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Effect of Blended Online and Digital Learning and Teaching on Students' Academic Performance

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Abstract: - Since 2016, blended online and digital (BOLD) learning and teaching has been implemented for all mining engineering courses in an Australian university of more than 150 years' experience in mining education and training. This study investigates the impact of this pedagogical approach on mining engineering students' academic performance compared with traditional face-to-face teaching. Statistical data from 10 undergraduate courses were analyzed to examine trends in student performance using four key indicators: success rate, fail rate, retention rate, and attrition rate. The findings indicate that BOLD learning and teaching has generally enhanced academic outcomes, with notable improvements observed in seven courses—characterized by increased success rate and reduced fail rate—while one course showed little change, and two courses exhibited negative trends in student performance from 2011 to 2019.

Keywords: blended learning and teaching, mining engineering higher education, success rate, retention rate.

I. Introduction

Mining plays a significant role in the economy. In Australia, the resources and energy sectors contribute around 10% of the GDP[1]. The mining industry is currently experiencing a super-boom, driven by the industrialization and urbanization of Asia[2]. This boom presents both challenges and opportunities for the mining sector, including a significant challenge for the higher education sector to produce enough mining engineering graduates to meet the industry demand. There are nine universities offering mining engineering programs in Australia. The number of undergraduate students enrolled in mining engineering peaked at around 400 in 2012 but declined to fewer than 100 students in 2017, 2018, and 2019[3].

Peak bodies in the Australian mining industry, such as the Minerals Council of Australia (MCA) and the Australasian Institute of Mining and Metallurgy (AusIMM), have been at the forefront of addressing the skill shortages facing the sector. The MCA Workforce and Innovation Committee initiated strategic education partnerships and pathways to broaden access to a wider talent pool [4]. In July 2019, the MCA invited Australian universities offering mining education to propose innovative new pathways, and by December 2019, three proposals were selected to pilot these practices. Additionally, the AusIMM, in partnership with the Victorian Government, hosted a Resources Education Collaboration Summit on 3 October 2019. This summit provided a platform for education, industry, and government bodies in the resources sector to collaborate on mining education, discussing how it could be enhanced to ensure a sustainable future workforce. A key theme was the enhancement of existing education pathways and the development of new ones to better serve the sector[5].

Blended learning is an approach that combines face-to-face and online learning experiences to create effective, efficient, and flexible learning environments[6-8]. This approach is also known as Blended On-Line and Digital (BOLD) learning or hybrid learning. Learning and teaching in this context consist of three main components: the learning environment, instructional strategies, and media. A learning environment can be either synchronous, where learners engage with the teaching process in real-time, or asynchronous, where learners interact with pre-recorded or pre-prepared teaching materials. The media component involves the tools and platforms used to deliver the teaching content, while the instructional component focuses on employing appropriate strategies to achieve the desired learning outcomes[9]. Blended learning can take various forms, ranging from predominantly face-to-face to entirely online, depending on the combination of these components [9, 10]. Although there is a broad consensus on the definition of blended learning, the specific proportion of online components in blended courses can vary significantly across universities, ranging from as little as 1% to as much as 99%[11].

Online learning can overcome the constraints of time and physical classrooms, support unconventional teaching methods, and reach a larger number of students without requiring additional resources[12]. It also provides a flexible educational environment[13]. Ubell (2017) suggests that digital pedagogical strategies may be highly effective, offering advantages that traditional classroom settings struggle to provide, such as anonymity, learning analytics,

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and communication through writing[14]. Numerous studies demonstrate that combining BOLD learning and teaching with traditional face-to-face instruction can lead to superior learning outcomes.

Heterick and Twigg (2003) reported on a course redesign program involving 30 institutions, where all participants reduced their costs by 20 to 86 percent. Of these projects, 19 improved student learning, while the remaining 11 showed no significant differences[15]. Similarly, Facharzt et al. (2013) conducted a comparative study in clinical medicine between a traditional face-to-face teaching group (61 students) and a blended learning group (60 students). They found that blended learning was statistically significantly better than traditional methods in all aspects of the educational environment, except for social perception, as well as in all examinations[16]. Lee and Hung (2015) reported on a comparative experiment involving three groups—traditional, blended learning, and fully online—in an e-learning system for an income tax law course. The study found that the blended learning group, which combined online learning with paper-and-pencil testing, achieved the highest learning outcomes among the three groups[17].

Surveys on virtual learning environments indicate that the majority of students have positive views of blended learning in foreign language studies[18, 19]. Nazarenko (2015) found that 60 students liked blended learning, 8 disliked it, and 32 were undecided[19]. The findings summarized in Table 1, further show that blended learning was highly favored by students.

Table 1. Suitability of virtual study environment for German language study [18]

	Very suitable	Suitable	Average	Unsatisfactory
Semester 1	38	48	12	2
Semester 3	40	40	20	0

With the widespread adoption of blended learning in tertiary education, many benefits have been recognized. Blended learning can help mitigate fiscal and pedagogical challenges, integrate informal learning with formal education, and promote lifelong learning, which is highly valued in engineering careers. It is believed to offer advantages to students, teachers, and administrators, such as increased access and convenience, the ability to facilitate both synchronous and asynchronous interactions, the incorporation of new technologies, enhanced retention, greater flexibility, improved learning outcomes, reduced costs, progress tracking, faster feedback, self-paced learning, and a student-centered approach [6, 8, 10, 13, 15].

Blended learning is considered one of the most significant pedagogical developments in education during the digital era, becoming a widespread phenomenon in higher education in Australia and around the world. At Federation University Australia, blended learning is referred to as BOLD learning and teaching. The engineering department had implemented BOLD strategies in some courses for many years before it received a government grant to further develop online courses in 2015. Since 2016, all engineering courses have integrated the BOLD strategy, meaning traditional face-to-face teaching is supplemented with online, web-based resources to enhance the learning and teaching experience.

While blended learning can transform higher education institutions by addressing fiscal and pedagogical challenges, it is essential to evaluate its effectiveness[13]. Lecturers may face challenges in applying appropriate strategies to deliver courses effectively, and students may need time to familiarize themselves with the online system to maximize learning outcomes[20]. Heterick and Twigg (2003) reported that there was no significant difference in student learning in 36 projects[15]. Although there are many recognized benefits to implementing BOLD learning and teaching, it is prudent to assess whether and to what extent it has improved students' academic performance. This paper aims to explore this fundamental question through an analysis of student performance data in engineering courses from 2011 to 2019, including the four years from 2016 to 2019 when the BOLD learning and teaching pedagogy was implemented.

II. Research Methodology

To address the research question, this project analyzes student academic performance data from 2011 to 2019. Students' performance is recorded as marks out of a total of 100, typically comprising assignments and final examinations. These marks are then graded according to the criteria outlined in Table 2. The study focuses on 10 courses that are divided into two groups: five common engineering courses (EC) that are compulsory for all engineering students, and five disciplinary specialty courses (DSC).

Table 2. Grading system

Marks	Grade	Description	Classification
>=80	HD	High Distinction	
70-80	D	Distinction	Success
60-70	C	Credit	
50-60	P	Pass	
40-50	MF	Marginal Fail	Fail
<40	F	Fail	
No marks	XF	No submission	Attrition
Withdrawal	W	Withdrawn	

Four parameters are used to analyze students' academic performance: course success rate, fail rate, retention rate, and attrition rate. The retention rate is the percentage of students who enrolled in and studied the course relative to the total number of students enrolled. It can be calculated as the sum of the success rate and fail rate. The course attrition rate is the percentage of students who enrolled but did not complete the course, either by not submitting enough academic work for assessment or by withdrawing after the census date. In calculating these rates, the total number of students post-census date is used as the denominator. Therefore, success rate + fail rate + attrition rate = 100%.

III. Results And Analyses

Given the relationship between retention rate (RR) and attrition rate (AR), where RR + AR = 100%, only the RR results are reported in this section.

A. Students' performance in common engineering courses

Students' performance in the five common engineering courses (EC) is presented in Table 3. Except for EC2, there has been a clear improvement in student performance across all courses since 2016, with higher success rates (SR) and retention rates (RR), and lower fail rates (FR). Overall, the RR is consistently high across all years, but the SR varies among courses, and the FR could exceed 50% under traditional face-to-face pedagogy. Students are generally well-engaged in their studies, with RR typically above 90% and often reaching 100%. EC1 has the highest SR, showing an increasing trend and reaching a 100% success rate in 2019, followed by EC5. The SR for EC2, EC3, and EC4 is comparatively lower, typically ranging from 50% to 80%.

Table 3 Success, fail and retention rates (%) of five engineering common courses

year	EC1			EC2			EC3			EC4			EC5		
	SR	FR	RR	SR	FR	RR	SR	FR	RR	SR	FR	RR	SR	FR	RR
2011	52.6	38.6	91	67.5	27.7	95	55.6	41.7	97	45.9	51.4	97	78.0	22.0	100
2012	81.2	18.8	100	88.9	11.1	100	46.7	51.1	98	42.9	57.1	100	80.6	19.4	100
2013	89.6	10.4	100	63.4	32.9	96	70.2	29.8	100	78.9	21.1	100	100	0.0	100
2014	82.4	17.6	100	70.3	29.7	100	74.5	25.5	100	58.7	41.3	100	84.2	15.8	100
2015	81.3	12.5	94	76.5	19.6	96	56.9	41.5	98	66.0	32.0	98	67.9	32.1	100
2016	84.4	12.5	97	56.4	33.3	90	65.8	34.2	100	69.0	31.0	100	81.1	18.9	100
2017	88.9	11.1	100	65.0	27.5	93	75.9	24.1	100	82.8	17.2	100	88.6	11.4	100
2018	94.1	5.9	100	69.6	26.1	96	78.3	21.7	100	69.6	30.4	100	65.7	26.9	93

2019	100	0.0	100	46.4	42.9	89	56.4	39.7	96	66.7	14.3	81	88.0	12.0	100

Table 4 Success, fail and retention rates (%) of five disciplinary specialty courses

Year	DSC1			DSC2			DSC3			DSC4			DSC5		
	SR	FR	RR	SR	FR	RR	SR	FR	RR	SR	FR	RR	SR	FR	RR
2011	100	0.0	100	84.6	15.4	100	85.7	14.3	100	83.3	16.7	100	100	0.0	100
2012	100	0.0	100	90.0	5.0	95	92.9	7.1	100	83.3	16.7	100	90.9	0.0	91
2013	100	0.0	100	75.0	25.0	100	96.0	0.0	96	83.3	11.1	94	95.8	4.2	100
2014	100	0.0	100	92.3	7.7	100	96.3	3.7	100	93.5	6.5	100	94.1	5.9	100
2015	95.5	4.5	100	81.0	14.3	95	95.7	4.3	100	85.7	14.3	100	94.1	5.9	100
2016	88.2	11.8	100	92.9	7.1	100	71.4	21.4	93	92.9	7.1	100	88.9	11.1	100
2017	100	0.0	100	100	0.0	100	100	0.0	100	100	0.0	100	100	0.0	100
2018	71.4	14.3	86	100	0.0	100	100	0.0	100	100	0.0	100	100	0.0	100
2019	87.5	12.5	100	50.0	0.0	50	100	0.0	100	87.5	12.5	100	100	0.0	100

B. Students' performance in disciplinary specialty courses

Student performance in five disciplinary specialty courses is shown in Table 4. With the exception of DSC1, there has been a clear improvement in student performance across all courses since 2016. Overall, students have engaged well in their studies, as evidenced by a retention rate (RR) of 100% in some instances. However, there were occasions of low RR when one or two students dropped out from a small class. For example, in 2019, when the class size for DSC2 was only four students, two dropped out, resulting in a retention rate of 50%.

IV. Discussions

To further illustrate the impact of BOLD learning and teaching on student performance, a graphical analysis is used to depict the trends in success rates and failure rates for each course in both groups.

A. Trends of SR and FR in EC courses

The trends in SR and FR from 2011 to 2019 for the five common engineering courses are shown in Figs. 1-5. Courses EC1, EC3, and EC4 show strong positive trends, with SR increasing and FR decreasing (Figs. 1, 3, and 4). Conversely, EC2 shows a negative trend, with SR declining and FR rising (Fig. 2). For EC5 (Fig. 5), the SR remains around 80%, and the FR around 20%, having very stable trend lines. Overall, the trend lines suggest that BOLD learning and teaching have had a positive effect on student academic performance in most of the common engineering courses included in this study.

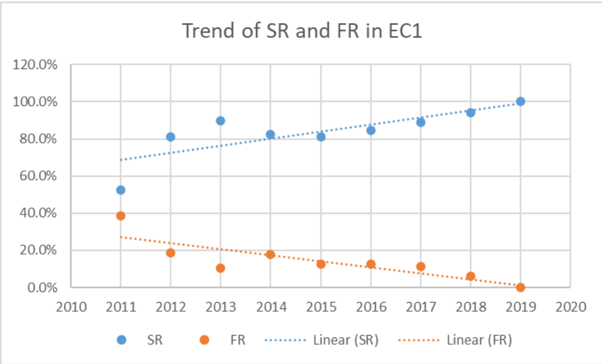

Fig. 1 Success rate and fail rate in EC

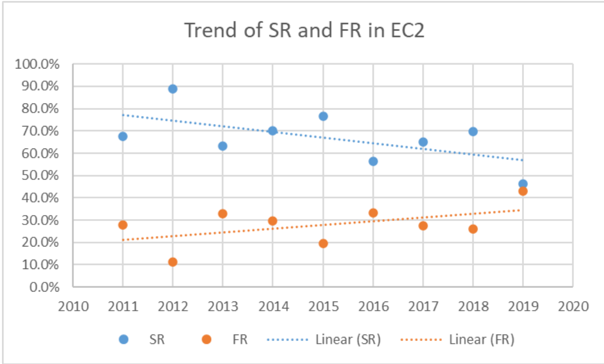

Fig. 2 Success rate and fail rate in EC2

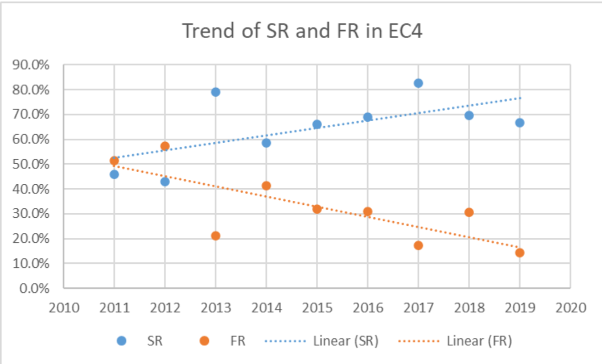

Fig. 3 Success rate and fail rate in EC3

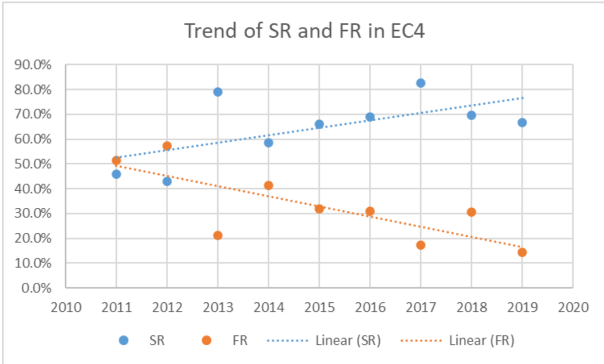

Fig. 4 Success rate and fail rate in EC4

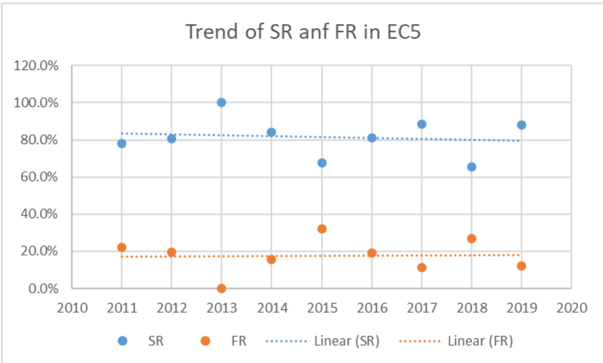

Fig. 5 Success rate and fail rate in EC5

B. Trends of SR and FR in disciplinary specialty courses

As shown in Table 4, over the nine years from 2011 to 2019, the success rates of the five disciplinary specialty courses were typically above 80%, while the failure rates were generally less than 20%. Interestingly, in 2016, when BOLD learning and teaching was first universally implemented for engineering courses, the SR saw a slight decline. The trends in SR and FR for the five courses are illustrated in Figures 6-10. While SR remains high and FR low, DSC1 shows a somewhat negative trend, with a declining SR and an increasing FR (Figure 6). In DSC2 (Figure 7), FR is trending downward, and SR would be trending upward if not for an unusually high attrition rate in a small class, as mentioned earlier. DSCs 3-5 are all trending positively, with rising SR and declining FR (Figures 8-10). Overall, the trend lines suggest a broad and positive impact of BOLD learning and teaching on student academic performance in disciplinary specialty courses.

C. Limitations of the study

Blended learning and teaching is not merely about replicating face-to-face activities in online environments; it should be transformative, leading to improved learning outcomes[8]. In higher education, much of the existing research on blended learning does not address issues related to institutional adoption, highlighting the need for further research to guide higher education institutions in strategically adopting and implementing blended learning pedagogy[11]. This study aims to objectively assess the broader trends in students' academic performance since

2016, when BOLD learning and teaching were introduced across all engineering courses, by using statistical data from 2011 to 2019. It seeks to systematically evaluate the impact of adopting BOLD learning and teaching at the institution. However, there are some limitations to this study, including:

This study does not account for other factors that can affect students' academic performance, such as course content, the individual teaching styles of lecturers and tutors, class size, and students' learning styles.

The study does not consider all engineering courses. Engineering curricula have evolved continuously, with many current courses undergoing significant changes over the nine years or not existing previously. Therefore, only courses with comparably equivalent content are included in this study.

From a statistical perspective, data spanning nine years is limited, and a single data point can significantly alter the trend direction (e.g., DSC2). Additionally, using a linear trend line to represent the trends in success and failure rates can sometimes result in SR values exceeding 100% or FR values dropping below 0% in some graphs. Despite these limitations, the linear trend line remains an effective indicator and serves the study's purpose.

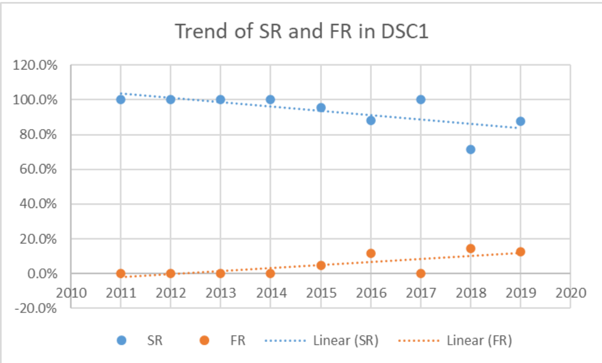

Fig. 6 Success rate and fail rate in DSC 1

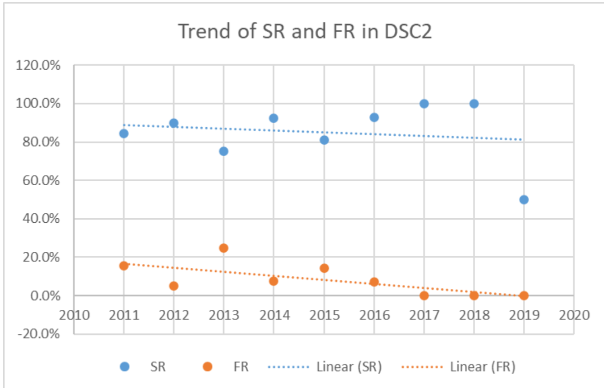

Fig. 7 Success rate and fail rate in DSC2

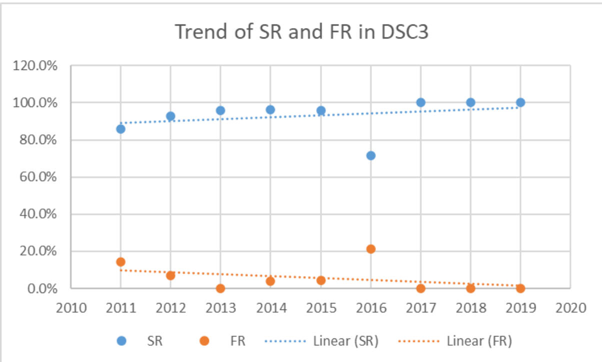

Fig. 8 Success rate and fail rate in DSC3

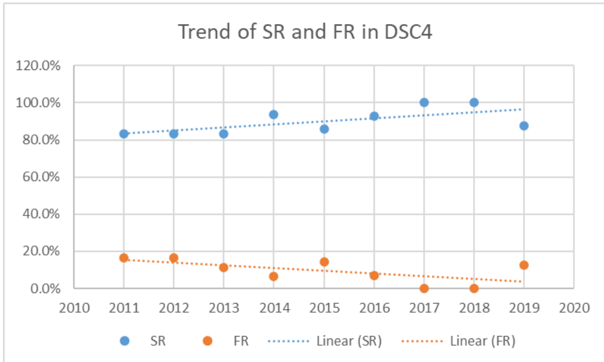

Fig. 9 Success rate and fail rate in DSC4

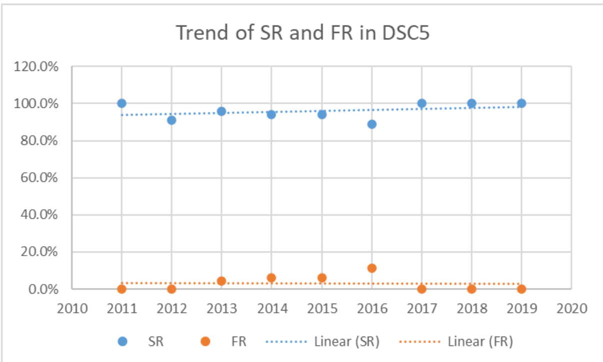

Fig. 10 Success rate and fail rate in DSC5

V. CONCLUSIONS

Based on the study of 10 courses examining the impact of BOLD learning and teaching on students' academic performance in mining engineering at Federation University Australia, the following conclusions can be drawn: Compared with traditional face-to-face teaching, the BOLD learning and teaching pedagogy can enhance students' academic performance, including an increase in success rates and a decrease in failure rates. However, the extent of improvement varies among the courses covered in this study, with the majority demonstrating clear improvements since the implementation of the BOLD pedagogy. Out of the 10 courses studied, seven showed clear improvements in student performance, such as rising success rates and declining failure rates, while one course showed little change, and two courses exhibited negative trends from 2011 to 2019. This suggests that BOLD learning and teaching is not a one-size-fits-all approach and may need to be complemented with other high-impact teaching strategies to further enhance student engagement.

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