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PAPER

Survey Analysis on Engineering Students' Experience of Future-fit Classroom Learning Environment

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ABSTRACT

The success of every educational activity hinges on the quality of the students' learning experiences. This survey-based study analysed engineering students' perceptions of their learning experiences in a future-fit classroom (FFC) compared with conventional classrooms. In this study, structured interviews using online questionnaire, that were filled out by the students, was employed as a tool. Descriptive statistics for mean, coefficient of variation (CV), as well as linear correlation coefficient, were performed to evaluate the connection between their responses using the KNIME analytical software. According to the study, the typical response rate at which individuals responded to agree to questions regarding their educational experience in the FFC classroom is approximately 82 mean percentage score (MPS) with a CV of 0.196. Also, the mean response rate from the students who agreed that the University management should invest in FFCs is 86 MPS and 0.288 CV. Key insights from the further analysis include the correlation of students' responses to interpret the determining factors for their responses. These results indicate that most of the students that participated in the study are prepared to have more experiences in the FFCs for improved technology-enhanced learning and new pedagogy. Education policymakers should consider the use of communication and information technology in university classrooms to enhance students' engagement and improve pedagogy, which can lead to improved academic performance.

KEYWORDS

innovative learning environment, future-fit classroom, engineering students' perception, communication technology, pedagogy

1 INTRODUCTION

Future-fit classroom (FFC) learning environments are being built all over the world because of the growing impact of technology in higher education and the societal trend towards embracing intelligent systems [1]. Students today want more from their universities and are more open to trying new teaching techniques, including smart classroom equipment [2]. Trends in academia are following the same pattern.

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The use of technology in education has always impacted both the content and delivery of lessons, but recently technologies like artificial intelligence are reshaping how we learn and discover new things. Therefore, technology in schools is evolving from its traditional role as primarily a pedagogical instrument and a method of gaining access to information for the achievement of big ideas [3], [4].

The term "future-fit classroom" refers to an innovative approach to teaching and learning using technological tools that help students grow in their thinking, knowledge, and literacy. In other words, an FFC is a traditional classroom that has been upgraded to include advanced instructional technologies and educational resources. In this setting, students can engage in formal education in ways that go beyond what is achievable in conventional classrooms [5].

The contributions of this work include the validated results that showed that an FFC offered a better teaching and learning experience for instructors and learners as experimented with a class of engineering students who are enrolled in academic programs at the University of Johannesburg, located in South Africa. The coefficient of variation method and mean method were used for calculation and the correlation of the responses was used to find the determining factors of the student's responses.

The remaining sections of the paper are organised as described below: Section 2 provides a literature review, Section 3 outlines the methodology, Section 4 presents the results, and Section 5 contains the discussions and conclusions.

2 LITERATURE REVIEW

The FFC has been shown to increase students' enthusiasm to study, foster an atmosphere of active learning, and boost overall academic achievement as argued by [6]–[9]. Furthermore, various studies, including [10], have observed that the educational setting has an impact on how people behave, and this impact can lead to both immediate and long-term effects on academic performance and instructional effectiveness. Therefore, researchers study how to implement FFCs since doing so will inherently encourage students to be more active scholars. In the literature, "future-fit classrooms" are used frequently as "smart classrooms" or "blended learning" [11], [12]. Although an FFC can improve student learning, the extent of this effect is less certain.

Analysis of data from global research done to verify the dynamic model of educational efficacy by [13] showed that students' evaluations are a viable and reliable way to evaluate the model's components using learning analytics. Learning analytics involves the collection, analysis, and appropriate distribution of relevant data generated by students, which can be used to provide appropriate cognitive, administrative, and other forms of support to enhance the learning experience [13]. KNIME, which stands for Konstanz Information Miner, is open-source software and it is utilised to analyse data [14]. The software can generate visual depictions of diverse types of data, making it comprehensible for other users as well. KNIME has demonstrated its adaptability and usefulness across various fields of knowledge [15].

In this study, we use a case study approach with objective sampling. The study's findings will be relevant to the emerging topic of "future-fit classrooms" or "future learning environments". The perceived contradiction between innovation theories and practices in higher education and ICT sectors prompted the study. To that aim, this research explores how students perceive their ideal learning settings in the future, with a focus on how they aspire to the technology being integrated and their desired learning experience.

3 METHODOLOGY OF THE RESEARCH

In this section, we present the primary objectives and inquiries of the research, along with the classroom feedback mechanism, information origins, individuals, research method, and analytical approach.

The layout of the FFC at the University of Johannesburg where the lecture sessions were held is depicted in Figure 1. This comprises a range of equipment such as a touchscreen display, digital content projectors, collaborative tools between students and teachers, automated evaluation and response systems, cameras for capturing and archiving lectures, and a smart physical environment that uses sensors to control the temperature, humidity, air quality, and sound in the room.

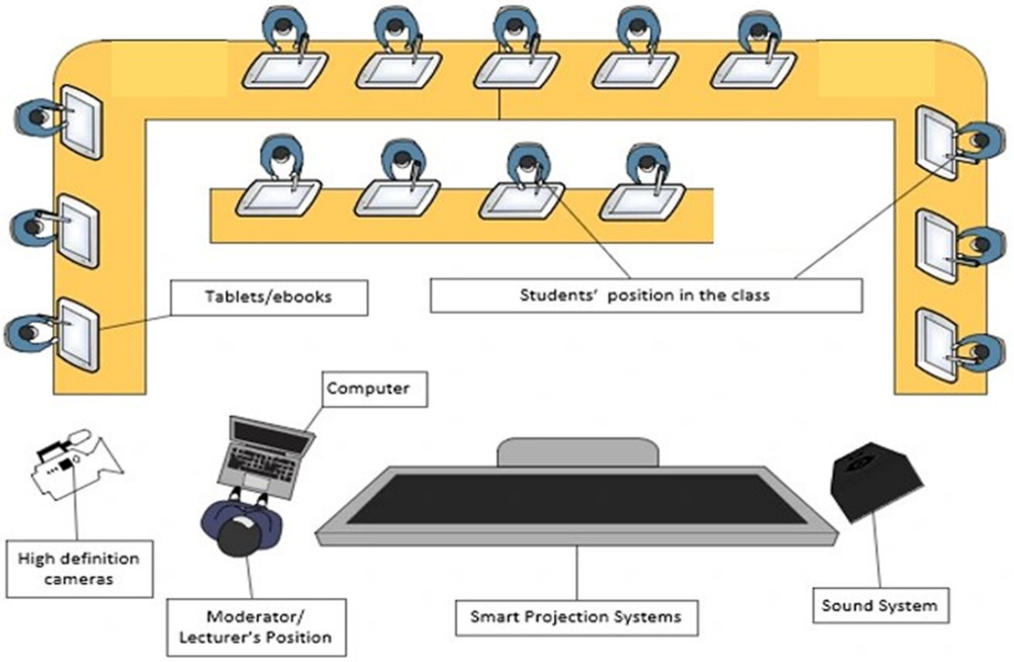

Fig. 1. Layout of the experimental future-fit classroom at the University of Johannesburg

3.1 The research goal and questions

The descriptive qualitative and quantitative methodology was used for this study's research design to present a comprehensive description of the research study. This research strategy fits most well with explanatory and exploratory critical theories like constructivist learning theory [16]. The aim of this study, which uses both qualitative and quantitative descriptive methods, is to provide a detailed summary of the response of the students to an FFC. The individuals involved in the research were first-year students enrolled in the Department of Electrical and Electronic Engineering Science at the University of Johannesburg (UJ) during the academic year of 2022. They participated in the future-fit classroom learning in the module called Project Communication 1B (PJCEEB1). Engineering students form a good sample space for such a study as these as they have been constructively used in previous pedagogy studies such as the studies presented in [17] for technical engineering students, and [18]–[20] for degree engineering students.

The subsequent research inquiries were established to provide answers to the following research questions:

- What inspired the students to willingly participate in the future-fit classroom?
- What did the students appreciate about the future-fit classroom?
- Are there any recommendations or remarks from the students that could enhance the FFC for future use and deployment in the university and country at large?
- Is there a noticeable contrast in the students' learning experience between the conventional classroom and the FFC?

3.2 Data collection and sampling

The classes were held in hybrid mode; hence some students attended the class in-person at the FFC while others attended virtually on Blackboard Collaborate Ultra, which is the official Learning Management System used at UJ for teaching, learning, and examination [21]. The total sample population who attended the FFC hybrid classes was 60 registered students of the module. Fifteen students attended the in-person class since that is the maximum capacity of the FFC, while forty-five students joined the class online through the Blackboard learning management system of UJ.

According to Alamri's demonstration in [22], Slovin's formula in equation (1) was utilised to determine the smallest amount of representative sample size required in the research:

$$\eta = \frac{N}{1+(N \times e^2)} \tag{1}$$

The formula provided includes three variables: 'η' which represents the sample size, '*N*' which represents the population, and 'e' which represents the acceptable level of sampling error that is 10%. According to (1), the minimum number of participants required for the in-person attendance group in this study is 13, while the minimum number of participants needed for the virtual attendance group is 31. The survey received responses from 14 in-person and 36 online students, totaling 50 students that participated in the survey (83% of total responses received).

The instrument employed in the form of a questionnaire was created using Google Forms so that students could readily reply to the teaching methods conducted by the course instructor during the FFC lecture sessions. The researchers used both the previous literature and the questions generated by the project studies to obtain the questions they wanted to be answered in their assessment of students' experience at the FFCs. In addition to standard demographic questions, the questionnaire explored respondents' perceptions toward and interest in the FFC's pedagogical methods. It also consisted of multiple-choice questions scored on a scale of five ("strongly agree" (5), "somewhat agree" (4), "neutral" (3), "somewhat disagree" (2), and "strongly disagree" (1)). The participants were also asked some open-ended questions.

Validity and reliability limitations were circumvented by asking specific and unambiguous questions. Expert academics and lecturers in the field of engineering education and technology reviewed the questionnaire for content validity [23]. The research questions were evaluated based on reflectiveness to assess understanding, discrimination, or evaluation. This was to ensure that the questionnaires were clear and did not include any terminology that would make the participants lose interest in the survey.

3.3 Ethical considerations

The research was conducted following national and international research ethical requirements such as autonomy, beneficence, non-maleficence, and justice, including those presented in [24]. This study was conducted with informed and voluntary consent from all the students involved. Prospective participants were also informed of the significance of their involvement and what would be done with the information they submitted. Approval from the faculty's ethics committee was obtained before the research commenced.

3.4 Data and visualization

Analysis of the qualitative data was based on content analysis. Content analysis is a known data analysis strategy that has progressed in interpreting textual data [25]. Students' perspectives, acceptance, and the necessity for FFC were the three major themes identified by the analysis of all the responses. The students' feedback was exported into a spreadsheet (MS Excel) from Google spreadsheet and saved using the comma-separated-value (CSV) format for further analysis. The responses to the Likert-scale questions were then converted from strings to numbers and the quantitative data obtained from the study were analysed and presented using the KNIME analytical software.

The numeric variables were analysed using descriptive statistics, specifically the mean and standard deviation. Since the scoring system varies between 1 and 5, it is important to recognize that each question's number corresponds to a distinct level of agreement. A low mean value for a question interprets that the students disagree, whereas a higher mean value interprets that the students agree. The CV method as used in [26] is used to weigh the responses to the questionnaires. The CV represents the relationship between the standard deviation and the mean, expressed as illustrated in equation (2):

$$CV = SD/m \tag{2}$$

In equation (2), *CV* represents "coefficient of variation", *SD* represents "standard deviation", and *m* represents "mean". It calculates the variation degree of the responses index in the data by directly using the information contained in each index, and it is an objective weighting method. If the responses from sample A and sample B vary less, it implies that the data points are dispersed around the mean value, which provides a simple data interpretation. The data that has a CV score that exceeds 1 is regarded to require further analysis in order to draw a conclusion.

The data preprocessing procedures executed on the KNIME workflows include reading the input file, column filtering, and checking for missing data. An information examination process comprises a pipeline of a node associated with edges that transport either information or models. The workflows were executed, and students' response data visualization results were obtained. The designed KNIME workflow is presented in Figure 2.

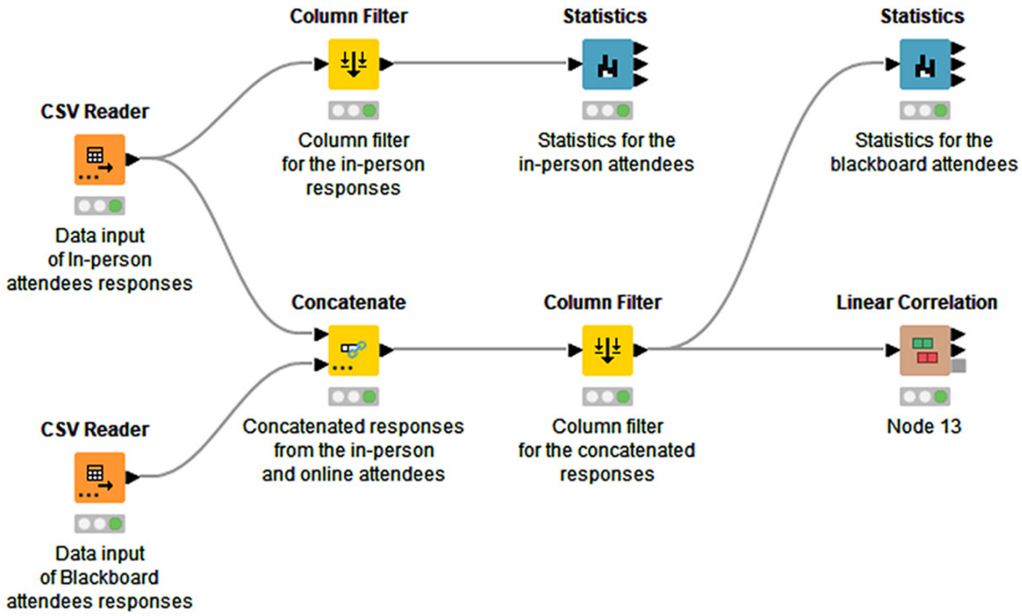

Fig. 2. KNIME software workflow with built-up nodes

4 RESULTS AND DISCUSSION

An evaluation of the student's learning experience and level of satisfaction with the FFC lecture section is presented in this section. The survey measures students' concentration, engagement, perceived learning, motivation, and satisfaction. This survey received 50 responses from the students – 14 responses from in-person attendees and 36 responses from virtual attendees.

4.1 Analysis of Students' satisfaction levels

After collecting the responses in numerical format, we proceed to determine the mean value of the answers for each question. We employed the KNIME mathematical formula node to compute both the mean values and the correlation coefficient. This section presents the statistics data for the responses from the two groups of students that participated in the FFC session. The attendees who were physically present provided answers to questions regarding the facilities that aid in learning activities within the FFC. Both the in-person and virtual attendees' feedback assessed the extent to which the FFC facilitated learning activities. The maximum and minimum scores are 5 and 1, respectively. Low scores mean that the students did not agree with the question while a high score means that the students agreed with the question as explained in Section 3.2 of this paper.

Response to questions in Table 1 was targeted to the in-person attendees and was analysed based on responses from the in-person attendees only. It presents the quantitative analysis of responses of students to analyse the FFC physical environment and classroom facilities.

Table 1. Quantitative analysis of in-person attendees' responses

Questionnaires	Min	Max	Mean	MPS (%)	Std. Deviation	CV
"The future-fit class allowed the lecturer to ask each of us if we understood what she was teaching and to assist us if we had any questions."	3	5	4.22	85	0.764	0.181
"The future-fit class provided an adequate balance of theoretical and practical knowledge."	3	5	4.143	83	0.535	0.13
"The future-fit classroom amenities (ventilation and air quality, space and size of the classrooms, soundproof wall, lighting, internet connection, teaching facilities, and temperature control) met your needs."	3	5	4.572	92	0.852	0.187
"The future-fit classroom's teaching environment aided better learning and understanding of the course content."	3	5	4.286	86	0.612	0.143
"The room temperature of the future-fit classroom is conducive for learning."	4	5	4.786	96	0.426	0.089
"There are no unnecessary sounds in the future-fit classroom."	4	5	4.858	98	0.364	0.075
"The lighting in the future-fit classroom is adequate for teaching and learning."	3	5	4.858	98	0.535	0.111
"I can hear the lecturer and other students (online and in-person)."	4	5	4.14	83	1.196	0.289
"I can effectively collaborate with a classmate on class tasks during a hybrid future-fit class."	3	5	4.04	81	1.106	0.274
"In-person future-fit classes allow for real-time formative assessment by the lecturer."	3	5	4.643	93	0.745	0.161
"I have enough space in the future-fit class to place my textbooks, tablets, PCs, and other materials."	3	5	4.5	90	0.651	0.145
"The classroom layout is appropriate for my learning styles."	3	5	4.643	93	0.634	0.137
"The blackboard and projector are in the ideal location for teaching and learning in the future-fit class."	3	5	4.358	88	0.842	0.194
"I understand educational content easier and faster when it is taught from a smart screen than just on a projector screen."	3	5	4.143	83	0.865	0.209
"I can share my learning experiences easily with others."	4	5	4.14	83	0.809	0.196
"The future-fit classroom is roomy enough for all class activities."	2	5	4.072	81	0.998	0.245

The finding in Table 1 was useful in evaluating the perception of students' satisfaction level in the physical FFC session. The analysis of responses on the facilities provided in the physical FFC session is highly positive with an overall average MPS of 88%. However, there is still a need for improvement as not all the students are fully satisfied with the facilities provided by the FFC. Table 2 presents the quantitative analysis of the total responses received in the survey from both in-person and online participants of the FFC.

Table 2. Quantitative analysis of all FFC hybrid class attendees' responses

Questionnaires	Min	Max	Mean	MSP (%)	Std. Deviation	CV
"All lecture halls at UJ should have smart screens and boards, similar to the future-fit classrooms"	1	5	4.277	86	1.16	0.288
"Do you believe investing in the future-fit classroom by the University management was worthwhile?"	1	5	4.000	80	0.794	0.196
"Do you believe the University offers you appropriate facilities for optimal learning in a regular classroom setting?"	1	3	3.532	71	0.764	0.22
"How likely are you to recommend the future-fit classroom session to your friends or colleagues based on your overall experience in it?"	1	3	4.360	87	1.174	0.27
"How would you rate your entire academic experience with the lecturer in the future-fit class?"	2	5	4.086	82	0.829	0.195
"I can hear the lecturer and other students (virtual and in-person)"	1	5	4.107	83	0.612	0.143
"I can share my learning experiences easily with others"	2	5	4.107	83	1.018	0.245
"Introducing future-fit classrooms for all modules will effectively improve my academic performance"	1	5	4.128	83	1.085	0.277
"Introducing the future-fit classroom will effectively prepare me for the job market"	1	5	3.894	78	1.143	0.286
"The future-fit class allowed the lecturer to ask each of us if we understood what she was teaching and to assist us if we had any questions"	2	5	3.915	79	1.196	0.289
"The future-fit class provided an adequate balance of theoretical and practical knowledge"	2	5	3.490	70	0.809	0.196

As seen in Table 2, based on the response to the question, "Do you believe the University offers you appropriate facilities for optimal learning in a regular classroom setting?" the students agree that the university offers the appropriate facilities considering the response with 71% MPS value and 0.22 CV. This low MPS could be because there were more online than in-person participants in the survey who didn't have direct interaction with the FFC. However, in the case of recommending the FFC based on their experience, their responses had an MPS value of 87% and a CV of 0.27, which can be motivation for the authorities to deploy more FFC across the campus. Considering the FFC's rating on assisting the student's academic experience, it was observed that the MPS to the question is 82%, and the CV is 0.196. This might also be the justification for the result of the question "Introducing future-fit classrooms for all modules will effectively improve my academic performance," where the MPS is 83% and the CV is 0.277. Furthermore, to evaluate the level of student satisfaction based on the response to the question, "All lecture halls at UJ should have smart screens and boards, similar to the future-fit classrooms," we observed the students' responses have an MPS of 86% and 0.288 CV. Hence, these are positive indications that the FFC would offer more benefits to the students than the traditional classrooms even as the university management addresses the shortcomings of the FFC.

4.2 Correlation of students' response to the FFC

The purpose of this section is to explore the correlation between answers to questions treated as factors and determine how strong or weak they are. Also, this gives us an idea of how a response to one factor affects others. This will be achieved by applying a linear correlation between these results, and based on the results, we will be able to determine the correlation between them. According to our research results, we will classify values ranging from 0 to 0.29 as indicating weak positive relationships, values ranging from 0.3 to 0.69 as indicating moderate positive relationships, and values ranging from 0.7 to 0.99 as indicating strong positive relationships. Firstly, it is important to comprehend that the correlation coefficient falls within the range of –1 to +1. A value of +1 signifies an ideal positive correlation. A score of 0 indicates the absence of any correlation, whereas a score of –1 signifies a completely inverse correlation.

The correlation value between "Were you part of the hybrid future-fit class teaching and learning?" and "How would you rate your entire academic experience with the lecturer in the future-fit class?" is 0.24. The weak correlation between students' rating of the FFC and the mode of participation can be explained by the environmental variables namely the location, noise level, distractions, reliable internet and/or computer, and inadequate interpersonal interactions as reported in their responses.

4.3 Analysis of open-ended responses

The qualitative data received from the survey was analysed and categorised into four primary themes, namely inspiration, appreciation, displeasure, and feedback/suggestions for the FFC on UJ campus. The results are summarised and presented in Table 3.

Table 3. Analysis of motivations to participate in the FFC

Primary theme	Question	Secondary Theme	Selected Students' Responses
Inspiration	"What inspired you to willingly participate in the future-fit class?"	The use of innovative technological gadgets	"I was interested in technological innovations"
			"I want to experience the futuristic nature of learning"
		Experience of a new classroom setting	"To see how the integrated classroom operates"
Appreciation	"What do you appreciate best about the future-fit classroom and explain why."	Study materials handling	"I have more space to put your study materials"
		Class Interaction and students engagement	"I was able to ask questions"
			"I appreciate the interactive communication between virtual and in-person students"
Displeasure	"Mention one thing you disliked most about the future-fit classroom and explain why?"	Interruption of the network connection	"The technical difficulty caused the waste of some lesson time"
		The small size of the class	"There should be more space to accommodate more students in the in-person participation of the FFC session"
		Cost	"It looks expensive."
Feedback comments and suggestions	"Do you have any suggestions or comments to help improve the future-fit classroom experience for students?"	Improvement in smart devices and furniture	"Practical equipment can be installed to aid the learning of practical subjects."
			"The capacity of the future-fit classroom needs to be increased to accommodate more students"

4.4 Discussion

The results of this study address the research objective to analyse engineering students' perceptions of their learning experiences in a technologically enhanced classroom (FFC) compared to conventional classrooms. The quantitative data was evaluated thoroughly using the MPS, CV and linear correlation methods to identify indicators for the different responses.

The findings of this study are consistent with earlier research that examined how students perceived similar technologies like the FFC for different applications such as intellectual disabilities [27], STEM subjects [28], flipped classrooms [29], smart classrooms [30], subject websites [31], and remote learning [32]. Student satisfaction was found to be predictably associated with classroom facilities. The results of this study are crucial because nearly all the participants were enthusiastic about trying the FFC session at the university for the very first time. Moreover, the introduction of the FFC was a novel occurrence at the university. Consequently, we obtained a restricted number of devices and amenities that students could utilise during the session. Although many factors influence students' satisfaction levels, our research indicates that the absence of a face-to-face classroom environment is a significant contributor to negative perceptions among students who joined virtually as previously opined by the work in [33].

The literature shows that previous assessments have analysed students' perceptions from different academic levels, but this research focused mainly on the perspectives of engineering students in higher institutions towards the FFC. According to the findings of the qualitative analysis of the survey, students' perspectives and expectations regarding the FFC are labelled under four primary themes, namely inspiration, appreciation, displeasure, and feedback comments/suggestions. Most of the respondents concurred that the classroom amenities were beneficial, and efficient, and facilitated their learning process without many drawbacks except for issues of network connectivity, class sitting capacity, cost, and inability to conduct laboratory practicals there.

5 CONCLUSION

A study of students' experience and responses to the FFC learning environment at the University of Johannesburg has been presented in this article. The questions and answers were submitted and received electronically through Google Forms. The surveys asked participants to evaluate their levels of motivation, engagement, enjoyment, perceived learning, and overall satisfaction with the classroom's preparation for the future of learning at the university. These findings provide more evidence that students opined that the digital equipment used in a future-fit classroom aids their education and boosts their focus, interest, enthusiasm, and drive to study. It also increased their learning capability by making students more self-aware of their progress in the subject being taught in the class. In addition, the scholars perceive that their feedback and viewpoints are esteemed by their instructors and will be utilised by the university administration to enhance the quality of education.

Furthermore, the traditional classroom was shaped by the industrial age and the future-fit classroom will be shaped by the digital revolution.

This study has limitations due to the limited sample size, small sitting capacity of the FFC, and a focus on convenience sampling. Hence, further research should focus on testing different student groups' classroom experiences and examining the learning outcomes of large samples in a larger FCC. Considering the study's discoveries, forthcoming investigations could investigate how technology affects student learning achievements across diverse academic fields and educational stages.

However, this study has shown that the deployment of more and larger FFCs is the right way to go at the University of Johannesburg, which other institutions can also invest in for the good of their students.

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