Positive: "Honestly, we have learned a lot through this course. The learning outcomes of this course are completely different from other courses. I think doing this course has enhanced my personal skills. Above all, the greatness of this course is incomparable."

Neutral: "It would be really helpful if students got to know the basics of CCNA, Cisco, etc. These things have high value in the practical field and also relatable to this course's topics."

4.6. Impact of the training and mentoring programme on the teachers' experience of designing and teaching in a BL environment

This section presents the teachers' experiences with designing and teaching in a BL environment. Using interviews of the 20 teachers participating in the study, we employed an activity theory framework to analyse the resulting data.

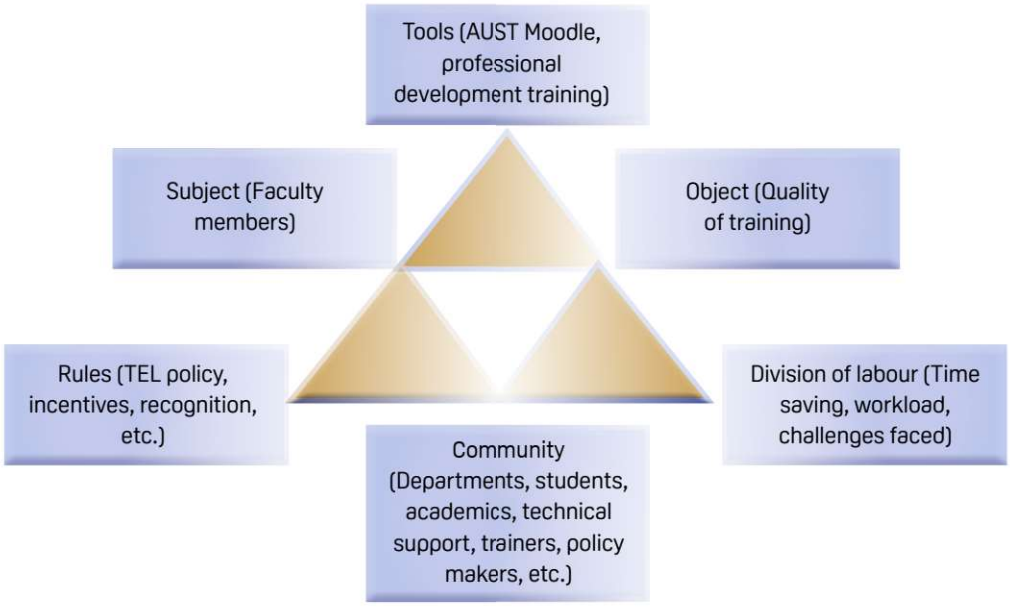


Figure 2. Activity system triangle based on Engeström's (1987) activity system.

Teachers expressed concern about the professional training they had received. Our objective here is to relate the instructors' insights and the outcomes of the training. Figure 2 presents the activity framework model we used. This activity framework model has six elements: subject, object, tools, community, rules, and division of labour. The participating teachers are the *subjects*. An *object* generally represents the subjects' goals; here, object refers to the quality of the training the subjects received. In the BL environment, the teachers utilised Moodle to design the courses and teach interactively. The LMS is referred to as *tools* in the model. The AUST's TEL policy corresponds to the element *rules* in the model. The *community* element refers to the key actors in our system, namely the teachers, training providers, AUST management authority, and university ICT centre with all its support staff, who worked hard to successfully carry out this training. The *division of labour* component plots the relations between object and community and can be viewed as the challenges the teachers faced during the BL implementation process.

4.6.1. SUBJECT–TOOLS–OBJECT

All 20 of the interviewed faculty members had received training on how to use Moodle properly. The interview data indicated the faculty members were highly satisfied with the training. It introduced them to the requisite technological tools, which in turn was reflected in their experience of carrying out their courses effectively. For example, one professor stated: "I have learned blended learning course design elaborately in the training. I have also learned how to implement a blended course design. Finally, I have implemented it successfully." Another faculty member said: "I have learned how to present my teaching material for students using a variety of the learning approaches and incorporating technology

in the teaching environment [as well as] evaluating students by taking online testing and assessments with reporting features."

In a blended learning approach, students can benefit from doing part of their learning independently in a digital environment, and part of it in a classroom. The instructors mainly emphasised that they could effectively design and deliver course materials due to the training programme made available to them prior to the real-time in-class teaching activities. For example, one instructor remarked: "It helped me to design the course effectively in Moodle." Another responded: "Training has made me confident using Moodle." One of the respondents even said: "I have trained our new faculty members and also part-time faculty members of the blended course."

The faculty members also expressed that the blended learning training provided to them helped a lot during the COVID-19 pandemic. For example, one instructor responded: "During the current pandemic, the training helps me to develop blended content for the other courses taught by me." Another respondent mentioned: "During COVID-19 pandemic, most of the classes I had to take were online. Therefore, my training during blended learning training helped me a lot in both conducting my course as well as assessment of the students." A few faculty members showed some notable concerns as well. One respondent pointed out: "Unavailability of high-speed Internet to students and sometimes, to faculties." Another instructor remarked: "It requires net/wi-fi connection in each classroom, along with high bandwidth." Most of their concerns were about technical facilities, especially having a stable ICT platform.

4.6.2. TOOLS–RULES–DIVISION OF LABOUR

To ensure that its blended courses run smoothly, AUST has gradually developed a TEL policy, in co-operation with the Commonwealth of Learning. AUST also ensures that the technical support staff for TEL provide excellent help, and that parties receive the required ICT devices, evidence of which was found in the teachers' review. One of the faculty members expressed gratitude: "AUST supported by all means to support blended learning by arranging workshops, increasing Internet bandwidth, providing a laptop for the course teachers, providing access to different OER sites, etc." The teachers also felt that the AUST Moodle LMS was quite flexible and convenient to use. They could access the system remotely from anywhere, without any issues. In this regard, one respondent stated: "Easier and faster communication, more interaction, dynamic ways of interaction."

4.6.3. SUBJECT–RULES–COMMUNITY

The community elements of our activity theory model were instrumental in ensuring the blended learning system ran efficiently. AUST's top management — the Chairman of the Board of Trustees, Vice-Chancellor, Treasurer, deans, and heads of departments/ school — came forward to inspire faculty members to use a blended learning model in their courses. The instructor interviews show evidence of this. For example, one instructor responded: "AUST authority is supportive towards blended learning and all the time ICT helped and guided us." The faculty members were very supportive, helping their colleagues by sorting out any course

design issues, sharing materials and giving necessary feedback. Though most faculty members were self-motivated, they extended helping hands to motivate others whenever necessary. This kind of experience sharing enhanced the blended learning environment and contributed towards the positive performance outcomes. Having a well-established TEL policy also played a vital role in this regard.

4.6.4. SUBJECT–COMMUNITY–OBJECT

The major issue was found in the subject–community–object triad, in faculty members' responses to the question: "To what extent are your colleagues aware of blended learning?" Their comments suggested that many believed their colleagues were not very aware of the BL mode. Figure 3 presents the results. On a 5-point scale from lower to higher awareness, 35% of the faculty responded with a 3 (average awareness), 20% with above average, and 45% with below average.

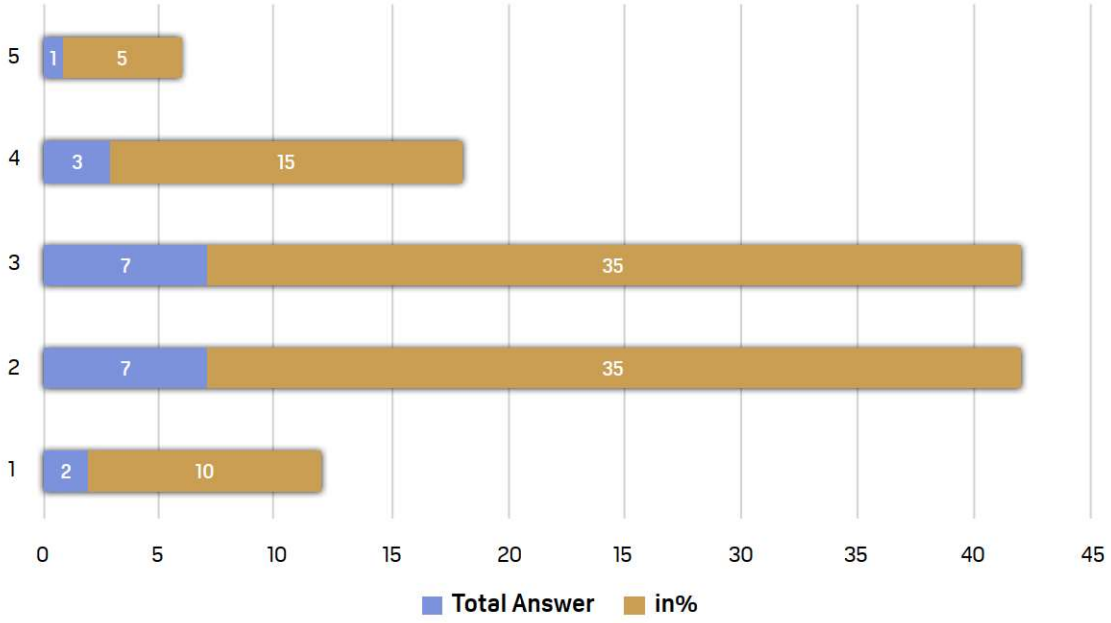


Figure 3: Teachers' responses to the interview question, "To what extent are your colleagues aware of blended learning?" using a 5-point scale.

4.6.5. OBJECT–COMMUNITY–DIVISION OF LABOUR

This triad in the activity theory framework highlights the significance of teamwork, and faculty statements support this. For example, one respondent said: "Yes, collaboration is needed for blended because collaborative learning facilitates active learning, knowledge sharing. Also promote social interaction and a supportive eLearning community." COL also promotes the practice of collaboration to develop a sense of community within organisations implementing TEL. AUST can take this opportunity to overcome any challenges in TEL implementation. Continuous review of comparable courses and the provision of necessary feedback can help with course design and delivery methods. Continuous social interactions within the community also disseminate positivity, which can bring overall improvement to TEL implementation by overcoming unforeseen challenges.

5. Discussion and Conclusion

To assess the impact of blended learning at Ahsanullah University of Science and Technology, we formulated several research questions and approached learners and teachers to search for answers. We were interested in whether a pragmatic statistical analysis applied to data collected from a survey, the IUMS, and interviews could provide empirical answers to our questions.

The first research question was intended to investigate whether the BL teaching methodology could improve students' achievements in terms of earned grades. The results showed that students using the BL method received significantly better grades than those in the non-BL group. This outcome is in line with the findings of some earlier authors (Asarta & Schmidt, 2017; Angelini & García-Carbonell, 2019; Lin et al., 2017), who have generally found that students perform better in a BL environment. In our case, students in the BL group showed significantly better performance, validating the idea that if students are presented with a proper technology-enabled teaching and learning environment, they can feel more connected, be more interested in participating in discussions, remain relaxed, and be more confident about learning, which can translate into overall improved performance.

The next research question continued from the first one, with an additional fact-checking component. We wanted to determine whether there was any significant difference in performance for students in different achievement categories — specifically, high-CGPA, average-CGPA and low-CGPA. In our case, the obtained results showed that irrespective of their category, students had significant performance improvement. Authors of another study (Owston et al., 2013) suggested there may be significant performance improvement in BL-based courses only for high-achieving learners. Surprisingly, in our study, the difference in final grades between non-blended and blended groups was much higher for the low-achiever group. This result is a vote in favour of blended learning. We think the students were more focused on the course materials, could ask for clarification at any time and communicated with their peers more freely

than in a classroom-only environment, which helped them receive better grades, regardless of what achiever category they were in.

Whether there were any significant correlations between digital literacy, motivation, learners' perceptions, and final grades was our third research question. We performed several statistical analyses and found a significant relationship between *learning experience* and *course design*, which means course design strongly affected participants' learning experience. There was also a correlation between the variables *digital literacy* and *final grade earned*. Students with sufficient technological knowledge had access to the course materials, videos and discussion forums, which related to their final grades earned. A correlation between *final grade* and *satisfaction* was observed, the implication being that the students' satisfaction level played an important role in their final grades.

The fourth question asked how learners described the effectiveness of the blended learning environment in their course of study. We sought the students' feedback through an open-ended question that asked them to comment on anything not covered in the survey. The goal was to see how the learners described the effectiveness of the BL environment in their course of study. Aspect-based sentiment analysis revealed that the students had mostly positive feedback, although some negative feedback was also offered. Students were satisfied with the course materials available online, which they could examine anytime, ask questions about and discuss with their peers. A few students said they found the BL system too complex and were not satisfied with their grades; some felt they had been presented with numerous additional topics not directly related to the examination, and this translated into more pressure for them.

The fifth research question sought to identify the impact of training on the teachers' involvement in the BL environment. An activity theory framework model was created based on the teachers' feedback. The trainers acknowledged that although they found it slightly difficult to design a course curriculum in the beginning, they gradually got used to the TEL environment. The professional training provided to them was helpful in this regard. The teachers were very positive about the BL methodology and expressed satisfaction about the support provided by AUST's ICT department.

Finally, a stepwise regression analysis was performed to answer the last question — i.e., whether there was a significant relationship between self-regulated learning behaviour indicators and student performance in the BL environment. Students' self-regulated learning behaviour was measured by their forum access, login frequency, course views, and file access. The results showed that students' self-regulating learning behaviour had a negligible effect on their final scores. According to the standardised coefficient, forum access was a more significant predictor than login frequency. Notably, students with more forum participation had a slight edge in terms of final score over those who participated less in group discussions.

The overall statistical findings showed that blended learning in the AUST environment was effective and the students benefited significantly from it. Learners were also very satisfied with the BL environment and managed to engage in the tutorials provided by trained teachers. Aside

from a few students experiencing discomfort in some areas, the application of blended learning at AUST boosted students' happiness and overall academic results.

5.1. Recommendations

Based on the empirical results obtained from our analysis, we have arrived at the following recommendations, which may be very useful for shifting the quality of blended learning implementation at AUST to the next level.

IMPROVED AND STABLE INTERNET CONNECTIVITY

The parties involved in BL implementation mentioned concerns about poor or unstable Internet connectivity. A few participants missed out on classes due to network delays or similar events.

AUST already has a gigabit fibre-optic backbone to support Internet connectivity. Now, it is high time to move towards increased bandwidth for Internet connectivity as well. In addition, reliable and stable Wi-Fi coverage throughout the classrooms and open spaces of the AUST campus would allow students to access digital content anytime, from any type of device, without a hassle. This would allow students to spend more time on the content of the curriculum rather than thinking about how to reach the content.

OVERHAULING THE LEARNING MANAGEMENT SYSTEM

Learner feedback indicated that Moodle, the back-end application framework used as the LMS, was probably not user-friendly and was complex to operate. Proper fine-tuning is needed to accommodate users' suggestions and introduce more features that may help them operate the LMS with more flexibility in the future. A version upgrade to Moodle 3.10.3+ is recommended, to gain updated features and greater stability. Due to the COVID-19 pandemic, the trainers were forced to mix LMSs — for example, to use Google Classroom and Moodle together. A single LMS with a proper configuration is needed to increase responsiveness and features that can help both teachers and learners. Moreover, Moodle has a number of APIs in its core that provide tools for writing Moodle scripts. These can be utilised to build customised Moodle plugins that meet additional student demands. A team of ICT professionals could be engaged to look into this matter and check whether the students' requests for content sharing, discussion platforms, etc. can be realised through additional Moodle plugins.

ENGAGING THE STUDENTS THROUGH TRAINING TO USE THE LMS PROPERLY

Data analysis revealed a significant relationship between the learners' digital literacy and their final grade, implying that a learner with better digital literacy achieved better grades in the blended courses. We saw from the Moodle log that the students only infrequently accessed many of the LMS features. If we can train the students properly on the various features of Moodle and how to access them effectively, we can expect additional performance gains for them. Learners could be trained either before commencing blended courses or during, to keep them engaged throughout the semester. AUST students could also be encouraged to take COL's C-DELTA course to develop digital education skills. AUST could adopt

this online course as a non-credit offering for its students. Student feedback should be periodically elicited to see whether any further steps are needed to keep them fruitfully involved in the BL environment. Students must receive dedicated and prompt support whenever they encounter difficulties. A separate team of IT personnel is recommended for this purpose.

TRAINING FOR THE TRAINERS

We have identified a close relationship between students' learning experience and good course design. To improve the impact of BL, it is very important to continuously monitor and enhance the BL course structure, upgrade materials, and fine-tune course contents. In addition, to keep trainees engaged, it is also important to ensure the course design is interesting and appealing. Professional training for teachers must therefore be continued. We also need to encourage teachers to collaborate with others so they can design blended courses more effectively. Student attention was highly related to course design, again pointing to the importance of providing ongoing training. All teachers must be trained properly before commencing a blended course. The TEL policy should stipulate timely prior training for teachers and the provision of continuous professional development on online and blended learning.

ENSURING LEARNERS AND TEACHERS HAVE ACCESS TO THE REQUISITE DIGITAL DEVICES

Digital literacy is a prerequisite for teachers who conduct blended courses. We recommend enhancing the current support provided to teachers by offering them the necessary devices either free of cost or on a flexible payment system. This will encourage them to use the latest technology, which will, in turn, support the BL environment. Proper training on how to use the devices is also recommended. A dedicated team of ICT personnel could provide real-time support for device management and Internet connectivity issues. AUST may wish to update its TEL policy accordingly and consider providing similar devices and connectivity support to students as well.

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