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Secondary School Students' Experiences in Online Physics Learning During the COVID-19 Pandemic: A Phenomenological Examination from Trinidad and Tobago

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ABSTRACT

The world lived through a pandemic over the 2020-2022 period, which forced drastic changes in every sector and every aspect of our lives. One such change in the education sector was the immediate shift to online learning as educational institutions across the world responded to the pandemic. Educational institutions in Trinidad and Tobago, like everywhere else, shifted from face-to-face to online instruction in all courses and programmes, including physics. While the conduct of physics lessons through virtual classrooms may have several advantages, it is not without disadvantages. The latter resulted in challenges, especially for students, and it is important for us to understand how students experienced and managed their learning in the fully online environment. The aim of this phenomenological study is to capture and describe the experiences of students in online physics learning in a virtual classroom – specifically their experiences in preparing for online physics learning, managing learning in the virtual physics classroom, and benefiting from opportunities in online physics learning. Three major themes emerged from this study – students' readiness for online learning, students' challenges during online learning and the role of follow through facilitation after online lessons. Despite their preparations, students encountered challenges such as network connectivity, reliability of supporting systems, and distractions in their learning environment at home. However, they were optimistic that the reality presented opportunities to improve their technological competencies and to maximize their online learning experiences as they engaged in the learning of physics concepts in a non-traditional way.

Keywords: COVID-19 pandemic, online physics learning, phenomenology

Introduction

The COVID-19 pandemic challenged educational systems across the world and forced most, if not all, educational institutions to shift from traditional pedagogical methods to online teaching and learning. This necessary shift in educational instructional delivery was critical to maintain continuity in teaching and learning that would otherwise have been severely compromised in the face of massive global shutdowns in every sector across the world. This sudden change meant that educators and students had to make immediate adjustments to adapt to this new normal in education. In making these adjustments, the existing inequity in education systems the world over, which had laid somewhat dormant for decades, became vulgarly apparent. In Trinidad and Tobago, this inequity in education is undeniably pronounced and the transition to online teaching and learning drastically amplified the reality in all disciplines inclusive of science.

Science education is one of the most critical subjects at the secondary school level due to its relevance to students' lives and the universally applicable problem-solving and critical thinking skills it uses and develops (Arrieta et al., 2020). These lifelong skills allow students, especially those intent on pursuing science at levels beyond secondary school, to generate ideas, weigh decisions intelligently, to understand concepts and theories behind natural phenomena, and to be able to share these understandings with others. Furthermore science education and specifically for the purposes of this study, physics education, is about teaching and learning that engages students in inquiry-based investigations in which they interact with teachers and peers to establish connections between current knowledge and scientific understanding, and to recognize how these apply to their everyday lives. Equally important in physics education is the cultivation of problem-solving, planning, and reasoning skills that students develop when they work in collaborative group settings to perform experiments, investigate phenomena, and evaluate evidence (Contant et al., 2018).

Prior to the onset of the pandemic, science classrooms, inclusive of physics classrooms and laboratories in Trinidad and Tobago, were dominated by peer-peer interactions and brainstorming so that all students, even those in disadvantageous circumstances, had good opportunity to develop those lifelong 21st century skills, and in the case of science education, those critical scientific skills. When education, inclusive of science education transitioned into a remote mode in March 2020, navigating the new reality to ensure a productive and meaningful learning experience for science students meant that teachers and educators had to rethink their practice to ensure that pre-pandemic learning outcomes remained attainable even in the pandemic reality (Brown, 2020). The apprehension to teach science entirely online was a phenomenon that teachers the world over had to confront (Brown, 2020; Gilles & Britton, 2020; Graham et al., 2020). Students too were intimidated by the new reality, even more so than teachers were, as online methods for most of them had been limited to emails, web-surfing, and gaming applications. Teaching and learning had not been previously thought of, in the fully online context, for most students and teachers (Arietta et al., 2020; Brown, 2020). Reasonable adaptations to delivery methods, assessments, and modes of interaction between students and teachers for all courses had to be made quickly and responsibly (Vasquez, 2020). Teachers in Trinidad and Tobago responded as they were best able to, but with the transition to online learning, it remained difficult to ascertain the extent to which all students were able to manage their learning in the context of what they were accustomed. There was speculation that students were challenged in the online environment and that those with inequitable resources were most disadvantaged. At that time, it was unclear how science students in Trinidad and Tobago were coping with remote learning, how they were experiencing online learning, and what challenges they were encountering in the online environment. These are the concerns which prompted the conceptualization of the current work, which reports on data collected over the period from March 2020 to December 2021.

Literature and Theoretical Framework – Online Learning

Online education and e-learning are not new in the field of education. The versatility offered by Information and Communication Technology (ICT) resources and capabilities, presents educators with attractive options to address many of the issues that, in the past, made instructional opportunities for students difficult and even impossible in some cases. ICT is defined as a diverse set of technological tools and resources used to transmit, store, create, share, or exchange information. These technological tools and resources include computers, the Internet (websites, blogs, and emails), live broadcasting technologies (radio, television, and webcasting), recorded broadcasting technologies (podcasting, audio and video players, and storage devices) and telephony (fixed or mobile, satellite, visio/videoconferencing, etc., (UIS, 2009; UNESCO, 2017). Prior to the influx of online education, which was further triggered by the pandemic, delivery of instruction was limited by factors such as geographical remoteness, limited offerings by institutions, and the complex lives of students (Dziuban

et al., 2018). Today, learning in an online environment offers the convenience of an "anytime and anywhere" education for both students and teachers. This provides students with increased opportunities for flexibility, collaboration, and interaction through the use of educational technologies that allow for the design, delivery, and management of learning at anytime and anywhere (Gedera et al., 2015; Obbink & Wheeler, 1993). While this new dispensation is different from face-to-face learning, and it may challenge the efforts of some teachers, the reality is that it has found acceptance with a notable cross section of the current generation of technophobes in our classrooms. Science classrooms have become virtual labs, simulation stations, and computer aided demonstration centers. The use of devices such as computers, cellphones, and tablets together with numerous online video conferencing platforms and applications enabled students to continue to learn, practice, and experience science even during the pandemic. Many students have embraced the novelty of technology supported science and have easily adapted to this new way of learning science, but this new mode of instructional delivery is not without its challenges for many other students.

Research on the nature of online science learning, including the benefits, challenges, and implications of this new approach was well underway even before the onset of the pandemic but gained much more traction soon after in early 2020 (Furtak & Penuel, 2019; Linn et al., 2016). At the onset of the pandemic, experts in science education were curious to find out what works, and what were the experiences of the stakeholders in this paradigm. Questions seeking students' views and perceptions on the successes and the challenges of online science learning have been targeted and available findings have revealed that while online learning has allowed for science education in the global context to continue through the pandemic, it has been problematic for both students and teachers in significant ways. In fact, in science education in particular, the transformation of hands-on practical activities and experimentation into virtual experiences through simulations and online demonstrations has significantly subtracted from the nature of the science experience that characterizes the scientific process (Dorn et al., 2020). The face-to-face investigative collaborations, which define the scientific approach, were lost when the online transition occurred. But, perhaps the most telling revelation arising from the consequences of online learning in all subject disciplines, including science, is that online learning has exposed more clearly than ever before the inequities in education systems across the world (Borup et al., 2020). While there is acknowledgement of the fact that inequities existed in education systems long before the pandemic and the transition to remote learning, the necessity for online learning brought on by the pandemic served to amplify these inequities (Rempel, 2020).

In a pre-pandemic study of online learning, Blackmon and Major (2012), reported that students were highly displeased with online learning for several reasons, but primary among them were loss of connectivity, instructor inaccessibility, autonomy in learning, and lesser peer interactions. Other pre-pandemic research on online learning have suggested that for learners who had access to devices and ICT resources, many were also fortunate to have access to reliable and stable connectivity and for them, the transition to online learning was quite easy (Salamat et al., 2018). Their access to resources also meant that the transition from traditional face-to-face learning to synchronous participation in online classes was smooth. The reality though, is that as much as 70% of learners globally did not have ready access to devices or Wi-Fi connectivity at the onset of the pandemic (Rempel, 2020).

Existing research suggests that online learning has worked well in some contexts and for some students and teachers, but several published works have highlighted places where, and circumstances under which, online learning has not worked very well. In non-science disciplines, Demirkol and Kazu (2014) found that the online mode of instruction led to improved academic performance and positive changes in attitudes and habits for students. Conversely, Zhu et al. (2013) reported that despite noted positive effects of e-learning on academic performance, students' perceptions towards online learning were unpredictable and students displayed undesirable learning habits in many instances. Blackmon and Major (2012) evaluated the pre-pandemic online learning experiences of students and reported

that students who took online distance learning experienced device and Internet connectivity challenges as well as feelings of isolation from their peers and their teachers, both of which led to high levels of frustration associated with the online learning experience. Similar findings were reported by Loades et al. (2020) and Miller (2021) when the online learning experiences of science students during the pandemic were analyzed. Furthermore, while many students in those works suggested that human interactions needed to establish peer support and the ability to facilitate profound discussions in the online environment were inadequate and distant, some indicated that online learning made them more responsible and accountable for their learning. The latter was found to be the case primarily for students with access and support as reported in works by Singh et al. (2020).

In the science disciplines, the findings were similar – several reports of positive views of online science learning from students with access and resources, but many reports which highlight students' displeasure with online science learning (Gedera et al., 2015; Kalloo et al., 2020). In later work, in the pandemic era, in which Chen et al. (2021) interviewed groups of science students in early 2020, the findings noted that the displeasure with online science learning expressed by science students were linked mainly to the disconnect they felt from the live scientific process. Students suggested that the virtual environment cannot replicate the scientific process no matter how user-friendly or sophisticated it may be. Also emerging from research in both the early-pandemic and mid-pandemic eras are the challenges experienced by science students after online learning had occurred (Kalloo et al., 2020; Lapitan et al., 2021).

The pandemic disrupted the familiar structure of science learning for many students. The sequence of science lessons was no longer familiar to students. The familiar whole class discussions, collaborative experimental work, and real time idea sharing were disrupted. Monitoring students' progress by way of these engagements became an inconsistent exercise for teachers (Brown, 2020). It was difficult for teachers to maintain consistent classroom oversight in the traditional way given the numerous and sometimes lengthy online disruptions that students experienced in teaching sessions. Sometimes, teachers too experienced connectivity challenges. Disruptions and inconsistencies, coupled with the intangibility of hands-on learning, made online science learning less engaging for students to the extent that many science students expressed sentiments of rejection in response to the unrealistic feel virtual labs and simulations gave to the traditional experimentation and investigation they had become accustomed to (Mercado, 2021). Many science students and teachers experienced high levels of frustration and dissatisfaction with the online delivery of science instruction (Barrot et al., 2021).

Context

Classes in all subjects, for the latter part of the 2019-2020, all of 2020–2021 as well as the initial semester of the 2021-2022 academic years, for secondary schools in Trinidad and Tobago, were conducted virtually. Physics teachers and students yielded to the hastened change in 2020 almost willingly, mainly because they recognized that physics learning had to continue but perhaps also with the expectation that the pandemic would have been short-lived. While the transition must have been challenging for teachers, it seems that students were the hardest hit stakeholders in the sudden shift to online physics learning. For students and teachers in the Trinidad and Tobago context, the transition to online learning was not a smooth or easy one. Many students had no access to digital learning devices and reliable online connectivity. Some teachers as well had connectivity challenges and many teachers were not trained in online delivery methods. The mandate to continue classroom learning in an online environment had parents scurrying to secure devices for their children, which, in a lock down mode was a slow, costly, and painstaking endeavor. Many students were therefore out of school for periods of up to eight weeks, while they took steps to secure devices, connectivity, and study space in the home environment. Despite the lack of confidence by many teachers to deliver

online classroom instruction, most proceeded bravely; learning along the way, and adapting as they learned. The shift meant that both teachers and students had to rely on the strengths of each other and to adapt to the limitations of each other while learning in an uncertain and evolving context.

This study sought to explore and gain insights from a group of secondary school physics students about their experiences in learning physics during the time of the pandemic. The experiences and perceptions of students drawn from this study will provide a reflective evaluation of online physics learning during the pandemic and will be instructive for general teaching and learning of physics using online platforms.

Purpose of the Study

The main purpose of this study was to explore, describe, and gain insights from the experiences of secondary school physics students in learning physics through online platforms. In seeking to achieve this purpose, the following research question guided the approach adopted in this work: What were students' perceptions of online physics learning as gleaned from their lived experiences over the period from March 2020 to December 2021?

Methodology

Research Design

To explore the experiences of the students in learning physics in what was called the new normal during the pandemic; this study utilized a Descriptive Phenomenological Research Design. Phenomenological design is a type of qualitative research that focuses on the commonality of a lived experience within a particular group. It emphasizes experiential, lived aspects of a construct, that is, how the phenomenon is experienced at the time that it occurs, rather than what is thought about the experience or the meaning of it subsequently (Creswell, 2013; Gibbs, 2018). In this work the intent was to unveil students' perceptions of their present lived experiences of online physics learning, in the context of an ongoing pandemic, and to interrogate these perceptions for patterns and themes to arrive at general understandings. With that intent in mind, the descriptive phenomenological research design was deemed suitable.

Sampling

The participants in this work were a group of fourth-year secondary school physics students who were undertaking a course of physics study which was to culminate in sitting for an external standardized examination in June 2022. It was a mixed group comprised of 21 males and 23 females ranging in age from 14 – 16 years. The school was located in a semi-urban area in south Trinidad and was classified as an average performing school based on the Ministry of Education's classification of schools (Ministry of Education Trinidad & Tobago, 2012). The group was conveniently selected in response to an explicit request from the group's physics teacher, who was very interested in finding out her students' perceptions of online physics learning (Etikan et al., 2016).

Data Collection and Instrumentation

Given the phenomenological research design adopted herein, a targeted interview protocol was deemed the most suitable data collection instrument that would allow for gathering of relevant and rich data to adequately and meaningfully answer the research question. The interview protocol was designed with three sections. Questions in section one of the protocol were explored in the period

March 2020 to July 2020. The intent with these items was to ascertain students' initial perceptions of online physics learning. Questions in section two targeted students' perceptions having been engaged in online physics learning for an extended period and were administered during the period September 2020 to December 2020. The final section of the interview protocol focused on students' perceptions having been engaged in online physics learning for more than one school year and was administered in the period January 2021 to June 2021. The initial interview protocol was designed by the researcher in consultation with the class teacher. The teacher's input was important to ensure that the items aligned with the context, circumstances, experiences, and realities of the students. The initial version went through two iterations over the period February 2020 in which both researcher and class teacher reviewed the instrument individually in the first instance, and then collaboratively, to ensure that the items were context relevant and unambiguous. Following this phase of review, experts in curriculum and assessment were asked to validate the interview protocol. After this validation process, the instrument was modified for further clarity and focus.

Once the validation was complete, the researcher wrote to the principal of the school seeking permission to conduct the study at the institution with the selected group of students and class teacher. Correspondence, by way of consent letters, was also sent to all participants, using their email addresses, inviting them to participate in the study. In the email, they were informed of the nature and purpose of the research, their right to participate voluntarily, their right to withdraw from the study at any time if they so desired and that their participation was in no way linked to their final grades. Participants were also informed that the findings of the study will be kept confidential and will be used only for the purposes of the current work. They were asked to sign and return the letters of consent within one week.

Once all the briefing and consent protocols were met, arrangements were made to begin conducting interviews with the 44 students in the group. Students were interviewed individually, at a date and time that was mutually convenient. The interviews were done online, and students were asked to turn on their cameras so that the researcher could observe facial expressions as they responded. This was to allow for probing in the event that the interviewee appeared confused, fatigued, or anxious when questions were asked. An average of three interviews per week were conducted (in light of issues such as scheduling and connectivity), so that data from questions in section one of the protocol were collected over the initial three-month period students were engaged in online physics learning. Interviews were audio recorded to facilitate subsequent transcription of the interview for data analysis. Sections two and three of the interview protocol were administered in the respective periods and with similar duration as described above. Interviews were similarly audio recorded and transcribed for analysis.

Data Analysis

Analysis Approach

The transcribed interview data were analyzed using Colaizzi's phenomenological method, as described by Wirihana et al. (2018), which is the preferred method used by researchers to reliably understand people's experiences. Colaizzi's method depends on rich first-person accounts of experiences and provides a rigorous analysis, with each step staying close to the data. The end result is a concise yet all-encompassing description of the phenomenon, validated by the participants. Colaizzi's seven-step method involves careful review by reading and rereading of transcripts, extracting and summarizing significant statements, formulating meanings from significant statements, categorizing statements with common or similar meanings into clusters of themes (validating with original text), describing the clusters of themes, returning to the participants for member checking/cross-checking, and finally incorporating changes based on participants feedback.

Analysis Procedure

Data collection for this work was completed in September 2021. Audio recordings were transcribed over the period September 2021 to November 2021. Once this was completed, the researcher engaged in the familiarization process by reading through the accounts of all 44 participants several times. This familiarization was done in three phases corresponding to transcripts from the three sections of the interview protocol. In each phase, the final reading was a deliberate exercise in which the researcher highlighted all statements in the accounts that were of direct relevance to the phenomenon being investigated – students' perceptions about online physics learning.

The researcher then proceeded to carefully study the highlighted statements to attach emerging meanings relevant to students' perceptions of online physics learning to these statements. While complete bracketing may not be possible according to Colaizzi (1978), the researcher made every effort to set aside her presuppositions and to stick closely to the phenomenon as revealed from the data. The identified meanings were subsequently clustered into themes that reflected commonality of meanings across all accounts and meanings in each theme. Again, bracketing was ensured to avoid any potential influence of existing theories the researcher may possess. Once the clusters of themes were determined, the researcher proceeded to write, in the first instance, a full and inclusive description of the phenomenon which incorporated all the themes that emerged, and then later to condense the exhaustive description down to short, dense statements that captured just those aspects deemed to be essential to the structure of the phenomenon. This fundamental structure of dense statements was returned to all participants to inquire from them if it captured the experiences they reported on during the interviews. Participants' feedback was used to modify interpretations if necessary.

Findings

Colaizzi's (1978) treatment of the data led to the emergence of three overarching themes into which students' perceptions of online physics learning could be placed. These were: *readiness for online learning, challenges during online learning and follow-through after online classes.* Each overarching theme contained subsets of perceptions, which in turn, were supported directly by the raw data. Each theme will now be discussed.

Phase 1 – March 2020 to July 2020

Readiness For Online Learning

In phase one of the research, students indicated that the sudden need to shift from face-to-face instruction to online instruction, imposed by the pandemic, met them highly unprepared for online physics learning. While online learning was not completely new to them, they admitted that the idea of all learning happening in a virtual environment was something they never thought seriously about simply because they never imagined it would be a reality they would have to experience. Their unpreparedness was partially a mental state, but mainly it was in terms of support systems, resources, and ICT competency. Lack of support in the form of not having internet access was perhaps the most common among the students. While some students had internet access at the start of the pandemic, 48% of the students in this group did not, and they attributed this to their low socio-economic livelihoods. For those who had access at that time, many indicated that connectivity was either weak or unreliable. Many students also spoke about power outages being quite common in the areas they lived – as much as three times per week lasting up to an hour in some instances. In addition, almost all the students in this work indicated that their homes were not well-fitted for online school, pointing

out that they did not have a fixed conducive work area for extended online learning. Responses from students, which captured their level of unpreparedness, included the following:

> "… I did not know what I had to do …"
> "… having classes on the computer was like … weird … miss was not nearby"
> "I had no wifi … but we had to get it for class …"
> "When electricity went in the past I did not bother … but for my class it was a big problem … and I had no desk at home …"

Access to resources to facilitate online physics learning such as devices inclusive of laptops, tablets, and smartphones, as well as items such as desks and chairs, were immediate requirements to facilitate online learning, which many students did not have. In fact, 66% of the students in this work indicated that they were 'out-of-school' for at least two weeks and up to eight weeks in some cases, after the pandemic started, while their parents tried to secure devices and desks for them to engage in online classes. The following verbatim responses further summarizes the challenges students had in terms of access:

> "My mom had to find the money to get me a desk and a chair"
> "…the old iPad was okay for games…but it was not good for my class...it was cutting-off…"

While some students had a functional level of ICT competency, which included basic skills such as navigating interactive online teaching platforms, these were in the minority. In fact, only about 25% of the students indicated that when online classes started in March – April 2020, they were able to follow instructions and use their devices to access the teaching sessions. Things like sharing videos, uploading artifacts, participating in online activities through simulation applications and sharing their screens to make presentations were skills required to participate meaningfully in online learning. However, 75% of the students in this work simply did not have those skills at the start of fully remote learning. The following excerpts summarize the situation for the majority (75%) of students in this work at the start of the pandemic:

> "I did not know which box to press to share my screen"
> "I did not have my friends around to ask for help … I was alone …"

Challenges During Online Learning

Interview data from phase one of the research revealed that in the initial months following the onset of the pandemic, students experienced much frustration in their online physics classes. Online demonstrations, virtual labs, and simulated inquiry activities replaced the hands-on, collaborative real-time approach they were familiar with. Considering their high levels of unpreparedness, particularly in the terms of support systems and ICT competencies in this phase of the study, meaningful participation in the physics activities in the virtual environment was extremely difficult for many students and impossible for some. Students missed peer interactions, with 52% of students citing group work in the physical setting as the interaction they missed most. They acknowledged the fact that online group work continued to be part of their online classes but were adamant that it *'will never be like in the real classrooms'*. Students agreed that simulations and virtual labs were *'less messy'* and *'visually appealing'* but were unhappy that they could no longer *'touch and hold'* physical manipulates, for example to connect circuits or perform experiments like investigating elastic limit applying Hooke's Law. As much as 80% of the students indicated that this was the most frustrating part of online physics learning for them. They noted however that their teacher would sometimes ask them to gather manipulates

from their homes to perform certain activities and experiments while the simulations were presented, but lamented that *'it could never be the same thing…'*

Feeling isolated during learning from teachers as well as peers was another aspect of online learning that students said they missed. In fact, 90% of the students in this work discussed this explicitly during the interview. Many indicated that they were not motivated to ask questions in their online classes in the same way they did in the pre-pandemic classroom. Even when prompted by the teacher, students said that they preferred to stay quiet. At least six of the students interviewed said that *'the screen/computer/device was a like a barrier from miss.'* Some students admitted that they were usually quite *'talkative in physics classes'* but would only rarely volunteer responses or ask questions during online physics learning. For reasons that were uncertain to the students themselves, the online environment was somewhat *'discomforting'*. Sharing ideas with and learning from their peers were experiences they had to engage with in a different way in online classes. While they praised their teacher for efforts made to facilitate online class discussions and to include teacher feedback and peer input in these discussions, 32% of the students said that they still did not feel as if they were *'part of the class.'* Many students also said that even though the interactions were happening as the class progressed, it still did not feel like they were engaged in *'real-time participation'* in their online physics classes. Many students shared sentiments similar to those captured below:

> "I could not ask my friend for help with my work … I missed that"
> "…doing the lab by myself … on my home table was not interesting … like in school"
> "… knowing where to send my work was hard … miss said there was a folder … I could not find it and I did not want to ask again"
> "I got into the thing that showed how light bended, but I could not move to the next thing to see how it reflected"

Follow-through After Online Learning

Students indicated in their phase one interview responses that after online physics lessons ended, their teacher was very careful to insist that they complete and submit assigned tasks in a timely manner. She had email addresses for all students and would send reminders about due dates and would inquire if assistance was needed to complete the assigned tasks. She was also very prompt with guidance and clarification when students asked and was prompt with marking assignments and providing feedback. Students admitted though that for them personally, managing their time to complete the tasks was a bit new to them because even though they were required to manage time in pre-pandemic times, the '*more loose'* pandemic circumstances, made it easy for them to procrastinate. They appreciated their teacher's persistence with them outside of official online teaching time and credited her attention as a major factor in reducing their procrastination. In fact, 43% of students indicated that had it not been for the extra attention shown by their teacher, they would have *'easily procrastinated'* their '*homework and lab reports'*. Students also indicated that in pre-pandemic times, collaboration with peers to complete assignments and homework during recess and lunchtime, as well as after school, was very helpful to them both in terms of building further understanding while completing tasks and in providing encouragement and motivation to them personally. The latter they lament, was '*the most missed experience'* after an online class ended. Overall, 82% of the students said that there was meaningful follow-through and monitoring of their progress after online lessons, as indicated below:

> "I did not feel I had to do my homework … like when miss gave us it in class … and asking for it the next day …"
> "miss sent us reminders on our phones to do the revision so I went and did it"

Phase 2 - September 2020 to December 2020

Readiness For Online Learning

Interview data from phase two revealed that students were still experiencing levels of unpreparedness for online learning. However, many of them indicated that they either were much more aware of issues that may arise and had taken steps to address them or knew how to resolve or to prepare proactively to deal with them when they arose. For example, many students who did not have Internet access initially had access by phase two of the research, and those who had access took steps to improve connectivity strength. Some students indicated that their parents made arrangements with relatives and friends to accommodate them in the event of power outages at home. One parent even installed a home generator to ensure that his daughter would have power for her classes in the event of a power outage. Several students said that while it was a financial strain on their parents, many parents tried to outfit an area in their home for them to do their online classes. By the time phase two of the research was done, 70% of the students indicated that they had the required resources to effectively participate in online learning. Students also reported that their teacher made extra efforts to help them develop the required ICT competencies so they could engage in the online sessions. Notwithstanding, it seemed to take longer for some students to grasp the required skills; by phase two, 48% of the students indicated that they were *'comfortable'* learning in the online environment through interactions with the various online resources. Responses, which support this transition, include:

"I can use the computer better now … but some things still hard …"
"I now understand how to share my work with my friends on the computer"
" when the current go … I know how to get back my work now"

Challenges During Online Learning

While students admitted that their levels of frustration were somewhat reduced in phase two of the research, which they hinted may be attributed to increased familiarity with the applications, activities, and demonstration used in online physics learning, their responses seem to suggest that they surrendered to online learning out of an overall sense of complacency rather than acceptance of reality. Many students responded with sentiments such as *'I'm learning to do the simulations because that's the only way to do them now'*, or *'I still don't like it but if I don't do it I will not learn the physics.'* So, while the data showed that the number of students responding with explicit expressions of frustration reduced from 80% to just over 50% in phase two of the research, that did not necessarily mean that more students embraced online physics learning. Furthermore, even after exposure to online physics learning for well into eight months, responses from students in phase two of the research showed that most students continue to insist that the online learning experience remained an isolated and lonely one for them personally. By the end of phase two, 84% of students continue to describe their engagement in online physics learning with words and phrases such as*, 'alone', 'away from my friends', 'distant', 'by myself'* and *'why only me.'* Comments, which suggest that students were becoming more comfortable, learning in the online environment even though they continued to feel isolated, include:

"I am not so confused as when we first started to use the computer for class"
"I still prefer to be in class … but I am okay with online now …"
"I feel lonely while learning … I miss my friends …"

Follow-through After Online Learning

In phase two of the research, students' responses were very similar to those provided in phase one, in terms of follow-through. Aided by the teacher's guidance, students felt they received adequate support to complete lab reports, homework, and out-of-class assignments. In fact, the data showed very little difference in students' perceptions of supportive follow-through to keep them on track with their work. Students continue to acknowledge the important role their teacher's supportive oversight had on compelling them to manage their out of class time to submit assignments on time. Very interesting were responses which indicated that even though they had teacher guidance during class, they missed the out-of-class collaboration when working on 'out-of-class' tasks and assignments. The data showed that in phase two, 64% of students indicated that they missed this type of collaboration, as compared to 40% in phase one who explicitly indicated that they missed 'out-of-class' collaboration. Students' comments, which captured their views and feelings in respect of follow-through in phase two include:

"it is good that miss keeps messaging to remind me to do my work when I am home"
"I wish I could do my homework with my friends … to talk about the homework"

Phase 3 – January 2021 to June 2021

Readiness For Online Learning

In phase three of the research, students reported low levels of unpreparedness citing their over eight months experience with online learning. In fact, all students indicated that they felt prepared for online learning except for bouts of anxiety associated with the occasional internet drop or disconnection from the classes, which sometimes happened and which they simply had no control over. There was however, less panic and feasible contingency plans when these occurred, so they did not take away much from the online experience. Students admitted though that they continue to feel a sense of *'unease'* knowing that such disruptions can happen at any time and that they are entirely out of their control. By phase three of this work, 76% of students said they felt 'well-prepared' for online learning in spite of unforeseen interruption. The following two excerpts capture the sentiments expressed by most students.

'I am really good with the online things now"
"It is easy for me now … I am not stressed … even when current goes…"

Challenges During Online Learning

While levels of frustration appeared to have dropped in phase three, feelings of isolation did not. Interview data in phase three of the research revealed that 93% of the students used the words *'lonely'* or *'isolated'* in their responses to challenges experienced during online learning. Probing students' responses seem to suggest that they came to the shocking realization that their anticipation that online physics learning would be short-lived was in fact unrealistic and the likelihood that learning will continue like this for an indefinite period, was a reality they must accept. The thought of no physical interaction with peers and their teacher seemed to have further amplified their feelings of isolation; so much so that students, who did not explicitly share their feelings of loneliness in the earlier phases of the research, did so in phase three. The following captures students' sense of isolation:

"…online is okay now but it is going on for too long…I really…really miss my classmates…"

"I feel better when I talk about the work with my friends…I am fed-up of doing it by myself"

Follow-through After Online Learning

In phase three of the research however, responses about follow-through after online lessons suggested that things had changed. Students indicated that there was reduced follow-through from the teacher, even though the demand to complete and submit assignments, lab reports, and homework remained. Students reported that their teacher was not as meticulous in following through with reminders or with providing guidance and feedback in a timely manner. Furthermore, assignments including homework tasks were not always marked and returned promptly. While students did not openly voice their views on why they felt this change occurred, their responses seem to implicitly suggest that the change may be associated with teacher burn-out. This change in teacher follow-through directly affected students to the extent that 68% of students said that they were procrastinating more than they had done in phases one and two. Increased procrastination, coupled with their existing discontent about out-of-class collaborations, resulted in a situation where at the end of phase three students were vocally disappointed with the effort made by their teacher to facilitate meaningful follow-through learning. The reasons for this view held by the students were not explicitly solicited, nor were they ascertained herein. While it would be interesting to know these reasons, the aspect was deemed to be outside the scope of the current work. The following sentiment, expressed by one student, captures the view of many students in the class and is telling in this regard:

> "…it is like miss [is] too fed-up with online … and maybe with us … she is not sending us reminders on the phone like she did before …"

Table 1 summarizes the excerpts from students' responses for the themes in phase one of the study. Table 2 summarizes the excerpts from students' responses for themes in phases two and three.

Table 1

Excerpts From Students' Responses During Phase One

Study Phase	Emerging Theme	Students (verbatim) comments
1	Readiness for online learning	• *"… I did not know what I had to do …"* • *"… having classes on the computer was like … weird … miss was not nearby"* • *"I had no wifi … but we had to get it for class …"* • *"When electricity went in the past I did not bother … but for my class it was a big problem … and I had no desk at home …"* • *"My mom had to find the money to get me a desk and a chair"* • *"I did not know which box to press to share my screen"* • *"I did not have my friends around to ask for help … I was alone …"*
	Challenges during online learning	• *"I could not ask my friend for help with my work … I missed that"* • *"…doing the lab by myself … on my home table was not interesting … like in school"* • *"… knowing where to send my work was hard … miss said there was a folder … I could not find it and I did not want to ask again"* • *"I got into the thing that showed how light bended but I could not move to the next thing to see how it reflected"*
	Follow-through after online learning	• *"I did not feel I had to do my homework … like when miss gave us it in class … and asking for it the next day …"* • *"miss sent us reminders on our phones to do the revision so I … did it"*

Table 2

Excerpts From Students' Responses During Phases Two and Three

Study Phase	Emerging Theme	Students (verbatim) comments
2	Readiness for online learning	• *"I can use the computer better now … but some things still hard …"* • *"I now understand how to share my work with my friends on the computer"* • *" when the current go … I know how to get back my work now"*
	Challenges during online learning	• *"I am not so confused as when we first started to use the computer for class"* • *"I still prefer to be in class … but I am okay with online now …"* • *"I feel lonely while learning … I miss my friends …"*
	Follow-through after online learning	• *"it is good that miss keeps messaging to remind me to do my work when I am home"* • *"I wish I could do my homework with my friends … to talk about the homework"*
3	Readiness for online learning	• *"I am really good with the online things now"* • *"It is easy for me now … I am not stressed … even when current goes…"*
	Challenges during online learning	• *"…online is okay now but it is going on for too long … I really miss my classmates …"* • *"I feel better when I talk about the work with my friends … I am fed-up of doing it by myself"*
	Follow-through after online learning	• *"…it is like miss [is] too fed-up with online … and maybe with us … she is not sending us reminders on the phone like she did before …"*

Conclusions

This work revealed that at the onset of the pandemic, physics students in this group were unprepared for online learning in several ways and mostly because of the unfamiliar learning pathway that lay ahead for them. Many did not have a functional online work area, and most did not have access to reliable internet and Wi-Fi connectivity even though they may have had access to devices. These elements of unpreparedness, however, were addressed as online physics learning continued through the pandemic. By the end of phase three of this work, students were well equipped to engage in online learning, except for the looming sense of unease many claim to continue to experience in respect of disconnectivity or electrical power failure.

Regarding the challenges during online learning, students experienced high levels of frustration at the onset of the pandemic. These frustration-driven challenges were mainly a result of not being able to engage in the scientific process in the traditional way through engagement in real-time, live laboratory experiments and hands-on learning activities in the familiar collaborative setting. Linked to the absence of face-to-face peer collaboration, students indicated that peer sharing, input, and feedback were not the same as in pre-pandemic learning. The pandemic arrangement had transformed their personal learning into a very isolated and lonely exercise. Elevated levels of isolation and loneliness only served to intensify their levels of frustration as online physics learning continued through the pandemic. By phase three of the study, students had become complacent and surrendered themselves to online learning, though frustration levels and feelings of isolation remained high.

Teacher support and attention to follow-through after online lessons were helpful to students in terms of keeping them engaged, motivated, and on track with the completion of homework, lab reports, and other assignments. They were very appreciative of this effort from their teacher and reported that it made online learning 'workable' for them. Unfortunately, this level of support was not sustained through this work. By phase three, students indicated that they were not receiving the same kind of support from their teacher as in phases one and two. While the reason for this remains largely uncertain, there was implicit speculation arising from students' responses, that it may be linked to

'teacher burn-out.' Notwithstanding, students were unanimous in their views that this occurrence had a negative impact on their online physics learning which led to higher levels of procrastination and increased feelings of frustration. The latter unfortunately being a reality in phase three in spite of the fact that students were better prepared and had fewer challenges than in phases one and two.

Recommendations

The concept of teacher burnout has been a concerning one even before the pandemic. This study seems to suggest that it continues to be a troubling educational issue during the pandemic and in fact may have become a more critical issue in the online teaching and learning environment. In that regard, future work on the prevalence and nature of teacher burn-out in the online teaching environment and how it impacts online learning for students is worthy of pursuit. In addition, this work looked at online learning in a physics class and while some aspects of the findings here may be applicable to online learning in other science subjects, it may not be generalizable for online learning in other subject areas. It will therefore be useful to interrogate students' online learning experiences in other disciplines and compare those findings with that of the online physics learning experiences revealed in this work.

Implications

This study is instructive for online learning in general but particularly for online learning in science disciplines. It highlights students' concerns, their challenges, preparedness, and their expectations in the online learning environment. Science teachers now have a view of students' experiences and feelings and may be better able to understand students' behavior and levels of participation during online lessons. While teachers, for the most part, may have been facilitating learning in the online environment in the best way they know, they now have at their disposal students' perspectives, in the form of formative feedback, which can be used to further inform their online practice.

Technology in teaching is here to stay and while the pandemic has ushered in online teaching and learning in a hastened manner, it is something that teachers and students would have eventually had to contend with. While this work pointed out some of the pitfalls with online learning, it showed that it is an approach that can be adopted post-pandemic. Furthermore, this work revealed some of the common considerations that should be taken into account when planning for online instruction so as to alleviate the challenges and shortcomings highlighted herein. No one knows if or when we will experience another pandemic or other pandemic-like situations. Even now, circumstances remain uncertain. The pandemic has shown us the importance of preparing our students for a world in which remote learning, partially or entirely, is a likely option. One way students in the Trinidad and Tobago context can prepare is to reflect on the experiences, views, and feelings revealed by students in this work who took an online physics course for over one year. The experiences of these students can shed light on the concerns, challenges, and learning opportunities of remote learning. The insights gleaned from this work might help students to better prepare to navigate the challenges of online learning and may be helpful to them succeeding in learning science in an online platform.

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