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Bachelor of Education Science Students' Beliefs, Perceptions, and Experiences of Online Learning during the COVID-19 Pandemic: A Case of Disadvantaged Students

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Abstract: This study examined Bachelor of Education science students' beliefs, perceptions, and experiences of online learning during the COVID-19 pandemic. The investigation adopted an explanatory mixed method research design and involved purposively selected students enrolled for Bachelor of Education degree specialising in Physical and Life Sciences at a South African university. These students came from rural areas, townships, and informal settlements, which are characterised by a myriad of socio-economic challenges. These challenges have profound implications for students' resilience within the higher education sector. The study was underpinned by Technology Ac ceptance Model as the theoretical framework. Quantitative data was collected through administration of a questionnaire while qualitative data was collected through semi-structured interviews. Quantitative and qualitative data were analysed using SPSS and Atlas.ti, respectively. Findings showed that the students struggled to acquire appropriate digital devices and to access internet connectivity amongst other challenges because of their socio-economic backgrounds. They however demonstrated resilience through successful completion of their studies in the face of these critical challenges. Notwithstanding their socio-economic backgrounds, the students competed favourably with their peers from privileged backgrounds. The study has important implications for the alleviation of existing socio-economic disparities within the South African higher education system.

Keywords: beliefs; COVID-19 pandemic; experiences; perceptions; resilience

1. Introduction

The outbreak of COVID-19 pandemic induced unplanned and sudden transition from face-to-face to online teaching and learning. The pandemic outbreak disrupted and changed how people socialise, work, and engage in the learning process [1]. The impact of the pandemic was particularly more pronounced in the higher education sector [2]. The pandemic presented formidable challenges and enormous opportunities for teaching and learning at higher education institutions [1,3]. While the prevalence of COVID-19 pandemic disrupted traditional models of learning [4], it provided opportunities to both academic personnel and students to harness pedagogical affordances of digital resources in online teaching and learning. Online learning was characterised by heavy reliance on the utilisation of digital devices during the COVID-19 pandemic. The transition from face-to-face to online teaching and learning was challenging as it required digital competence on the part of academic personnel and students. While the transition engendered heavy workloads for academic personnel [5], students encountered fundamental challenges when adapting to the abrupt and unplanned shift to online learning [6].

1.1. Contextual Realities Facing Students Coming from Disadvantaged Socio-Economic Backgrounds

Rhetorical issues have been raised about the preparedness of South African students to undertake university studies. Such issues stem from the historical inequalities perpetuated

by the Apartheid regime before the dawn of democracy in South Africa in 1994 which resulted in the high dropout rates among students undertaking university studies [7]. The transition from face-to-face to online learning has been viewed from various perspectives. For instance, Marwala [8] viewed the transition as a 'forced opportunity' while Mavuru and Ramaila [9] viewed COVID-19 pandemic as a catalyst for fostering reformed pedagogy in science education. In addition, the transition offered new experiences and perspectives and pushed education advances forward [10]. On the other hand, university students and civil groups viewed the transition as an abrupt disruption to the normal learning situation which exacerbated socio-economic disparities existing in South African communities and education system [11]. While there had been calls to adopt technology in response to the key imperatives associated with the advent of the fourth industrial revolution (4IR) before the outbreak of COVID-19 pandemic [12], universities are still grappling with the fulfilment of this key strategic mandate. The students from rural areas, informal settlements, and townships were largely affected by lack of digital devices, lack of conducive study spaces, and inadequate access to internet connectivity [13–15]. Schleicher [16] lamented that school learners from disadvantaged communities lack access to appropriate digital learning resources and lack resilience to engage in independent learning.

Prior to the outbreak of COVID-19 pandemic, various education systems were already grappling with limited learning resources [17]. McDonald [18] highlighted inadequacies and inequities regarding access to broadband, acquisition of appropriate digital devices, and the creation of conducive environments for online learning. Only a fifth of South-West Asian and sub-Saharan African households have internet connectivity [19]. In support of this assertion, Mavuru and Ramaila [9] contend that the COVID-19 pandemic has significantly widened the digital divide. During online learning, preservice science teachers were not only taught methodology, but they also learned Life Sciences and Physical Sciences content during the 2020 and 2021 academic years. Online science learning was challenging during the COVID-19 pandemic as science learning ought to provide meaningful opportunities for hands-on tasks, problem solving, and performance of practical work. Students were exposed to virtual laboratory experiences as online learning hindered laboratory practical work [20]. Exposure to virtual laboratory experiences required digital competence and stable internet connectivity. Lobos et al. [21] observed that online learning was an increasingly difficult undertaking for students pursuing STEM studies in view of the operational challenges which resulted in limited opportunities for students to engage in laboratory activities.

1.2. Purpose of Study

The aforementioned practical considerations underscore the need to explore students' disposition about the complexity of online learning during the COVID-19 pandemic. To this end, this study specifically examined Bachelor of Education science students' beliefs, perceptions, and experiences of online learning during the COVID-19 pandemic at a South African university. The study sought to answer the following research questions: 1. What were preservice science teachers' beliefs and perceptions about online learning during the COVID-19 pandemic? and 2. How did the preservice science teachers experience online learning during the COVID-19 pandemic?

2. Literature Review

2.1. Resilience in Higher Education

Resilience refers to one's ability to adapt to stress and adversity [22,23]. One of the crucial factors for adaptability is optimism which Scheier and Carver [24] described as the expectation of achieving positive outcomes in the future. In the case of university students, failure to adapt may result in poor academic performance and withdrawal from university academic activities [23]. Highly resilient students have adaptive skills which enable them to learn from stressful situations [25]. A study conducted by Spain et al. [26] demonstrated that optimism is a significant predictor of resilience amongst students. In

addition, optimism acts as a protective factor that enhances students' resilience levels during their transition to university [26].

In the wake of COVID-19 pandemic and the concomitant transition from face-to-face to online learning, university students needed to be resilient for them to succeed. The students struggled to access adequate resources and were further confronted by a digital divide which exacerbated existing inequalities [27]. In some disadvantaged communities, students have no access to electricity in addition to poor internet connectivity [28]. Miliszewska [29] questioned the ability of online tools such as online videos, digital content, and discussion forums to provide meaningful teaching and learning. The transition from face- to- face to online teaching and learning was abrupt and unplanned as students were not provided with opportunities to acquire appropriate digital devices and the digital competence required for coherent and meaningful online learning [11,13,14].

2.2. Students' Beliefs about Online Learning

The significance of the exploration of students' beliefs about online learning within the context of COVID-19 pandemic cannot be over-emphasised. Self-efficacy beliefs refer to students' beliefs about their ability to navigate and diligently engage in activities and tasks assigned in the virtual learning environment [30]. Various studies revealed that when students are cognisant of their learning beliefs about an online platform, they academically perform well [21,31,32]. Epistemic and learning beliefs have been found to significantly affect students' learning participation and perceived learning by mediating their achievement goals [33]. A study conducted by Almomani et al. [34] found that university students believe that COVID-19 pandemic pushed them to learn new skills. The newly acquired skills included the use of Zoom, Moodle, Google Classroom, and use of online books [34]. When examining undergraduate STEM students' beliefs about emergency remote teaching during the COVID-19 pandemic, Lobos et al. [21] observed that students demonstrated negative disposition about the learning opportunities provided during emergency remote teaching.

2.3. Students' Perceptions about Online Learning

The prevalence of COVID-19 pandemic propelled higher education institutions to extensively use digital devices to provide online learning. The abrupt nature of the transition from face-to-face to online learning underscores the need to examine students' perceptions about online learning itself. Critical examination of students' perceptions about online learning would provide insightful elucidation into the extent to which students harnessed online learning to maximise their academic experiences. A study conducted by Muthuprasad et al. [35] demonstrated that a substantial number of students fully embraced online classes to manage the curriculum during the COVID-19 pandemic. While the students expressed fundamental appreciation of the flexibility and convenience of online learning, they bemoaned broadband connectivity issues in rural areas which rendered students' participation in online learning activities increasingly difficult [35].

At another pragmatic level, a study conducted by Hara and Kling [36] showed that there was no significant difference between online learning and face- to- face class regarding students' satisfaction. In fact, Hara and Kling [36] argue that online learning can be as effective as traditional learning if it is designed appropriately. On the contrary, Tratnik [37] observed significant differences in student satisfaction levels between online and face-to- face learning. This dichotomy represents a key conundrum that ought to be resolved through evidence-based research to provide a critical understanding of the ontological foundation of online learning. The design and navigation of appropriate online learning environments can be an arduous task for both instructors and students at higher education institutions. This task requires critical knowledge of the key pillars that underpin the design of appropriate online learning environments. The design of appropriate online learning environments is dependent upon well-structured course content, well-prepared instructors, and advanced technologies as well as feedback and clear instructions [38,39]. Furthermore, a study conducted by Bali and Liu [40] demonstrated that students were

comfortable with online learning as it afforded them opportunities to be innovative by using technological devices. However, Kemp and Grieve [41] found that students preferred to complete activities face- to- face rather than online.

By its very nature, the online learning environment differs from the traditional classroom situation in respect of students' motivation, satisfaction, and interaction [42]. This difference calls for the adoption of a coherent and established framework to underpin online teaching and learning interventions. In this regard, Garrison, Anderson, and Archer [43] proposed the Community of Inquiry (COI) framework which provides a convenient baseline for online teaching and learning interventions. The COI framework is predicated on the notion that success of web-based instruction is determined by creating a students' group which can serve as a catalyst for collaborative construction of knowledge. The COI framework envisages that learning in this group is anchored on three interdependent elements: (1) social presence, (2) cognitive presence, and (3) teaching presence.

2.4. Students' Experiences of Online Learning

Developing a broad understanding of students' learning conditions and their experiences of online learning during the COVID-19 pandemic remains a key strategic imperative. While various research studies provided insightful elucidation into the fundamental challenges students experience during online learning, they hardly provide critical information about students' learning conditions and future expectations. There is a crucial need to examine students' experiences of online learning with a view to paving the way for students to harness pedagogical affordances of digital devices in online learning environments. The advent of the 4IR provided opportunities for both instructors and students to fully embrace digital transformation. According to Yan et al. [44], students' online learning experiences vary significantly across school years. In addition, students experience various difficulties related to the delivery of online learning [44].

As pointed out earlier, the abrupt transition from face to face to online learning induced by COVID-19 pandemic disrupted traditional mode of teaching and learning. Barbour and Reeves [45] argue that this sudden transition is problematic for students as they often lack prior online learning experience, particularly students from disadvantaged socio-economic backgrounds. Other challenges associated with the delivery of online learning encountered by students include difficulty to adapt to online learning due to various vulnerabilities and inadequate academic performance [46], feeling of isolation [47], and lack of learning motivation [48]. The key consequence of the COVID-19 pandemic is that the design of learning environments may never be the same again as the increased adoption of online learning could have a lasting impact on the education systems across the globe. In support of this sentiment, Molnar et al. [46] maintain that the adoption of online learning may potentially accelerate and expand the rapid growth of virtual schools on a global scale.

Several major concerns on students' online learning experience during the COVID-19 pandemic have been identified. These concerns include issues with internet connectivity [49,50], problems with information technology equipment [51,52], limited collaborative learning opportunities [51,53], reduced learning motivation [50,52,53], and increased learning burdens [52]. There is a need for information that could assist higher education institutions to better comprehend students' difficulties with a view to improving their online learning experience. A study conducted by Agung et al. [49] reported issues of unstable internet, insufficient internet data, and incompatible learning devices in rural settings in Indonesia and South Africa is no exception. Access to appropriate technological devices helps students to adapt to online learning [54]. However, a considerable number of students in higher education institutions use incompatible devices for online learning and technical issues surrounding technological devices make online learning an unpleasant experience for students (Agung et al., 2020). According to Barbour and Reeves [45], students need to have a high level of digital literacy to access relevant information and communicate with others through technological devices. However, not all students have

the appropriate digital competence required to effectively use digital devices in online learning environments.

2.5. Theoretical Framework

The study is underpinned by the Technology Acceptance Model (TAM) proposed by Davis [55] as the underlying theoretical framework. As illustrated in Figure 1, TAM is anchored on two factors that determine whether a computer system will be accepted by its potential users: (1) perceived usefulness, and (2) perceived ease of use. Perceived usefulness refers to the degree to which a person believes that using a particular system would enhance their job performance [55]. Perceived ease of use refers to the degree to which a person believes that using a particular system would be free from effort [55]. As its key feature, this model puts particular emphasis on the perceptions of the potential user. In essence, TAM is an information systems theory that models how users come to accept and use technology. The model suggests that when users are presented with a new technology, several factors influence their decision about how and when they will use it. External variables such as social influence is an important factor affecting attitudes. According to Davis [55], when these building blocks are in place, people will have the attitude and intention to use the technology. However, the perception may change depending on age and gender because everyone is different.
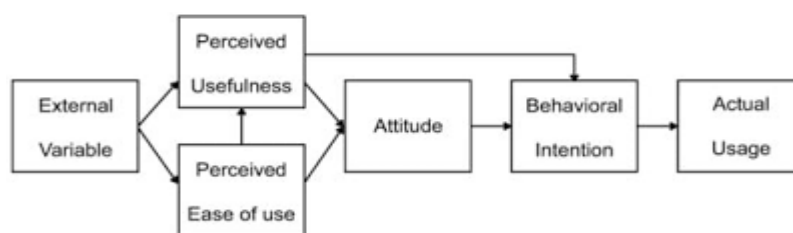

Figure 1. Illustration of Technology Acceptance Model [55].

3. Methodology

3.1. Research Design

The study adopted explanatory sequential mixed-method research design. The design consists of quantitative and qualitative phases [56]. More specifically, the design firstly involves collection of quantitative data followed by collection of qualitative data to help explain or elaborate on the quantitative results [57]. This two-phase approach is particularly useful when conducting research aimed at explaining the findings emanating from quantitative data collected in the first phase of the study with the qualitative data collected during the second phase. The key advantage of this design is that quantitative data and results in the first phase provide a general picture of the research problem which requires more analysis specifically through qualitative data collection in the second phase to refine, extend or explain the general picture. This configuration provides meaningful opportunities for qualitative data to be used in the subsequent interpretation and clarification of the results from quantitative data analysis. Explanatory sequential mixed-method design was appropriate for this study as it involved the collection of both quantitative and qualitative data in phases. In this regard, Teddlie and Tashakkori [58] posit that mixed method research provides better inferences and minimises uni-method bias.

3.2. Research Paradigm

The study is located within the interpretive paradigm. A paradigm is defined by Ponterotto [59] as a conceptual framework that includes a set of interrelated assumptions which provide philosophical values and beliefs for the organised study in a social world. The interpretive paradigm provides insightful elucidation into identified unit of analysis through discovery of meanings by obtaining an understanding of the subjectively created social world [60,61]. In addition, the interpretive paradigm is useful in exploring the

richness, depth, and complexity of phenomena. According to Packer [62], the interpretive paradigm can be harnessed to characterise how people experience the world, the ways they interact together, and the settings in which these interactions take place. Furthermore, an interpretive paradigm is perceived as an inductive paradigm as it enables argument from the particular to the general which means that a phenomenon is observed, and a pattern is developed, then hypothesis, and subsequent emergence of theory [63]. Within the context of this study, the interpretive paradigm provided insightful elucidation into science students' beliefs, perceptions, and experiences of online learning during the COVID-19 pandemic as the unit of analysis.

3.3. Selection of Participants

Using purposive sampling technique [64], 50 Bachelor of Education preservice science teachers in their fourth year of study were selected to participate in the study. A critical case sampling technique [65] was used to select participants who were likely to provide the most needed information about the phenomenon, which in this study was anchored on science students' beliefs, perceptions and experiences of online learning and their level of resilience when learning under adverse conditions. These preservice science teachers were enrolled for a Life Sciences Methodology course (n = 24) and Physical Sciences Methodology course (n = 26) at a South African University. The university draws its students' populace from various provinces in South Africa. These students were exposed to online learning induced by COVID-19 pandemic during the 2020 and 2021 academic years notwithstanding the fact that they enrolled for face-to-face programme. Furthermore, the students came from rural areas, townships, and informal settlements, which were characterised by a myriad of socio-economic challenges.

3.4. Data Collection

Firstly, the researchers adapted items from questionnaires used in previous studies conducted by Mavuru, Pila and Kuhudzai [11] as well as Mavuru and Ramaila [9]. These questionnaires explore the levels of preservice teachers' adaptation to remote teaching and learning and how COVID-19 pandemic acted as a catalyst for fostering reformed pedagogy in science education. To collect quantitative data, the adapted 5-point Likert Scale questionnaire (Appendix A) was administered to 50 preservice science teachers as an online google form. The questionnaire sought preservice science teachers' biographical information, beliefs, perceptions, and experiences of online learning during the COVID-19 pandemic. A high response rate of 90% was achieved probably because the preservice science teachers viewed their participation in this study as a meaningful opportunity to share their beliefs, feelings, and experiences. A third of the students were then interviewed using semi-structured interview schedule (Appendix B) to establish their levels of resilience when learning under challenging circumstances. The interview sought to unearth the participants' views on how they overcome challenges faced during online learning in terms of lecture attendance and submission of assessment tasks. Each interview was conducted in English as the language of teaching and learning, took 30 min and did not interfere with learning time.

3.5. Data Analysis

As a statistical tool, SPSS version 26 was used to analyse quantitative data. Quantitative data was analysed using descriptive and inferential statistics. Atlas.ti was used to analyse qualitative data. Axial coding was employed when analysing qualitative data. Axial coding is a qualitative research technique that involves relating data together to reveal codes, categories, and subcategories through a combination of inductive and deductive thinking in accordance with the Coding Manual for Qualitative Researchers developed by Saldana [66].

3.6. Reliability and Validity

To ensure its reliability and validity, the adapted questionnaire was piloted with a group of 50 third year preservice science teachers who were not part of the study. The Cronbach's alpha values of the various constructs investigated ranged from 0.74 to 0.82 and this represented an acceptable level of internal consistency of the items. To ensure validity of qualitative data collected through semi-structured interviews, trustworthiness measures such as credibility, transferability, dependability, and confirmability proposed by Lincoln and Guba [67] were considered.

3.7. Ethical Considerations

Prior to the execution of the research, ethical clearance was obtained from the Faculty Research Ethics Committee of the institution where the research was conducted. There was no harm or discomfort associated with the participation of preservice science teachers in the study. However, potential risks involved the participants' strong conflicting views, bias, and opinions about the delivery of online learning during the COVID-19 pandemic. In cases where such feelings arose, the participants were not obliged to answer questions and complete withdrawal from the study was guaranteed without any repercussions. Due to COVID-19 restrictions, the survey questionnaire was administered as Google forms which were made available to the participants online. Semi-structured interviews were conducted with selected participants on the Microsoft Teams platform. Confidentiality was always ensured to protect the identity of individual responses. Informed consent was duly obtained from the participants. Participation in the study was voluntary.

4. Research Findings

4.1. Demographic Profiles for the Participants

The following results in Table 1 show the demographic profile of the participants.

Table 1. Demographic profile of the participants.

Characteristics	Categor	n	Percentage
Gender	Female	27	54.0
	Male	23	46.0
Race	Black	45	90.0
	Coloured	2	4.0
	White	3	6.0
Residential area	Informal settlement	1	2.0
	Rural	19	38.0
	Farm	2	4.0
	Township	21	42.0
	Suburban	7	14.0
Electronic devices used	Cell phone	17	34.0
	Laptop	29	58.0
	Desktop	4	8.0
Source of connectivity	Data	42	84.0
	Wi-Fi	7	14.0
	Internet cafe	1	2.0

Table 1. *Cont.*

Characteristics	Categor	n	Percentage
	Natural Sciences	18	23.08
	Physical Sciences	26	33.33
Subject of specialisation	Life Sciences	24	30.77
	Geography	7	8.97
	Mathematics	3	3.85

Many of the participants were female (54%) while 46% were male. In addition, 90% of the participants were Black and came from rural (38%) and township (42%) communities. A substantial number of preservice science teachers specialised in Natural Sciences (23%), Physical Sciences (33%) and Life Sciences (31%). Laptops were largely used by the participants for online learning as compared to cell phones and desktop computers. Access to laptops can be attributed to the fact that the university procured laptops for registered students who qualified for the funding provided by the National Student Financial Aid Scheme (NSFAS) by virtue of their socio-economic background.

4.2. Preservice Science Teachers' Beliefs, Perceptions, and Experiences of Online Learning during COVID-19 Pandemic

The key constructs investigated through the administration of the questionnaire were beliefs, perceptions, and experiences of online learning during the COVID-19 pandemic. The Cronbach's alpha values for the constructs investigated are depicted in Table 2, which were above 0.7 affirming that the instrument measured what it was intended to measure.

Table 2. Cronbach's alpha values for the constructs investigated.

Construct	Cronbach's Alpha
Beliefs about online learning during the COVID-19 pandemic	0.78
Perceptions of online learning during the COVID-19 pandemic	0.73
Experiences of online learning during the COVID-19 pandemic	0.75

Table 3 provides specific details about science students' beliefs about online learning during the COVID-19 pandemic.

Table 3. Science students' beliefs about online learning during the COVID-19 pandemic.

	Description of Item	Strongly Agree/ Agree (%)	Neutral (%)	Disagree/Strongly Disagree (%)
1	I believe I could use technology effectively for online learning.	86	14	0
2	I believe I had a conducive environment for online learning.	50	24	26
3	I believe I had support from my family during online learning.	50	22	28
4	I believe I coped with my online learning tasks.	50	24	26
5	I believe online learning was beneficial for completion of my academic year.	66	16	18

Most of the participants (86%) believed that they could use technology effectively for online learning and that online learning was beneficial for completion of their academic year (66%). However, the participants bemoaned lack of conducive learning environment, lack of family support and inability to cope with online learning tasks as fundamental challenges that stifled their meaningful participation in online learning. Most of the participants

came from rural and township dwellings where availability of conducive study spaces can be problematic. Science students' perceptions of online learning during the COVID-19 pandemic are captured in Table 4.

Table 4. Science students' perceptions of online learning during the COVID-19 pandemic.

	Description of Item	Strongly Agree/ Agree (%)	Neutral (%)	Disagree/Strongly Disagree (%)
1	I preferred online learning more than the face-to-face.	48	26	26
2	Online learning challenged me in terms of my digital competence.	50	18	32
3	Online learning challenged me in terms of acquisition of technological devices.	54	22	24
4	I felt I was prepared for online learning.	36	22	42
5	I felt I had a quiet environment conducive for online learning.	46	22	32

The participants expressed reservations about their readiness to fully embrace online learning. Some of the participants preferred online learning more than face-to-face learning (48%). The participants identified lack of digital competence, challenges encountered in the acquisition of technological devices and lack of conducive learning environment as contextual factors that negatively influenced their participation in online learning. Table 5 depicts science students' experiences of online learning during the COVID-19 pandemic.

Table 5. Science students' experiences of online learning during the COVID-19 pandemic.

	Description of Item	Strongly Agree/Agree (%)	Neutral (%)	Disagree/Strongly Disagree (%)
1	I had connectivity challenges during online learning.	60	26	14
2	I coped well with online learning.	44	34	22
3	I experienced improved academic performance during online learning.	54	30	16
4	I could easily access learning materials and assessment tasks from Blackboard.	76	20	4
5	I felt isolated during online learning.	30	24	46
6	I had a conducive learning environment at home during online learning.	42	26	32

A considerable number of the participants (60%) encountered internet connectivity challenges during online learning which had an adverse impact on their ability to cope with the demands of online learning. However, a significant number of participants (76%) indicated that they could easily access learning materials and assessment tasks from the Learning Management System (Blackboard). A further 54% of the participants indicated that they experienced improved academic performance during online learning. Fewer participants (30%) indicated that they felt isolated during online learning which implies that online learning provided interactive opportunities notwithstanding the fact that the learning environment at home was not necessarily conducive. The following section presents results from analysis of qualitative data from interviews.

4.3. Preservice Science Students' Resilience during Online Learning

Table 6 that follows shows how the interview data was analysed to show codes, categories and the emerging theme. From the table one main theme emerged from the analysis of finding: Preservice science teachers showed resilience during online learning.

Table 6. Analysis of interview.

Codes	Categories	Emerging Theme
i. Not always easy ii. Constant loadshedding iii. Data constraints iv. Poor study space v. Overcrowded home vi. Noise from neighbours' homes vii. Allocated chores at home viii. Experienced technical difficulties ix. Missed lectures x. Failed to attend live lectures xii. Failed to complete online quizzes	i. Formidable challenges ii. Students residing in disadvantaged communities iii. Students hailing from socioeconomically disadvantaged families	
i. Visited and used relatives' Wi-Fi ii. Studied in shopping malls iii. Worked during the night iv. Borrowed electronic devices v. Begged for support from some family members vi. Created a Whatsapp working group with friends	i. Making it work aainst all odds ii. Became very resourceful iii. Adamant to succeed	Preservice science teachers showed resilience during online learning.
i. Worked ahead of task submission deadline ii. Constantly consulted with tutors iii. Working long hours iv. Saved daytime data bundlles for synchronous lectures v. Asked for extension for assessment submission vi. Downloaded videos of online lectures	i. Developed time management skills ii. Determined to complete the year successfully. iii. Became aware of limitations in prevailing situations	

The science students indicated that they participated in online learning despite critical challenges encountered. These challenges included load shedding, inadequate digital competence, lack of conducive learning environment at home due to overcrowding, inappropriate digital devices, and intermittent internet connectivity. The identified challenges adversely affected students' participation in online learning which resulted in late submission of assessment tasks in some instances. Students were also affected by increased levels of anxiety and feelings of isolation during online learning. Some students indicated that they relied on data provided by the university although it was in some instances not sufficient to sustain them for the whole month. Some students pointed out that they had to make alternative arrangements to get digital devices fully functional during loadshedding.

By its very nature, the transition from face-to-face to online learning during the COVID-19 pandemic, was abrupt and did not make provision for students to acquire appropriate digital competence. In this regard, one student said, "I had to adjust quickly in order to access and navigate various online platforms and assessment tools." Other students bemoaned lack of competence in the use of the Learning Management System (Blackboard) as the following excerpt illustrates.

> Nthabi: I struggled to access learning material from Blackboard since I did not attend the orientation for Blackboard but as time went by, I however had to quickly familiarise myself with how the Blackboard operates as my colleagues were living in other provinces.

The students demonstrated resilience through successful completion of their studies despite formidable challenges encountered during online learning. The students relied heavily on lecture video recordings to consolidate their understanding of content covered during power outages. The following excerpts illustrate how students navigated challenges encountered during power outages.

> *Puleng: As soon as electricity came back, I quickly downloaded lecture videos to catch up with the content taught in any missed lecture and in most cases I waited to use midnight data.*

> *Tshepo: To ensure that assessments were submitted successfully, I attempted the submissions earlier so that I could have time to notify the lecturer if I faced some challenges.*

> *Bushang: I used to go to a nearest school and connect to the Wi-Fi so that I could attend my classes.*

Other students indicated that they were compelled to go to nearest shopping malls to access free Wi-Fi for stable internet connectivity. These students indicated that the movement exposed them to mugging and as such some lost their laptops or cellphones whilst travelling using public transport. Lack of opportunities for peer discussions remained a source of frustration for the students. Adapting to online learning was increasingly challenging for the students as it required discipline and sustained commitment to pedagogic tasks as the following excerpts demonstrate.

> *Thandi: It was difficult adapting to online learning, and sometimes I would forget that I had a class to attend, but eventually I taught myself to wake up early and prepare for the day. So, I was able to overcome my challenges after all.*

> *Themba: At the onset of online learning, I would wake up and focus on an assignment and forget to attend online lectures. With time I set reminders that really helped me.*

Reflecting on the resilience demonstrated during online learning, one student said, "All I can say is that online learning taught me to be a soldier as I worked independently of others, a practice I never engaged in during face-to-face mode of learning".

5. Discussions

The science students believed that they could use technology effectively for online learning. They further believed that online learning was beneficial for successful completion of the academic year. However, the participants bemoaned lack of conducive learning environments, lack of family support and inability to cope with online learning tasks as fundamental challenges that stifled their meaningful participation in online learning. This dilemma could be attributed to the fact that many of the participants came from rural and township dwellings where availability of conducive study spaces could potentially be problematic. Various studies revealed students' ambivalent beliefs about online learning. For instance, it has been shown that students believe that online learning enables them to improve their academic performance while the converse is also true [21,31,32]. In this regard, Xie and Huang [33] posit that epistemic and learning beliefs have been found to significantly affect students' learning participation and perceived learning by mediating their achievement goals. The observations discerned showed that students' beliefs about online learning are commensurate with a study conducted by Almomani et al. [34] which found that university students believed that COVID-19 pandemic pushed them to learn new skills.

At another pragmatic level, the science students expressed reservations about their readiness to fully embrace online learning. The students' minimal preference for online learning can be attributed to contextual factors such as lack of digital competence, challenges encountered in the acquisition of technological devices and lack of conducive learning environments. However, a study conducted by Hara and Kling [36] showed that there was no significant difference between online learning and face to face instruction in terms of students' satisfaction. In fact, Hara and Kling [36] argue that online learning can be as

effective as traditional learning if it is designed appropriately. On the contrary, Tratnik [37] observed significant differences in students' satisfaction levels between online and face-to-face learning. Muthuprasad et al. [35] maintain that a substantial number of students fully embraced online classes to manage the curriculum during the COVID-19 pandemic.

A considerable number of science teachers encountered internet connectivity challenges during online learning which had an adverse impact on their ability to cope with the demands of online learning. Students experience various difficulties related to the delivery of online learning [44]. Other challenges associated with the delivery of online learning encountered by students include difficulty to adapt to online learning due to various vulnerabilities and inadequate academic performance [46], feeling of isolation [47], and lack of learning motivation [48]. In addition, several major concerns on students' online learning experience during the COVID-19 pandemic have been identified. These concerns include issues with internet connectivity [49,50], problems with information technology equipment [51,52], limited collaborative learning opportunities [51,53], reduced learning motivation [50,52,53], and increased learning burdens [52].

A significant number of science students further indicated that they could easily access learning materials and assessment tasks from the Learning Management System (Blackboard). Muthuprasad et al. [35] contend that while students express fundamental appreciation of the flexibility and convenience of online learning, they bemoaned broadband connectivity issues in rural areas which render their participation in online learning initiatives increasingly difficult. Furthermore, the students indicated that they experienced improved academic performance during online learning. Some participants indicated that they felt isolated during online learning.

Despite challenges encountered during online learning such as lack of conducive learning environments, lack of family support and inability to cope with online learning tasks, the students successfully completed the academic year. The successful pursuit of this difficult and complex undertaking bears testimony to the resilience demonstrated by preservice science students during the COVID-19 pandemic. In essence, the students demonstrated remarkable resilience in the face of critical challenges and this sustained courage paved the way for subsequent academic success. This implies that a disadvantaged background should not be a determinant of one's destiny as evidenced by the students' tenacity to turn adversity into success. For university students in particular, failure to adapt may result in poor academic performance and withdrawal from university academic activities [23]. Highly resilient students have adaptive skills which enable them to learn from stressful situations [25].

Interpretation of Key Findings in Terms of the Adopted Theoretical Framework

As indicated earlier, the study was underpinned by the Technology Acceptance Model (TAM) proposed by Davis [55] as the underlying theoretical framework. TAM is anchored on two factors that determine whether a computer system will be accepted by its potential users: (1) perceived usefulness, and (2) perceived ease of use. Within the context of this study, effective use of technology was largely hampered by contextual challenges such as lack of digital competence, challenges encountered in the acquisition of technological devices, internet connectivity disruptions and lack of conducive learning environments at home. In terms of the interpretive paradigm, these challenges appeared to have a detrimental impact on science students' perceptions towards online learning and behavioural intention which could potentially affect coherent use of learning technologies as a key pedagogical outcome. Despite the challenges encountered during online learning, the science students indicated that they could easily access learning materials and assessment tasks from the Learning Management System (Blackboard). These findings demonstrated the students' resilience during online teaching and learning despite the pervasive challenges encountered. Furthermore, the participants expressed fundamental appreciation of the pedagogical affordances of various technologies utilised during online learning as they essentially served to maximise their academic experience to a considerable extent.

6. Limitations

The study involved only 50 participants from one university and the findings cannot be generalized. However, detailed descriptions of the context and nature of the participants and learning environment have been explicated to allow researchers in similar contexts to replicate the study.

7. Conclusions and Recommendations

Despite formidable challenges posed by the abrupt transition from face-to-face to online learning because of COVID-19 pandemic, science students managed to adapt to change and successfully completed their studies. In addition, the students demonstrated resilience when navigating critical challenges during online learning. There is a crucial need to address socio-economic disparities in higher education to ensure parity in resource distribution with a view to foster enhanced epistemic and epistemological access. Acceleration of digital transformation remains a key strategic imperative for higher education institutions within the broader South African context. Progressive realisation of this key strategic imperative hinges to a large degree on coherent formulation of a coordinated response geared towards the fulfilment of transformational requirements associated with the advent of the 4IR. The higher education sector faces the key imperative to put pro-active measures in place for purposes of navigating future pandemics. In essence, the higher education sector cannot afford to be reactive when formulating coordinated responses to future pandemics. For further studies, more participants from various universities can be involved to allow statistical analysis on the correlation of different constructs.

Appendix A. Questionnaire

This questionnaire is meant to collect information from you, regarding your beliefs, perceptions, and experiences of online learning during the COVID-19 pandemic. Your honesty response is highly appreciated since there is no right or wrong answer.

The questionnaire is made up of four Sections A–D. Please complete all of them.

Participant consent

The purpose of the study has been explained to me. I understand the research project and my role in it. I understand the confidentiality clause as stated by the researcher. I understand that I can retrieve my consent and participation in the research and there will be no penalty against me.

If you consent to the above terms and conditions of the research, please indicate **by placing an X next to Yes**.

I consent to participate fully in the study	No	
	Yes	

Section A: Biographical information

Please place a cross (X) in the appropriate response.

1.   State your gender.

Female	1
Male	2

2.   Which race group do you belong to?

Black	1
Coloured	2
Indian/Asian	3
White	4

3.   Indicate the area you stayed in

Informal settlement	1
Rural	2
Farm	3
Township	4
Suburban	5

4.   I mostly used the following gadget for online learning during COVID-19 pandemic (choose one)

Cellphone	1
Tablet/iPad	2
Laptop	3
Desktop	4

5.   My main source of connectivity was (choose one)

Data	1
Wi-Fi	2
Internet cafe	3

6.   Indicate your subject(s) of specialisation

Physical Sciences	1
Life Sciences	2
Other	3 (specify)

Section B: Beliefs about online learning during COVID-19 pandemic

		Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	I believe I could use technology effectively for online learning.	1	2	3	4	5
2	I believe I had a conducive environment for online learning.	1	2	3	4	5
3	I believe I had support from my family during online learning.	1	2	3	4	5
4	I believe I coped with my online learning tasks.	1	2	3	4	5
5	I believe online learning was beneficial for completion of my academic year.	1	2	3	4	5

Section C: Perceptions of online learning during COVID-19 pandemic

		Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	I preferred online learning more than the face- to- face.	1	2	3	4	5
2	Online learning challenged me in terms of my digital competence.	1	2	3	4	5
3	Online learning challenged me in terms of acquisition of technological devices.	1	2	3	4	5
4	I felt I was prepared for online learning.	X	2	3	4	5
5	I felt I had a quiet environment conducive for online learning.	X	2	3	4	5

Section D: Experiences of online learning during COVID-19 pandemic

		Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	I had connectivity challenges during online learning.	1	2	3	4	5
2	I coped well with online learning.	1	2	3	4	5
3	I experienced improved academic performance during online learning.	1	2	3	4	5
4	I could easily access learning materials and assessment tasks from Blackboard.	1	2	3	4	5
5	I felt isolated during online learning.	1	2	3	4	5
6	I had a conducive learning environment at home during online learning.	1	2	3	4	5

Appendix B. Interview Schedule

1. Do you think you were able to overcome your challenges during online learning? Explain your answer.
2. How did you manage to attend online lectures despite the challenges you faced?
3. How did you manage to submit assessment tasks despite the challenges you faced?

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