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Blended Learning, Learning Motivation, and Academic Performance in Undergraduate Science Students

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ABSTRACT

Amid the Covid-19 pandemic blended learning (BL) has seen an exponential rise across the globe. Data on the effectiveness of BL have mostly come from developed Western countries which are essentially different from developing countries like Pakistan. This study aims to indigenously explore the relationship between students' views regarding blended learning (BL) and its effect on their academic achievement, possibly mediated by their learning motivation, in undergraduate science students of Pakistan. The participants included 239 (46.4%) male and 276 (53.4%) female students, aged 19 through 24 (M_{age} = 20, SD = 3.42), taken from GC University, Lahore, and Punjab University, Lahore. All the participants reported having a rich experience of BL during the Covid-19 pandemic. Learners' Views on Blended Learning (BL), and Motivated Strategies for Learning Questionnaire (MLSQ) were used to take data from the participants, and their GPAs were taken as their academic achievement. The results indicated that positive views of students' regarding BL are likely to enhance their learning motivation, whereas BL and learning motivation are likely to enhance their academic achievement. Further, learning motivation is also likely to mediate the relationship between BL and academic achievement. The results are consistent with most studies conducted in the West and support the generalizability and implementation of the Western BL models in the socio-cultural context of Pakistan. However, there is a need for further in-depth Indigenous studies on other aspects of BL before policy making and implementation.

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1 Introduction

Educational psychologists always strive to obtain empirical knowledge to facilitate the development of the most efficient and the most effective learning practices. The COVID-19 pandemic largely disrupted all areas of society including educational institutions (Aucejo, French, Ugalde Araya, & Zafar, 2020). The pandemic undermined almost all the prevailing educational practices and forced a massive, rapid, and unpredictable change in the learning and teaching strategies at all levels (Nerantzi, 2020). Hence, warranting an unprecedented and urgent need for educational psychology research to deal with this extraordinary situation.

The initial response, largely across the globe, was the complete closure of educational institutions and a gradual move towards online teaching/virtual learning (VL) where possible (Viner et al., 2020). Virtual learning, however, could not provide any alternative for the subjects where physical activities (e.g., sports) and lab work (e.g., science subjects) are mandatory (Aldhahi, Alqahtani, Baattaiah, & Al-Mohammed, 2022; Knudson, 2023). Therefore, with time, most educational institutions in developed countries and many in developing countries adopted a blended learning (BL) approach for teaching while the others, mostly for subjects without physical activities and lab work, committed to virtual learning (VL) only.

VL is generally described as functional and effective learning without the presence of traditional classroom settings (Simonson, Schlosser, & Orellana, 2011). Research findings on the effectiveness of VL are conflicted and indicate a strong need for traditional face-to-face communication with teachers (Lane & Whyte, 2006; Murphy, 2020). On the other hand, some aspects of VL (e.g., efficient use of time, relaxed environment, etc.) have some distinct advantages (Mishra, Gupta, & Shree, 2020). Therefore, BL – a combination of VL and aspects of face-to-face learning – approach has gained more popularity, and, hence, has also become the focus of educational research (Castro, 2019; Shim & Lee, 2020). One of the main aims of BL is to overcome the limitations of VL. Researchers have proposed different models for BL and the effectiveness of each is likely to vary, necessitating the importance of this research.

Constructivist learning theory asserts that the construction of knowledge depends upon the interaction with individuals as well as content (Piaget, 1977; Vygotsky & Cole, 1978; Woltering, Herrler, Spitzer, & Spreckelsen, 2009). Based on the types of interaction, BL, in general, has five (two face-to-face and three online) components (Alammary, Carbone, & Sheard, 2017). The first component of BL is a face-to-face instructor-led component where the instructor delivers the content and there is little to no opportunity for interaction and hands-on learning. However, it is beneficial concerning control (i.e., allows the teacher to design the best pedagogical strategy effectively) and efficiency (i.e., allows the teacher to deliver a substantial amount of material to a large number of students) (Gerzon, Heuer, Kibbee, Nielsen, & Veal, 2006; Griffin, Mitchell, & Thompson, 2009). The second component is a face-to-face collaboration which is based upon the interaction of students, i.e., encourages students to work in groups, discussions, etc. This approach is beneficial for an in-depth understanding of the content, engagement, development of critical thinking, and independent learning (Sarason & Banbury, 2004; Selvi & Perumal, 2012; Tutty & Klein, 2008).

The third component, instructor-led online learning through any virtual medium, has similar benefits to face-to-face instructor-led learning but also has an edge of flexible timing, free from space constraints (i.e., location) (Griffin et al., 2009). The fourth component, online collaborative learning, encourages students to interact online, like in face-to-face collaboration, and has the advantage of being free from time and location constraints (Gerzon et al., 2006). The fifth component, online self-paced, gives freedom to the students to learn at their desired pace at their preferred location and time (e.g., through online reading, watching lecture videos, etc.) (Moore, Dickson-Deane, & Galyen, 2011). Its main advantage is flexibility which allows

maximum inclusion of almost every eligible person across the globe (Müller & Mildenberger, 2021). However, research findings also indicate several potential disadvantages of BL as well. Therefore, more research is required on different aspects of BL (Shim & Lee, 2020). For example, what we are blending? Where are we blending? How are we blending? and what will be its impact? One very important aspect, the focus of this study, is investigating the relationship between BL, learning motivation, and academic performance.

In pedagogical settings, the achievement of learners and learning outcomes, in every learning scenario, has an association with the multidimensional construct of motivation (Brooker, Corrin, De Barba, Lodge, & Kennedy, 2018; Hsu, Wang, & Levesque-Bristol, 2019; Toste, Didion, Peng, Filderman, & McClelland, 2020). The motivation of learners becomes even more important when they must adopt BL (Zhang, Wang, Yang, & Wang, 2020; Zhou, 2016) e.g., for science students. Motivation, generally, implies incentives that are likely to lead somebody to behave spontaneously (Şahin, Keskin, & Yurdugül, 2020). Following the postulates of self-determination theory (SDT), learning motivation includes intrinsic motivation and extrinsic motivation and can be transited into achievement (Ryan & Deci, 2017). Intrinsic motivation leads student participation, with fun and pleasure, in learning activities without expectation of any reward or external pressure and results in taking challenges, curiosity, etc. along with an overall positive attitude (Gopalan, Bakar, Zulkifli, Alwi, & Mat, 2017). Extrinsic motivation, on the other hand, is concerned with those behaviors that are carried out with a reason and /without any relevance to inherent satisfaction (Ryan & Deci, 2017). This instrumental motivation can vary widely in its substance and character (e.g., externally imposed rewards as well as punishments for control) (Nolen, 2020). Effective learning strategies can increase the learning motivation of students and, hence, their academic performance (Chiang, Yang, & Hwang, 2014; Di Serio, Ibáñez, & Kloos, 2013). Generally, student behaviors indicating their learning motivation include diligence, persistence, interest in problem-solving, working independently, and finding innovative ways instead of following routine (Nolen, 2020; Ryan & Deci, 2017). Both BL and learning motivation have a strong influence on academic achievement (Nolen, 2020).

Academic achievement can be assessed in several ways and depends upon the context. The most common way is the assessment of academic achievement - to appraise the competencies of the student associated with specific learning aims - through test performance and class performance and the results are generally presented in the form of grade point average (GPA) or cumulative grade point average (CGPA) (Schneider & Preckel, 2017). This way, although most used, does have its limitations (e.g., may promote rote/surface-level learning only instead of in-depth understanding (Struyven, Dochy, & Janssens, 2005). However, empirical evidence suggests the reliability of these measures across classes and over time and for conducting research (Bacon & Bean, 2006).

2 Literature Review

BL is regarded as the future of education by some educationists, and they see the COVID-19 pandemic as an opportunity for the rapid development of this framework (Sangster, Stoner, & Flood, 2020). Research has indicated several advantages of the BL approach including flexible learning (Bower, Dalgarno, Kennedy, Lee, & Kenney, 2015), enhanced self-regulated learning (Li, Yang, Chu, Zainuddin, & Zhang, 2022), better student engagement (Butz, Stupnisky, Peterson, & Majerus, 2014). Further, social interactions facilitate learning and are considered important for academic success (Kim, Kwon, & Cho, 2011; Laffey, Lin, & Lin, 2006). Implementation of BL has reportedly enhanced the students' learning experience (Zhang et al., 2020), has the potential to adjust different styles of learning and emerge as the 'new normal' in education (Şahin et al., 2020), and is cost-effective (Graham, 2013). In many cases change from face-to-face to VL was perceived positive by the students (Baber, 2022) and reduced the dropout rate (Nolen, 2020). In many parts of the world, BL is fast becoming part

of their policies (Wu, Li, Zheng, & Guo, 2020). BL is regarded as an interactive and flexible learning method to accommodates more material (Afacan et al., 2016), is more adaptive to student needs (Ahmed, Alwi, & Akhtar, 2022; Benson & Kolsaker, 2015) has a positive effect on student performance (Spanjers et al., 2015). However, research also indicated that BL may be a limiting factor in the delivery of lectures (Lomer & Palmer, 2023).

The term BL, despite its widespread usage is, still, regarded as poorly defined (Han, Wang, & Jiang, 2019; Medina, 2018), however, integration of face-to-face and virtual learning is a common factor in all the definitions (Medina, 2018). The theoretical foundations of BL and its implementation for enhanced learning and performance still need more research in different pedagogical scenarios (Shand & Farrelly, 2018). Students may give more value to face-to-face learning in many instances which can compromise student engagement (Jeffrey, Milne, Suddaby, & Higgins, 2014; López-Pérez, Pérez-López, & Rodríguez-Ariza, 2011). Similarly, time to learn new technology, lack of technical support lack of resources, and complexity of work can present a major problem in effective learning in many parts of the world (Gedik, Kiraz, & Ozden, 2012; Mozelius, 2017).

Research also indicates that BL can enhance student motivation and commitment (Marriott, 2010). It can influence both the intrinsic and extrinsic motivation of students for learning (Goh, Hodas, & Vishnu, 2017; Kuo & Belland, 2019). Further, learning motivation has a direct impact on learning satisfaction which is likely to enhance academic achievement (Liang & Wu, 2010). Najafi and Heidari (2019) also support that students show better intrinsic motivation with BL, whereas McComas (2019) indicates enhanced extrinsic motivation while using BL compared to traditional learning only. Findings support that BL enhances the motivation of seventh-grade school students (Cole, 2020), secondary school students (Zainon & Yamat, 2021), and accounting students (Zainuddin, Farida, Keumala, Kurniawan, & Iskandar, 2022) while Permata and Nanda (2021) reported similar results for Indian students and (2020) for Malaysian students at school levels during the pandemic.

Several studies support that BL results in the enhanced academic achievement of students at different levels and in different geographic regions e.g. (Alsalhi, Eltahir, & Al-Qatawneh, 2019; Ezeanyika & Okigbo, 2021; Saiz-Manzanares, Escolar-Llamazares, & Arnaiz Gonzalez, 2020; Sibandze, Oloyede, & Pereira, 2020). Studies have also reported that motivated students show better academic achievement regardless of teaching style (Cabı, 2018; Cimermanová, 2018). Some studies have reported a significant but weak association between BL and academic achievement (Thomas, 2018). Other studies report that BL has a significant influence on both learning motivation and academic achievement (Islam et al., 2018). Studies have also reported subject-specific enhancement, at the undergrad level, in mathematics (Lin, Tseng, & Chiang, 2016), physics (Sulisworo, Agustin, & Sudarmiyati, 2016), English (Isti'anah, 2017) with BL compared to traditional learning, while studies also report its effectiveness at middle-school level for academic achievement of general science subject (Almasaeid, 2014; Ceylan & Kesici, 2017) and for medical students (Riad, Saadat, & Badawy, 2013).

2.1 Rationale

BL, VL, and all other teaching approaches have their distinct and unique advantages as well as challenges (Adnan & Anwar, 2020; Mishra et al., 2020; Shim & Lee, 2020). There is a need to empirically investigate the impact of all these approaches across different levels of education and in different cultures. The COVID-19 pandemic has changed our world in many ways. The impact of the closure of institutions across the globe has highlighted, perhaps like never before, the importance of educational psychology research. Blended learning (BL) is one of the most known research avenues in this regard. Most data on BL research have come from developed Western countries which are individualistic, egalitarian, and secular as compared to

collectivist, patriarchal, and predominantly religious countries like Pakistan (Holden & Ashraf, 2016). Indigenous research on BL is scarce and exploration of this aspect in the unique cultural perspective of Pakistan is needed. Therefore, this study aims to explore the effect of blended learning on the academic performance of the university students of Pakistan, possibly mediated by their motivation to study.

3 Methodology

A correlational research design was used to investigate the relationship between BL and academic achievement, possibly mediated by the learning motivation of the students. A purposive sample was drawn conveniently by including volunteer students of science subjects (botany, zoology, physics, sustainable development), from Government College University, Lahore, and Punjab University, Lahore, who had a recent experience of BL during the Covid-19 pandemic.

3.1 Sample

Volunteer participants including 239 men (46.4%) and 276 women (53.4%) studying science subjects (N = 515), distributed as evenly as possible among different departments (physics, botany, zoology, and sustainable development), age 19 through 24 (Mage = 20, SD = 3.42). All the participants were students at Government College University, Lahore, Pakistan, and reported to have a rich experience of BL during the COVID-19 pandemic.

Following the ethics guidelines for educational research in Pakistan, the research started only after the due approval from the board of studies of the Department of Psychology, Government College University, Lahore. All the participants provided their informed consent before the start of the study and were allowed to ask questions afterward.

3.2 Instruments

The following two instruments were used for data collection from the participants in the same order, whereas GPAs of the student's last semester, after their experience of BL, were noted from their transcripts as a measure of their academic achievement.

3.2.1 Learners' Views on Blended Learning and Its Implementation Process (BL)

This measure of BL (Akkoyunlu & Soylu, 2008) assesses the learners' views on BL in general and concerning its implementation. It consists of 50 items in total with response options on the Likert type scale from one to 10 (i.e., from not at all = 1 to true = 10). The first 35 items are aimed at tapping the learners' views regarding the implementation of BL (e.g., use of the internet, online media content search and use, and views on the BL method). The next 15 items tap the general responses of the participants regarding their BL experiences. The reliability of the measure with this study data was .89.

3.2.2 Motivated Strategies for Learning Questionnaire (MLSQ)

This measure was developed (Pintrich & De Groot, 1990) to quantify the types of academic motivation and learning strategies used by the students. This self-report questionnaire consists of 81 items and the response format is Liker type (i.e., from 1= 'not at all true of me' to 7 = 'very true of me'). The items of the scale tap student motivation and the cognitive and meta-cognitive strategies they use for the management of their efforts (i.e., the motivation section and the learning strategy section). Thirty-one items are part of the motivation portion, 19 items tap students' resource management, and an additional 31 items tap the strategies related to learning instructions. In line with the rationale of the study, only the total/composite score of the scale was used for analyses. The reliability of the data of this study was .91.

3.3 Data Analysis Techniques

Statistical Package for Social Sciences (SPSS) and PROCESS macro for SPSS (Hayes, 2017) were used for data analyses. The first step, after getting the complete data and scoring, was screening the data for any outliers and checking the assumptions of normality. Secondly, the reliability (Cronbach's Alpha), with SPSS, of all the instruments was analyzed. Thirdly, a t-test was carried out to investigate any possible gender-based differences in the scores on BL, MLSQ, and GPAs. In the fourth step relationship between BL and GPA, possibly mediated by learning motivation was explored by using PROCESS macro (model 4). The model used the maximum likelihood method, which "estimates model parameters that have the greatest chance of reproducing the observed data," (discrepancy and covariance), with 5000 bootstrapped samples and bias-corrected (BC) 95% confidence intervals (i.e., BC CI 95%) (Hayes, Montoya, & Rockwood, 2017).

PROCESS macro is a very easy-to-use and freely available computational tool with many pre-programmed models for conditional processes. It uses ordinary least square (OLS) regression analyses and produces bootstrap confidence intervals (CI) for observed variables only (Hayes et al., 2017). It uses a different method of estimation compared to structural equation modeling (SEM) but the choice is inconsequential for observed variables (Hayes et al., 2017; Igartua & Hayes, 2021).

4 Results

The data did not have any outliers and it did fulfil all the assumptions of normality. The scales showed very good reliabilities (mentioned in the instruments section). Mean-based differences in BL, MLSQ, and GPAs of men and women were investigated using an independent sample t-test. The results are presented below in Table 1.

Table 1

Mean Differences in BL, MSLQ, and CGPA of Men (n = 239) and Women (n = 276) Undergrad Science Students

Variables	Men	Women			
	M (SD)	*M (SD)*	*t(513)*	*p*	*Cohen's d*
BL	280.95 (10.21)	281.80 (10.01)	-.95	.39	0.08
MSLQ	273.54 (10.34)	273.22 (9.98)	.35	.72	0.03
CGPA	3.16 (.214)	3.18 (.211)	-0.02	.19	0.11

The results indicated the views of the undergrad science students regarding BL, their learning motivation and their academic achievement did not differ significantly across genders. The values of Cohen's d (effect size) were small and indicated enormous overlap in the responses of both groups.

Intercorrelation between study variables, across gender was explored to investigate if the relationships warrant further correlational analyses including mediation. The results are presented in Table 2.

Table 2
Inter-correlations Among Study Variables for Men (n = 239) and Women (n = 276) Undergrad Science Students

Sr#	Variable	1	2	3
1	Blended Learning	-	.81*	.82*
2	Learning Motivation	.94*	-	.79*
3	Academic Achievement	.91*	.95*	-

*p < .001; Note: The results for the men are presented in the upper diagonal and the results for the women are presented in the lower diagonal.

The results indicate very strong correlations among all the study variables for both groups and indicate the possibility of regression as well as mediation analyses. The results for female science students, however, indicate a much stronger correlation among study variables compared to male science students. Therefore, considering this difference, the relationship between BL and academic achievement, possibly mediated by learning motivation is explored across gender (i.e., differently for male students and female students using PROCESS macro for SPSS).

The direct effect of BL on learning motivation and academic achievement, the direct effect of learning motivation on academic achievement, and the mediating effect of learning motivation in the relationship between BL and academic achievement were analyzed, first for the male undergrad science students and then for the female undergrad science students using PROCESS macro for SPSS as mentioned in the analytical plan.

The results for the male students indicated a significant direct effect of the BL on learning motivation. The model was significant, $R2 = .95$, $F(1, 237) = 16573.50$, $p < .001$, and implied that 95% variance in learning motivation can be described by the students' views regarding BL. The result for the coefficient was also significant, $B = 0.98$, $SE = 0.01$, $t = 128.73$, $p < .001$, and indicated that one unit increase in BL is likely to increase academic motivation by 97%. The regression equation for this relationship can be formulated as, Learning Motivation = -8.985 + .98(BL). Also, the results indicated a significant direct effect of BL and learning motivation on academic achievement. The model was significant, $R2 = .92$, $F(1, 236) = 2247.01$, $p < .001$, and specified that 92% variance in academic achievement can be described by the combined linear effect of both BL and learning motivation. The results of the coefficients in this combined linear model were also significant for the direct effect of BL on academic achievement, $B = 0.006$, $SE = 0.002$, $t = 2.70$, $p = .007$, and for the direct effect of learning motivation on academic achievement, $B = 0.027$, $SE = .01$, $t = 10.63$, $p < .001$, and indicated that one unit change in BL and learning motivation is likely to result in .6% and 2% change in academic achievement, respectively The regression equation based upon this model can be formulated as, Academic Achievement = -2.26 + 0.006(BL) + 0.027(Learning Motivation). The indirect (mediating) effect of learning motivation in the relationship between BL and academic achievement was also significant, Indirect Effect = 0.027, SE = 0.005, 95% CI [0.016, 0.038], and indicated that learning motivation positively and partially mediate this relationship.

Similarly, the results for the female students indicated a significant direct effect of the BL on learning motivation. The model was significant, $R2 = .99$, $F(1, 274) = 20182.09$, $p < .001$, and showed that 99% variance in learning motivation can be described by the female

students' views regarding BL. The result for the coefficient was also significant, B = 0.97, SE = 0.01, t = 142.06, p < .001, and indicated that one unit increase in BL is likely to increase academic motivation by 97%. The regression equation for this relationship can be formulated as, Learning Motivation = -6.133 + .97(BL). Also, the results implied a significant direct effect of BL and learning motivation on academic achievement. The model was significant, R2 = .97, F(1, 273) = 2618.84, p < .001, and implied that 97% variance in academic achievement can be described by the combined linear effect of both BL and learning motivation.

The results of the coefficients in this combined linear model were also significant for the direct effect of BL on academic achievement, B = 0.013, SE = 0.002, t = 5.60, p < .001, and for the direct effect of learning motivation on academic achievement, B = 0.006, SE = .002, t = 2.78, p = .006, and indicated that one unit change in BL and learning motivation is likely to result in 1.3% and .2% change, respectively, in academic achievement. The regression equation for this model can be formulated as, Academic Achievement = -2.58 + 0.013(BL) + 0.006(Learning Motivation). The indirect (mediating) effect of learning motivation in the relationship between BL and academic achievement was also significant, Indirect Effect = 0.0068, SE = 0.004, 95% CI [0.001, 0.018], and indicated that learning motivation positively and partially mediate this relationship.

5 Discussion

This research conducted on Pakistani male and female undergrad science students explored the relationship between BL, learning motivation, and academic achievement. It investigated if the BL influences learning motivation if both BL and learning motivation influence academic achievement, as well as if learning motivation mediates the relationship between BL and academic achievement across genders in a patriarchal, collectivist country like Pakistan. The results for both male and female undergrad students did not differ widely, and the main results were similar i.e., BL has a significant positive influence on learning motivation, BL and learning motivation both have a significant positive influence on the academic achievement and learning motivation - significantly, positively, and partially – mediates the relationship between BL and academic achievement.

These results indicate that BL enhances learning motivation, therefore, the arguments that BL may be a limiting factor due to lesser engagement than face-to-face models (Jeffrey et al., 2014; Lomer & Palmer, 2023; Medina, 2018; Selwyn, 2016; Shand & Farrelly, 2018) is not validated in the light of these results. The results are quite consistent with other findings e.g. (Cole, 2020; Liang & Wu, 2010; McComas, 2019; Najafi & Heidari, 2019; Permata & Nanda, 2021). Hence, these results support the implementation of BL for enhancing the learning motivation of the students in Pakistan. However, as mentioned earlier, what we are blending and how we are blending needs further exploration. There is a need to explore which aspect/s of BL plays a major role in enhancing the learning motivation of the students. It may be some factors or a blend of different factors like flexibility (Bower et al., 2015), better engagement (Butz et al., 2014), facilitation (Kim et al., 2011), enhanced learning experience (Li et al., 2022) or cost-effectiveness (Graham, 2013) which is responsible for enhanced learning motivation of students. These aspects may vary from one culture and context to another as well as for other subjects and different educational levels. Therefore, an in-depth exploration of these factors can enhance the implementation of BL most effectively and efficiently with a perfect blend.

The results also indicated that positive views regarding BL implementation lead to higher academic achievement. These results are also convergent with earlier (mostly Western) works e.g., (Cabı, 2018; Ezeanyika & Okigbo, 2021; Sibandze et al., 2020; Thomas, 2018). Evidence against these findings is also present in the literature e.g., (Gedik et al., 2012; Medina, 2018). Both sets of findings indicate the further need for cross-cultural research on different factors of BL that may be contributing to this influence. As mentioned earlier there can be

several factors (may be in a combination or alone), in this context, for example, the accommodation of more material (Afacan et al., 2016), adaptive to student needs (Benson & Kolsaker, 2015) and enhanced motivation (Zainuddin et al., 2022) and self-paced study option (Zainon & Yamat, 2021) are playing an important role for better academic achievement. There is a need for further exploration of these aspects cross-culturally, across all subjects of study as well as at all educational levels for better implementation of BL.

Similarly, learning motivation was not only having a direct influence on academic achievement, but it was also mediating the relationship between BL and academic achievement (i.e., it was further enhancing academic achievement). These results are consistent with several studies with little to no contradictory empirical evidence e.g., (Cole, 2020; Goh et al., 2017; Kuo & Belland, 2019; Osman & Hamzah, 2020). There is a need to further explore whether intrinsic motivation or intrinsic motivation plays a better role or a combination of both types of motivations is likely to play a better role in enhancing academic achievement. Again, this aspect also needs to be explored across cultures, all subjects, and across all levels of education for devising the most effective policy accordingly.

5 Conclusion And Recommendations

The finding of this study indicates that positive views of students regarding BL implementation are likely to enhance their learning motivation and positive views regarding BL and more learning motivation is likely to enhance their academic achievement. Further, learning motivation also mediates the link between BL and academic achievement. The results are consistent with the above-mentioned studies supporting BL to enhance learning motivation and academic achievement (Nolen, 2020) and do not support the evidence against BL (Medina, 2018) in the socio-cultural context of Pakistan for undergrad science students. The findings of such studies can converge to provide strong empirical support for policy-making and implementation of BL at different levels in Pakistan.

The overall results are quite consistent with the studies conducted in the West and U.S (e.g., (Kuo & Belland, 2019; Li et al., 2022; Nolen, 2020; Saiz-Manzanares et al., 2020; Sangster et al., 2020). The consistency of the results with the Western studies indicates the potential generalizability of the BL models of the West and U.S. in our indigenous context and indicates that the pedagogical policies of BL may be aligned with these models. The results indicate that the BL can add value to the teaching strategy and can be effectively replaced with traditional face-to-face learning (Bentley, 2012) while indicating its clear advantage over VL models (Nolen, 2020).

However, apart from the learning motivation of the science students, many other factors and contexts may produce different results for these relationships. Also, there can be other factors associated with BL which may have a strong influence over academic achievement. Further, questions like what are we blending? How are we blending? Where are we blending? Why are we blending? and What is the context of this blending? Should be explored in detail concerning BL. Only ample empirical support to answer these questions should form the basis of policy-making for BL in the scenario of Pakistan at all levels of education for all the subjects. In general, more research and deliberation are essential to further improve definitions, models, and conceptualizations of BL.

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