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PAPER

Effectiveness of Blended Learning for Civil Engineering Students' Performance during COVID-19: A Case Study of a Rural University in South Africa

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ABSTRACT

In this study, the effectiveness of blended learning on the learning of civil engineering students during the COVID-19 pandemic was evaluated at a rural university in the Eastern Cape Province of South Africa. The imposition of lockdown due to the global spread of COVID-19 left educational institutions with no choice but to find alternative methods of teaching and learning. Students were sent home in order to control the spread of the virus. Secondary data were used to examine the students' performance in 2019, prior to the COVID-19 pandemic, and in 2020, during the COVID-19 pandemic. Furthermore, primary data was obtained through questionnaires to assess the students' opinions on blended learning. The Mann-Whitney U test was used to determine the extent of the difference in students' performance before and during COVID-19. Descriptive analysis results indicated the superiority of blended learning over face-to-face teaching methods, with blended learning achieving a 67% success rate compared to the 33% achieved by face-to-face methods. Similarly, the Mann-Whitney U test also showed a significant difference between blended and face-to-face teaching methods. In contrast to the descriptive analysis and Mann-Whitney U test, students' sentiments indicated otherwise. 80% of students neither agreed nor disagreed with blended learning methods as a preference over face-to-face teaching methods. The results of this study demonstrated the effectiveness of the teaching methods used during the COVID-19 pandemic. Furthermore, it revealed and, further, showed the sentiments of students regarding the teaching methods employed during this period.

KEYWORDS

COVID-19, student performance, pandemic, blended learning, face to face, performance

1 INTRODUCTION

The global outbreak of COVID-19 has had severe consequences worldwide, compelling various sectors to explore alternative methods to sustain their operations. The outbreak of pneumonia was first reported in December 2019 in Wuhan, China.

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SARS-Cov2, a new coronavirus, was officially reported by the World Health Organisation (WHO) as the pathogen responsible for the infectious respiratory disease known as COVID-19 [1]. The worldwide outbreak had a disastrous effect on many countries and terrorist groups [2]. This virus has affected individuals all over the world, regardless of their country of origin, gender, income, or level of education. However, many vulnerable have suffered severe consequences as a result of this outbreak. The increasing interconnectedness of the world has led to greater risks of infection as the viruses spread across national borders [3].

These negative effects on the general public also resulted in significant changes in education [4]. According to Abidah, Hidaayatulaah, Simamora, Fehabutar, and Mutakinati [5], the impact of COVID-19 has also extended to the education sector, which has not been exempt from the various efforts to control the transmission of the virus. The robust response to COVID-19, through lockdown, disrupted conventional schooling, with many schools closing for at least 10 weeks [3]. Approximately 1.6 billion learners in over 200 countries were affected by this disruption [2]. According to Marinoni, Hilligje, and Trine [1], approximately 185 schools and higher education institutions were compelled to close, affecting approximately 1,542,412,000 pupils worldwide. This measure was implemented to control the spread of the virus, similar to many countries implementing lockdowns and quarantines to minimise contact with others. After implementing lockdown regulations and suspending educational activities, educational institutions had no option but to explore alternative teaching and learning methods for students who were unable to attend school [5].

From midnight on March 26, 2020, South Africa (SA) implemented a nationwide lockdown that prohibited non-essential movement, non-essential businesses, and other services, and closed schools [6]. This lockdown declaration required many tertiary institutions in South Africa to implement various methods designed to ensure social isolation while continuing with their core business. While regular monitoring of emerging conditions was established, along with ongoing analysis, institutions continued to prioritise their primary objective of completing the academic year [7]. According to Bernatova, Bernat, Poracova, Rudolf, and Klucarova [8], the closure of schools has created an urgent need for distance education during this period. This situation has been highlighted, which has revealed the importance of finding practical and effective methods to ensure the continuity of education systems worldwide. Therefore, the rural university in the Eastern Cape Province of South Africa, which was selected as the case study for this research, opted for a blended learning model, moving away from the traditional face-to-face teaching approach. Compared to the traditional learning model, the blended learning model has been praised by many studies for its superiority [9], [10]. However, Makgahlela, Mothiba, Mokwena, and Mphekgwana [11] proved that student education and health were greatly affected worldwide during the COVID-19 pandemic. Makgahlela, Mothiba, Mokwena, and Mphekgwana [11] reported that students from previously disadvantaged universities who came from rural communities faced challenges during this period due to the lack of information and communication technology devices, as well as network problems.

Many studies have focused on the impact of COVID-19 on the education sector, including, but not limited to, Andreas [3], Tarkar [12], Pietro, Giorgio, Biagi, Costa, Karpinski, and Mazza [13], and Burgess and Sievertsen [14]. However, few studies have focused on the impact of this pandemic on rural universities in terms of students' performance and their perceptions of the teaching and learning methods used during the COVID-19 period. The university in this case study previously utilised a face-to-face, traditional teaching and learning model. However, due to the undeniable changes brought about by COVID-19, it was forced to adopt a blended learning

and teaching method. Based on a study by Muhuro and Kang'ethe [15], it was shown that implementing blended learning can be challenging, particularly in rural universities. Therefore, the objective of this study was to assess the effectiveness of blended learning on students' performance in the Department of Civil Engineering during the COVID-19 pandemic at a rural university in the Eastern Cape Province of South Africa. The purpose of this study was to test the following hypothesis:

- *Blended learning had no effect on the performance of civil engineering students during the COVID-19 pandemic.*

2 REVIEW OF PREVIOUS STUDIES

2.1 Blended learning

In a book by Picciano [16], blended learning is defined as an instructional approach that combines the benefits of face-to-face interaction with the use of technology to enhance learning. Picciano [16] mentioned blended learning as one of the critical vehicles for education in the 21st century. According to various researchers, blended learning provides teachers and learners with significantly expanded opportunities to understand how information is transmitted and received, how interactions occur in an educational environment, and how knowledge is constructed. Vaughan [17] cited Williams [18], who suggested that the concept of blended learning has been around since the early days of education. Researchers associate blended learning with the opportunity to improve an institution's reputation, expand access to its educational offerings, and decrease delivery costs. Contrary to these benefits, researchers suggest that blended learning poses additional challenges, such as a lack of alignment with institutional goals and priorities, resistance to change, and a lack of organisational structures and experience in collaboration and partnership with other institutions. Osguthorpe and Graham [19] stated six goals that educators should embrace when designing a blended learning environment, namely: pedagogical richness, access to knowledge of blended learning, social interaction, personal agency, cost-effectiveness, and ease of revision. Blended learning is described by other researchers as a combination of various technologies, pedagogies, or learning theories, as well as a blending of a range of contexts [20], [21].

The researchers demonstrated the effectiveness of blended learning applied in various fields within the educational sector. The results of a study by Nathaniel, Goodwin, Fowler, McPhail, and Black A. C. J. [22] showed that an adaptive blended learning approach improved academic performance among medical students. In a study on elementary school teacher education, Rachmadtullah, Subandowo, Rasmitadila, Humaira, Aliyyah, Samsudin, and Nurtanto [23] discovered that blended learning had a significant impact on the field of elementary school teacher education. The results of a study by Sefriani, Sepriana, Wijaya, Radyuli, and Menrisal [24] showed that blended learning was effective for students studying information technology education during the COVID-19 pandemic. Parallel to other researchers, Rahman [25] further demonstrated the effectiveness of blended learning in enhancing student experience and increasing overall student satisfaction. Blended learning has also proven to be effective for civil engineering students. The findings of a study by Lee, Isa, and Tahir [26] also showed that blended learning is effective and more motivating for students. The effectiveness of blended learning for student motivation in civil engineering was also investigated in a study [27]. In the present study, we examined the effectiveness of methods used by educational institutions during the COVID-19 pandemic. This research aims to contribute to the ongoing debates

surrounding the methods employed by education institutions during times of crisis. The findings of the study also contributed to the development of literature on students' perspectives regarding the learning methods used during the pandemic.

2.2 Use of blended learning in South Africa during COVID-19

In South Africa, many institutions used blended learning during COVID-19, and the following were the outcomes: According to El-Khalili and E1-Ghalayini [28], e-learning is increasingly being used as a supplementary technique to enhance traditional learning and teaching in higher education. However, designers of blended learning in institutions faced various challenges. In a study by Mahaye [29], the researchers reviewed the applicability of blended learning in academic recovery during COVID-19 in South Africa. It was found that blended learning improved learning outcomes. In a study [30], the author examined the opportunities and challenges that arose from the implementation of blended learning in the education sector in South Africa. The study revealed that, while the COVID-19 pandemic presented an opportunity for blended learning, there were also challenges related to inequalities and the digital divide. These challenges were further compounded by resource limitations and a lack of necessary skills. Additionally, Gqokonqana, Olarewaju, and Cloete [31] investigated the challenges faced by two students pursuing Cost Accounting at a selected higher education institution in South Africa that lacked technological resources. They found that blended learning was effective in addressing these challenges, as the institution provided ample information on how to use the system. However, much was noted regarding poor Internet access, limited access to learning materials, and the inability to access the library. For undergraduate bedside paediatric clinical training, Lala, George, Wooldridge, Wissing, Naidoo, Giovanelli, King, Mabeba, and Dangor [32] proposed blended learning as a possible method during the uncertainty of the COVID-19 pandemic. Moreover, Makura [33] examined the experience of female academics working from home in higher education during COVID-19 in three provinces of South Africa, namely Gauteng, the Eastern Cape, and the Free State. It was discovered that female academics did experience some challenges, but the COVID-19 pandemic provided them with an opportunity for professional growth through the use of a blended model of learning and fresh perspectives on supposedly shifting gender roles.

2.3 Students' performance in South Africa

Academic performance has been recognised as a key factor in student retention and graduation. It is considered the primary indicator of a student's ability to handle the academic pressures of university and, consequently, their likelihood of graduating [34]. Nonis and Wright [35] described student performance as a topic of major interest to higher education institutions, as it is closely linked to the costing process. Many researchers have associated student perfomance with motivation [36], [37], [38]. Furthermore, Shreiber and Yu [39] conducted a study at one of the historically disadvantaged South African universities. The study focused on student performance and engagement, and the results revealed that students from different racial groups perceived the campus as lacking support. Fraser and Killen [40] also conducted an empirical investigation in two South African universities, considering factors such as the perceptions of success among lecturers and students in their university studies. The findings revealed a strong agreement between lecturers and students regarding the factors that affected their performance. However, notable differences were observed in the factors that contributed to student failures. In particular, these differences were noted in relation

to a university that offers distance learning. Of all the factors that contributed to student performance, language was also identified as one of the key contributing factors. The results of a study conducted by Rooy V. and Rooy S. C. -V [41] comparing student performance and language, revealed that language proficiency was a useful predictor of success in student perfomance. However, an average matriculation pass of less than 65% could not be used to predict success at university. Rooy V. and Rooy S. C. -V [41] further demonstrated that the scores achieved in academic literacy modules were valuable indicators of academic achievement at universities in South Africa.

3 RESEARCH METHODOLOGY

3.1 Blended learning approach used by institutions

Kim [42] examined four blended learning approaches that could be used to enhance students' success. The first approach was a learning enhancement model, which is a type of blended learning where facilitation is done online to enhance student learning. According to the researcher, this model is mostly used to compensate for limited face-to-face facilitation. The second approach was an accessibility model, which is a type of blended learning that allows institutions to enhance learning and teaching by offering greater flexibility and accommodating large enrollments. This approach aims to increase accessibility to a course. The third approach was an instructor discretion model, designed to increase performance through the use of incorporated delivery, such as multimedia presentations with audio and video. The fourth approach was a cost-effective model, which is a type of blended learning introduced due to financial constraints on institutions.

Before COVID-19, the case-study university solely relied on a face-to-face learning approach. However, due to COVID-19 restrictions and the need to control the spread of the virus, the university implemented a learning enhancement model to support student performance, despite the limited movement of people. The university implemented learning management systems (LMSs) to distribute study materials to students. Online assessments were introduced to accommodate off-campus students, and teaching and learning activities were conducted both online and in face-to-face sessions. These sessions were held during different stages of the lockdowns implemented in South Africa, which allowed students to occasionally return to campus while also restricting their access at other times. The students assessed in this study had limited previous exposure to technology because they attended a rural university that had previously relied on traditional, in-person teaching methods.

3.2 Research methodology and design

A combination of quantitative and qualitative research methodologies was used for this study to investigate all the necessary factors. A descriptive research design and the Mann-Whitney U test were applied to evaluate the extent of the difference between a face-to-face and blended learning and teaching model.

3.3 Ethical clearances

Permission to conduct this study was obtained from the relevant higher education institution, and all necessary ethical issues were considered. This included obtaining informed consent from all participants.

3.4 Data collection

Secondary data was obtained from the Department of Civil Engineering at the research site. This data included students' results for the years 2019, when a traditional face-to-face model was used, and 2020, when blended learning was implemented. To assess the students' sentiments, we collected primary data through survey questionnaires using a five-point Likert scale.

3.5 Method used

Microsoft Excel for descriptive analysis. Microsoft Excel was used to conduct the descriptive analysis of the collected data. Microsoft Excel is known for its capacity to store quantitative data and to organise it in a meaningful manner. It is also recognised for its logical functions, which provide valuable assistance in qualitative analysis [43].

Mann-Whitney U test to assess the extent of difference. The Mann-Whitney test was used to assess the extent of the difference in the primary data collected. The test mentioned is a widely used non-parametric test to evaluate the null hypothesis in a quantitative method [44].

Five-point Likert scale. A five-point Likert scale was used to assess the students' perceptions of the two teaching and learning models. The Likert scale is primarily used for survey research, especially in social science, tourism, management, healthcare, education, and other sectors. It is used to quantify participants' responses by asking them to indicate the extent to which they agree or disagree with specific statements presented [45]. A five-point Likert scale (ranging from strongly disagree to strongly agree) was used to measure students' views on the use of face-to-face instruction in relation to blended learning. The scale was validated by experts in the field, and its reliability was found to be 0.70.

4 RESULTS AND DISCUSSION

This section is divided into two parts. In the first part, the study examines the outcomes of students in six core subjects in the years 2019 and 2020. The university employed a face-to-face teaching method in 2019, while a blended learning approach was adopted in 2020. Results were analysed using descriptive analysis and the Mann-Whitney U test. In the second part, the students' perceptions of using a blended learning teaching method during COVID-19 will be discussed.

4.1 Evaluating students' performance

Figure 1 shows the performance of students in six subjects: Documentation III (DOC36P1), Geotechnical Engineering (GEN36P1), Reinforced Concrete III (RCM36P1), Structural Analysis III (SAN36P1), Water Engineering III (WEN36P1), and Transportation Engineering (ETR33P2) in both years (2019 and 2020). These subjects were studied at the final level of the National Diploma in Civil Engineering in the years 2019 and 2020.

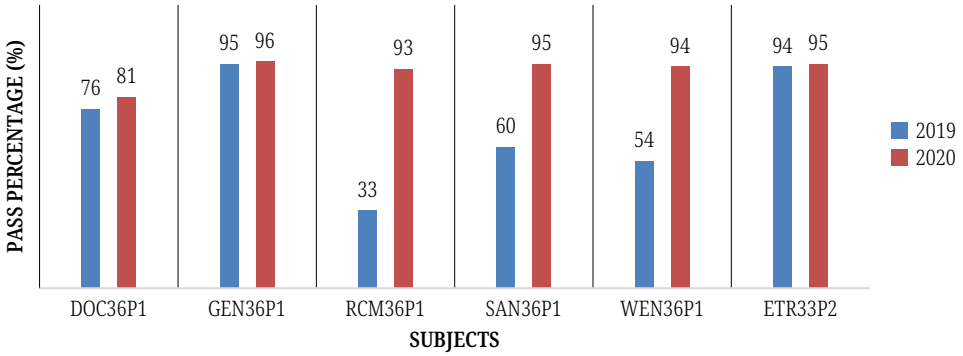

Fig. 1. Student performance for years 2019 and 2020

Figure 1 shows the pass percentage on the y-axis and the subjects on the x-axis. The year 2019 is indicated in blue, while the year 2020 is indicated in maroon. According to the results shown in Figure 1, students appeared to have performed better in terms of the pass percentage for the year 2020 compared to the year 2019. The results for all six subjects in 2020 showed significant improvement, particularly in subjects like RCM36P1, SAN36P1, and WEN36P1. These subjects had lower pass rates in 2019, which was the year when the university employed a face-to-face teaching and learning approach.

Additionally, a descriptive analysis was conducted to examine various variables, including the number of students, mean values, standard deviations, minimum percentage of pass, maximum percentage of pass, and pass percentage in 2019 and 2020, respectively. Table 1 displays the student enrollment for each course in the year 2019, which preceded the COVID-19 pandemic and utilised face-to-face instruction, as well as the year 2020, when blended learning was implemented. The mean values of two subjects, DOC36P1 (65.15 in 2019 compared with 45.55 in 2020) and GEN36P1 (50.50 in 2019 compared with 24.31 in 2020), indicate that students performed better during face-to-face teaching and learning. In contrast, four other subjects showed higher mean values, indicating improved class performance during blended learning. RCM36P1 had a mean score of 30.03 in 2019, compared to 57.60 in 2020. SAN36P1 had a mean score of 36.10 in 2019, compared to 54.10 in 2020. WEN36P1 had a mean score of 35.07 in 2019, compared to 62.64 in 2020. ETR33P2 had a mean score of 23.34 in 2019, compared to 48.46 in 2020.

Table 1. Descriptive statistics results

		N	Mean	Standard Deviation	Minimum	Maximum	Pass %
Documentation III (DOC36P1)	2019	66	65.15	9.65	40	80	76%
	2020	47	45.55	6.45	34	90	81%
	Total	113	110.7	16.1	74	170	
Geotechnical Engineering III (GEN36P1)	2019	56	50.50	11.74	32		95%
	2020	27	24.37	4.21	48	66	96%
	Total	88	74.87	15.95	80	156	
Reinforced Concrete III (RCM36P1)	2019	45	30.02	13.76	6	65	33%
	2020	40	57.60	8.74	14	71	93%
	Total	85	87.62	22.5	20	136	

(Continued)

Table 1. Descriptive statistics results *(Continued)*

		N	Mean	Standard Deviation	Minimum	Maximum	Pass %
Structural Analysis III (SAN36P1)	2019	45	36.10	11.30	25	75	60%
	2020	44	54.10	6.37	25	65	95%
	Total	89	90.2	17.67	50	140	
Water Engineering III (WEN36P1)	2019	48	35.07	11.04	15	69	54%
	2020	49	62.64	6.74	33	69	94%
	Total	97	97.71	17.78	48	138	
Transportation III (ETR33P2)	2019	40	23.34	11.65	28	89	95%
	2020	25	48.46	6.75	67	93	100%
	Total	65	71.8	18.4	95	182	

The results of the descriptive analysis indicated that students performed better in two subjects during face-to-face teaching and learning, based on mean values. However, blended teaching and learning showed a higher pass rate compared to face-to-face teaching and learning. The remaining four subjects showed that students performed better during blended learning and teaching, which is consistent with the higher pass rate achieved during this period. Therefore, the blended learning and teaching model showed a 66.7% improvement in students' performance, compared to a 33.33% improvement during face-to-face learning and teaching. Based on the above results, the null hypothesis is rejected, as blended learning outperformed face-to-face teaching in terms of the performance of civil engineering students during the COVID-19 pandemic. These results are very interesting, as they also agree with other research conducted by Zheng, Ma, and Lin [46] in the field of Chinese physical education. The results obtained by Eryilmaz [47] also showed that students essentially understand more in a blended learning environment.

4.2 Students' performance based on the Mann-Whitney test

Moreover, Table 2 shows the results of the descriptive analysis using the Mann-Whitney U test to assess the variation in students' performance between a face-to-face teaching and learning model and a blended learning and teaching model. For DOC36P1, the Mann-Whitney test showed that the mean ranks for the year 2019 were higher compared to a mean of 45.55 for the year 2020. This shows a 43% difference between 2019 and 2020. Furthermore, the sum rank for 2019 was 4300.00, which was higher than the sum rank for 2020, showing a difference of 43%. This indicates students' performance is higher during face-to-face teaching and learning. However, the Mann-Whitney test results ($U = 1013.00$, $Z = -3.137$, $p = 0.002$) indicated a significant difference in students' performance between face-to-face teaching and learning and blended learning ($p < 0.05$). These results coincided with the findings from the descriptive statistics, which indicated a higher average value for face-to-face teaching in 2019. This suggests that students performed better under this teaching and learning model, resulting in a higher pass rate. The Mann-Whitney test further indicated higher values of 50.50 for 2019 compared to a value of 24.37 for 2020 in GEN36P1. This indicates a difference of 107.22%. It was further noted that a higher sum rank

of 2828.00 was achieved in 2019 compared to the 568.00 obtained in 2020. Similarly, this shows a 107.22% difference between face-to-face and blended learning. Again, these results coincided with the descriptive statistics, which showed that students performed better during face-to-face learning and teaching. The Mann-Whitney test results, U = 280.00, Z = –4.631, and p = 0.001 (P < 0.05), showed a significant difference between face-to-face learning and teaching and blended learning. Based on the Mann-Whitney test results for DOC36P1 and GEN36P1, the null hypothesis is rejected. This test demonstrated a significant difference between the two teaching methods.

Table 2. Mann-Whitney test results

		NO	Mean Rank	Sum Rank
Documentation III	2019	66	65.15	4300.00
	2020	47	45.55	2141.00
	Mann-Whitney	Wilcox W	Z	Asymp Sib.
	1013.00	2141.00	–3.137	<.002
Geotechnical Engineering III	2019	56	50.50	2828.00
	2020	27	24.37	658.00
	Mann-Whitney	Wilcox W	Z	Asymp Sib.
	280.000	658.00	–4.631	<.001
Reinforced Concrete III	2019	45	30.02	1351.00
	2020	40	57.60	2304.00
	Mann-Whitney	Wilcox W	Z	Asymp Sib.
	316.00	1351.00	–5.152	<.001
Structural Analysis III	2019	45	36.10	1624.50
	2020	44	54.10	2380.50
	Mann-Whitney	Wilcox W	Z	Asymp Sib.
	589.500	1624.500	–3.291	<.001
Water Engineering III	2019	48	35.07	1683.50
	2020	49	62.64	3069.50
	Mann-Whitney	Wilcox W	Z	Asymp Sib.
	507.500	1683.500	–4.828	<.001
Transportation III	2019	40	23.34	933.50
	2020	35	48.46	1211.50
	Mann-Whitney	Wilcox W	Z	Asymp Sib.
	113.500	933.500	–5.217	<.001

Contrary to the results obtained using the Mann-Whitney test on students' performance in DOC36P1 and GEN36P1, higher mean values were noted for the remaining subjects: RCM36P1, SAN36P1, WEN36P1, and ETR33P2. The mean value for RCM36P1 was 57.10, compared to 30.03 obtained in 2019, showing a difference of 90.19%. Similarly, the higher sum of pf-word suggestion in 2020 compared to 2019 showed a difference of 90.18%. Furthermore, the Mann-Whitney test results (U = 316.00, Z = –5.152, p = 0.001, p < 0.05) showed a significant difference in student performance between the two teaching methods. Subsequently, higher values were noted in 2020 for SAN36P1,

with a mean value of 54.10 in 2020 compared to 36.10 obtained in 2019, representing a difference of 49.86%. This difference was also indicated by higher values of the sum rank, with 2380.50 in 2020 compared to 1624.50, which also showed a difference of 49.86%. The Mann-Whitney test results, $U = 589.5$, $Z = -3.291$, and $p = 0.001$ ($p < 0.05$), indicated a significant difference between blended learning and face-to-face learning and teaching during the two-year period. The subject with the third highest values in 2020 was WEN36P1. The average rank of 62.64 in 2020, compared to 35.07 in 2019, showed a difference of 78.61. The sum rank for 2020 was 3080.50, which was higher than the 1683.50 obtained in 2019, showing a difference of 78.61%. Furthermore, the Mann-Whitney test results ($U = 507.5$, $Z = -4.828$, $p = 0.001$, $p < 0.05$) indicated a significant difference between face-to-face and blended learning. Similarly, higher values were observed for ETR33P2, with a mean value of 48.46 in 2020 compared to 23.34 in 2019, indicating a difference of 107.63%. The sum ranks also indicated a 107.63% difference, with 2020 showing 1211.5 compared to the 933.50 obtained in 2019. The Mann-Whitney test results, $U = -113.5$, $Z = -5.217$, and $p = 0.001$ ($p < 0.005$), showed a significant difference between the face-to-face method and blended learning method. Accordingly, the null hypothesis is rejected as the Mann-Whitney Test indicated a significant difference between these two teaching methods. Again, the Mann-Whitney Test results are interesting as they also corroborated the findings of Haryadi, Situmorang, and Khaerudin [48]. Their study demonstrated a significant difference between the experimental and control classes, providing evidence that blended learning had an impact on students' performance. Consequently, these findings were consistent with the results of [23], [22], [49], as well as numerous other studies conducted worldwide to assess the efficacy of blended learning during the COVID-19 pandemic. These results further confirmed the superiority of blended learning over traditional teaching and learning methods, which aligns with the findings of Zhang [50].

4.3 Assessing students' perceptions

To assess student perceptions, survey questionnaires were administered to 56 students. The questionnaires included six statements, and students were asked to rate their agreement using a five-point Likert scale. These students were in the final stage of their studies and were engaged in both face-to-face and blended learning methods. All of the participants (100%) were students from the Faculty of Science, Engineering, and Technology in the Department of Civil Engineering.

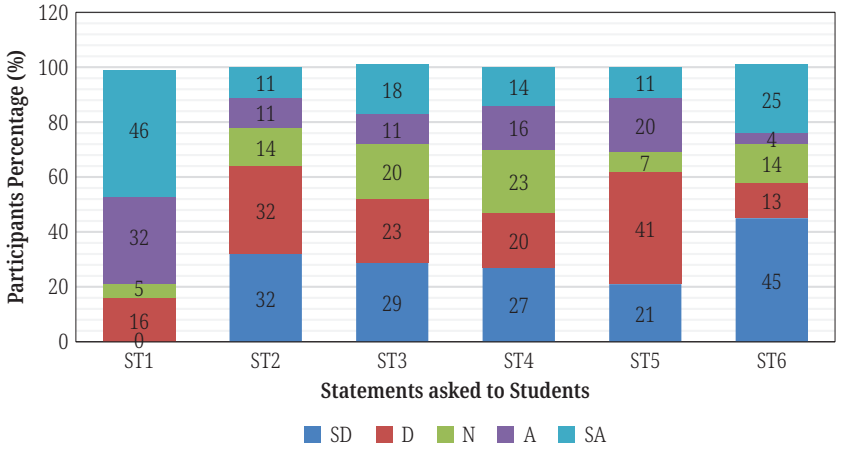

Fig. 2. Students' perceptions of six questions asked about blended vs face-to-face teaching methods

Figure 2 shows the students' perceptions of the six questions that they were asked. Statements, labelled as ST1, ST2, ST3, ST4, ST5, and ST6 (ST = Statement), were evaluated using a five-point Likert scale that ranged from strongly disagree, disagree, neither agree nor disagree, agree, to strongly agree. Strongly disagree is indicated in blue, disagree is indicated in red, neither agree nor disagree is indicated in green, agree is indicated in purple, and strongly agree is indicated in cyan. Figure 2 shows the percentage of students who agree with each statement based on their experiences in both 2019 and 2020. It was observed that ST1 had a high percentage of students who strongly agreed, ST2, ST3, and ST4 showed a high percentage of students who strongly disagreed, while ST5 had a high percentage of students who disagreed with the statements. Furthermore, ST 6 showed a high percentage of students who strongly disagreed with the statement.

Table 3 presents a comprehensive analysis of the students' perceptions, including the actual number of participants.

Table 3. Descriptive statistics of students' views on use of a blended teaching and learning method

Statement		Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree	Total Participants	Not Answered
There were significant changes between face to face and blended learning	ST1	0 (0%)	9 (16%)	3 (5%)	18 (32%)	26 (46%)	56 (100%)	0 (0%)
Switching to blended from face-to-face learning was easy	ST2	18 (32%)	18 (32%)	8 (14%)	6 (11%)	6 (11%)	56 (100%)	0 (0%)
Blended learning improved my study abilities	ST3	16 (29%)	13 (23%)	11 (20%)	6 (11%)	10 (18%)	56 (100%)	0 (0%)
Blended learning improved my performance	ST4	15 (27%)	11 (20%)	13 (23%)	9 (16%)	8 (14%)	56 (100%)	0 (0%)
I understood the concept of modules in detail during blended learning	ST5	12 (21%)	23 (41%)	4 (7%)	11 (20%)	6 (11%)	56 (100%)	0 (0%)
Blended learning should be adopted permanently	ST6	25 (45%)	7 (13%)	8 (14%)	2 (4%)	14 (25%)	56 (100%)	0 (0%)

Table 3 shows the results obtained from the survey questionnaires. It was observed that 46% of students strongly agreed and 32% agreed that there were significant changes between the two teaching methods. Moreover, 5% of the students seemed to be undecided, while 16% disagreed. It is worth noting that no students strongly disagreed with ST1. It was also noted that, in response to ST2, out of 56 participants, 11% strongly agreed, 11% agreed, 14% were unsure, 32% disagreed, and 32% strongly disagreed. Therefore, for ST2, the majority of students disagreed with the statement. It was further noted that, for ST3, 18% of students strongly agreed that blended learning improved their learning ability, while 11% agreed, 14% were undecided, 23% disagreed, and 29% strongly disagreed that there had been any improvement in learning ability. For ST4, which aimed to assess students' improvement in terms of performance rather than their ability to learn, the following observations were made: 14% of students strongly agreed with ST4, 16% agreed, 23% were undecided, 20% disagreed, and 27% strongly disagreed. These students believed that ST4 had no impact on their individual performance. This finding contradicts the results of the descriptive analysis statistics and Mann-Whitney test, which indicated that 66.7% of the subjects taken by students had higher mean values. This is further supported by the students' pass rate in 2020. It was also noted that in response to ST5, approximately 11% of students strongly agreed with understanding the module concept more during blended

learning, 20% agreed, 7% were undecided, 41% disagreed, and 21% strongly disagreed. Thus, it was evident that more students disagreed with understanding the concept of the module during blended learning. In response to the last statement, which presented the opportunity to decide whether blended learning should be permanently implemented by the department, approximately 25% strongly agreed, 4% agreed, 14% of students were undecided, 13% disagreed, and 45% strongly disagreed. It was noted that, the higher values in ST6 indicated that approximately 45% of students did not want blended learning to be permanently implemented by the university.

To gain deeper understanding of the survey responses, Table 4, shows a translated results using an interval scale that correspond to the verbal description provided by Pimentel [51].

Table 4. The responses of perceptions of the use of blended and face-to-face teaching methods

Likert Scale	Interval	Average	Interpretation
1	1.00–1.80	0.79	Strongly disagree
2	1.90–2.60	0.79	Disagree
3	2.70–3.40	0.79	Neither Agree nor Disagree
4	3.50–4.20	0.79	Agree
5	4.30–5.00	0.80	Strongly Agree

Source: Pimentel [51].

The descriptive interpretation of the weighted means, as shown in Table 5, can be explained as follows:

Table 5. Perceptions in response to use of blended learning

Statement	Weighted Mean	Description
ST1	4.09	Agree
ST2	2.67	Neither Agree nor Disagree
ST3	2.95	Neither Agree nor Disagree
ST4	2.98	Neither Agree nor Disagree
ST5	2.79	Neither Agree nor Disagree
ST6	2.93	Neither Agree nor Disagree

Source: Pimentel [51].

It could be concluded that students' perceptions of the blended learning method in relation to the face-to-face method were as follows: for ST1, students agreed that there were some significant changes between the two teaching methods used by the university. It could also be noted that students were unsure of ST2, ST3, ST4, ST5, and ST6. Therefore, this means that 83.33% of students who were part of this study were undecided about the use of blended learning in preference to a face-to-face teaching method, while the remaining 15.7% of students agreed with the use of blended teaching in preference to a face-to-face teaching method. Mali and Lim [52] conducted a study to examine students' perceptions of these two learning models. The findings suggested that during COVID-19, students preferred blended learning. However, once the pandemic was over, they expressed a preference for face-to-face learning.

5 CONCLUSION

This study focused on evaluating the effectiveness of blended learning on students' performance in the civil engineering department during the COVID-19 pandemic in a rural university in South Africa. The results of the year 2019, which preceded the adoption of blended learning, and the year 2020, when blended learning was implemented by the selected institution, were used to assess students' performance. From the findings, it can be concluded that blended learning was more effective, as evidenced by the improved class performances in 2020 when compared to the class performance in 2019. The results showed significantly improved performance during blended learning, particularly in three subjects: RCM36P1, SAN36P1, and WEN36P1. These subjects had a high failure rate in 2019, but in 2020, students achieved higher pass percentages. Furthermore, the results of the Mann-Whitney test confirmed the magnitude of the difference between the learning models. Similarly, the results demonstrated a significant disparity in student performance when using a blended learning model. Even though the results of the Mann-Whitney test showed a significant difference between the two learning methods, favouring blended learning, it is important to note that the mean values indicated that students performed well in 2019. This was the year when the university utilised face-to-face learning and teaching. Contrary to the positive student performance brought about by the use of a blended learning model, students seemed to prefer face-to-face learning. The lack of student satisfaction with blended learning could have been caused by the absence of support and the immediate exchange of learning and teaching methods, which were triggered by the COVID-19 pandemic. Lack of training in the system used while these students were at home due to restrictions, poor internet connection, power outages, and inadequate study environments could have been the main causes of these results. In the survey questionnaire, the responses to the first question indicated that students agreed that there were some differences in blended learning. However, in response to the remaining five questions, students were undecided. This could have been due to the challenges associated with the limitations of blended learning in the rural and impoverished Eastern Cape Province of South Africa.

Therefore, it can be concluded that blended learning improved students' performance in civil engineering during the COVID-19 pandemic. These results provide support for the effectiveness of blended learning compared to a face-to-face teaching model. However, it is important to note that other factors, such as access to internet connectivity, students' readiness to adapt to blended learning, and lecturers' readiness to use blended learning, were not investigated in this study. Blended learning can be adopted by the university in the Department of Civil Engineering. However, future research can be undertaken to conduct a broader investigation into lecturers' perceptions, training needs associated with blended learning, availability of the resources, and the conduciveness of off-campus study. This research is necessary because, based on students' perceptions, it was evident that they did not enjoy blended learning, despite their improved performance.

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