OPEN PRAXIS

The e-Leadership Challenge in Online Chemistry Learning in the Caribbean

RESEARCH ARTICLE

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ABSTRACT

This study unearthed the prevailing attitudes and perceptions of Caribbean Higher Education Leaders towards online chemistry learning prior to the COVID-19 pandemic and puts forward a case for more formal training in e-leadership for Caribbean Higher Education Chemistry leaders. This is based on the findings of a mixed method study which showed *inter alia* that there are some differences in the attitudes and perceptions between Caribbean Higher Education Administrators and faculty with regard to online and face to face chemistry lectures. The study was conducted among four Caribbean Departments of Chemistry and utilized a modified Science Teachers and Online Instructional Concerns (STOIC) survey. The findings point to the need for a more calculated approach to the professional development of Caribbean Higher Education Leaders as well as the surmounting of several barriers which hinder the implementation of alternative modes of delivery for the teaching and learning of chemistry in the Caribbean.

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INTRODUCTION

Prior to the advent of COVID-19 pandemic, the use of fully online chemistry courses and virtual laboratory activities within Chemistry programs offered by the Departments of Chemistry at several Caribbean universities were unheard of to say the least. Many other institutions in the developed world had already incorporated these aspects of online chemistry learning as the norm (edX, 2021; Oregon State University, 2021; Massachusetts Institute of Technology, 2021) despite that unfortunate Caribbean reality. Further, studies had also proven the effectiveness of these pedagogical practices in chemistry in the online mode (Faulconer et al., 2018; Winkelmann et al., 2017). The problem being presented was that Caribbean chemistry students may not have been benefitting nor even exposed to the best current pedagogical practices in the teaching and learning of chemistry and the reason for this needed to be explored. It was posited that the attitudes and perceptions of the educational leaders-faculty and administrators- could be a major factor that contributed towards this state and this could have been manifested possibly due to their lack of e-leadership skills (Arnold & Sangra, 2018; Avolio et al., 2014; Oh & Chua, 2018).

There is a scarcity of studies in the international literature with regard to the online learning experience of Caribbean populations and even so, the attitudes and perceptions of faculty and administrators towards online education. It was only within recent times there have been an emergence of Caribbean-based studies (Thurab-Nkhosi, 2010; Warrican et al., 2014; Williams, 2013). Thurab-Nkhosi (2010) examined students' perceptions of quality of an online course derived from data obtained from the course evaluations. Williams (2013) conducted a major study at a community college in Jamaica which focused on the attitudes, barriers and perceptions of Caribbean Higher Education Leaders towards the implementation of online learning. The most recent study done by Warrican et al. (2014) examined the predictors of student success on the online environment. Warrican et al (2014) found that this could have been attributed to student location and engagement with the course material. Since then, there has been limited studies if any, that have explored the attitudes and perceptions of Caribbean Higher Education Leaders towards online learning.

None of the previous work mentioned examined any comparison of the attitudes of faculty and administrators towards online science learning and even specifically in the discipline of chemistry, hence this study seeks to fill that gap. This study sought to determine the attitudes and perceptions of Caribbean Higher Education leaders towards the introduction of fully online chemistry courses and virtual laboratory activities within their chemistry programs and the perceived barriers to their implementation, using a mixed method research design.

The determination of potential course offerings and programs of Caribbean educational institutions come under the purview of Caribbean Higher Educational Leaders – the faculty and administrators. These courses and programs help to develop the region's career professionals since they are responsible for decisions that affect even students' online experience (Roby et al., 2013). As such, knowing the attitudes and perceptions of Caribbean Higher Educational leaders towards fully online chemistry courses and virtual laboratory exercises would have impact for the introduction and use of this technological resource in classrooms, the learning experience of students, as well as overall impact on the image of the institutions' adaptability to 21st century pedagogical practices. Thus, this study presents critical data that documents the attitudes, knowledge and experiences of Caribbean Educational Chemistry Leaders towards the use of the online learning for the teaching and learning of chemistry. Further, these opinions help shape decisions as it has been shown that the lived online experiences of administrators have shaped their leadership roles (Nixon, 2016). This data will be used to support the need for greater understanding, adoption and training in the area of the emerging concept of e-leadership in Caribbean Higher Education institutions and among its leaders. Therefore, professional development of these leaders should incorporate important and pertinent aspects of e-leadership training skills.

This research study also presents the perceived barriers that would need to be overcome in the Caribbean context with regard to the migration of face-to-face chemistry lectures and labs into the online mode of learning. This would be useful in assisting administrators and faculty across the Caribbean region in potential implementation strategies. It will also add to the practical application of the study. There has been very limited literature that explores the use of online learning in the Caribbean context (Warrican et al., 2014) and none at all in the area of online chemistry.

CONCEPTUAL FRAMEWORK

E-LEADERSHIP THEORY AND DEFINITION

The underpinning conceptual framework upon which this study was built was e-leadership theory. This term was first coined by Avoiio, Khanhai and Dodge (2001 cited in Avoiio et al., 2014) within the context of the business environment. The initial broad definition outlined e-leadership as "a social influence process embedded in both proximal and distal contexts mediated by AIT [Advanced Information Technology] that can produce a change in attitudes, feelings, thinking, behaviour, and performance" (Avolio et al., 2014, p. 107). Even before the COVID-19 pandemic there was some measure of the of use of technology in all sectors of Caribbean life including education, recreation and business. This concept can well be applied to the teaching and learning process since it can be facilitated by the use of technology and this has been prevalent in higher education institutions (Phelps, 2014). The further relevance to the online environment was emphasized by Van Wart et al. (2017) who posited that the definition be expanded to include the ability to determine the effective selection and use of ICTs for personal as well as organizational use. This focus on ICT adoption within higher education institutions has been prolific over the years and even so within this pandemic period. Another definition has also been put forward by Preston et al. (2015) saw e-leadership being defined as the "effective promotion and integration of technological learning and literacy into and within [educational] environments" (p. 991). Additionally, with rapid increase and expanding use of technology there will be the need to nurture and develop "leaders who have the qualities to lead in a digital culture" (Brown et al., 2016, p. 8). This is emphasized even more as the world was locked into remote emergency and online learning due to the pandemic conditions. Despite having reviewed over fifty articles within a short five-year span, 2013–2017, Arnold & Sangra (2018) lamented that it still remains somewhat of a vague definition and the concept still needs refinement. This also re-emphasizes the relative newness of the concept which Arnold & Sangra (2018) described as an overlapping of disciplines such as leadership, – management and business studies – education and education research field, which utilizes TEL (Technology Enhanced Learning). While the refinement of the definition is expected, it is clear that with the use of remote and online learning during the pandemic (Ali, 2020) that e-leadership skills will have to become a part of the 21st century educational leadership skills of higher education leaders (Sathithada & Niramitchainont, 2019). Additionally, in operationalizing the definition Liu et al. (2018) indicated that strong e-leaders need to have energy, need for achievement, willingness to assume responsibility, flexibility, analytic skills, continual learning, and technical skills.

In order to fully appreciate the diverse factors that influence e-leadership as a whole, the Oh and Chua (2018) model of e-leadership is shown in Figure 1. It can be seen that there are several key factors that influence e-leadership skills in order to produce e-leadership outcomes including the E-leader's skills and guidelines. These skills feed into a number of different areas including ICT skills which are shaped by attitudes, beliefs and knowledge of ICT. Therefore, within this

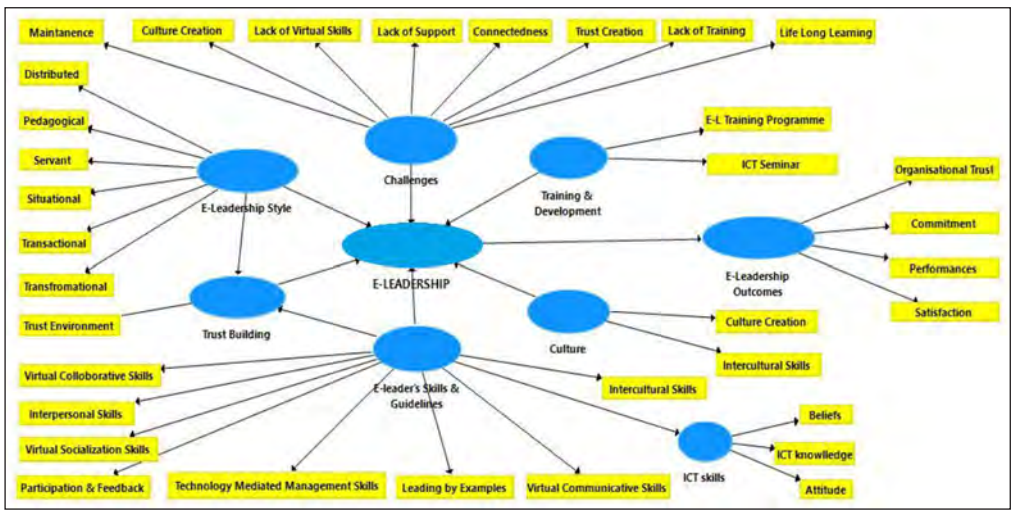

Figure 1 Proposed Model of e-leadership (from Oh & Chua, 2018).

study it is being posited that attitudes and perceptions of faculty and administrations towards online chemistry learning (use of online courses and virtual labs) shape the E-leader's skills and their abilities to effectively influence decision-making decisions with respect to the introduction and use of these strategies in chemistry programs. The study provided data that highlights the extent of congruence or non-congruence of faculty and administrators with online chemistry learning and their willingness to embrace it.

PREVIOUS RESEARCH

The only Caribbean study that has been reported in the literature that examined the attitudes and perceptions of Caribbean Higher Education leaders towards online learning or distance education was done by Williams (2013) at a community college in Jamaica. The study employed mainly a quantitative design however, Williams (2013) recognizing the weakness of a single method approach recommended that a qualitative study should have been a future possible study with greater insights from the interviews with faculty and administrators. This bears out the value of a mixed methods approach with regard to these types of studies. Williams (2013) found that here was an overall positive attitude and perception among faculty and administrators towards the implementation of distance education and there was no statistical difference among educational leaders to its implementation. She further recommended that the following influential factors should be considered in the implementation and adoption of online learning in the Caribbean. These included funding, incentives for faculty and technical support for administrators, students and faculty (Williams, 2013).

Specifically, in the area of online science learning there have been few studies that have dealt with the comparison of attitudes and perceptions of faculty and administrators towards online science learning. In fact, there have been two major studies that explored faculty attitudes towards science learning (Kopachena, 2018; Ward, 2008). A quantitative research design study was conducted by Ward (2008) using the Science Teachers Online Instruction Concerns (STOIC) survey instrument to determine the attitudes of college and university science instructors towards the online delivery of science courses to science majors and non-science majors This survey instrument was designed, piloted, validated (Cronbach's alpha coefficient = .80; Ward, 2008) and conducted among faculty in the state of Tennessee who fell under the Tennessee Board of Regents at the time. Ward (2008) analysed the data using Chi Square test of independence since the intention was to establish whether there were relationships or associations among categorical variables (Cohen et al., 2011). She found that the university and science college instructors despite their discipline, shared similar attitudes and there were no significant differences among them with respect to the delivery of an online general introductory science course (X^2 (3, N = 103) = 1.147, p = 0.766) and the use of online delivery for science courses designed for non-science majors (X^2 (3, N = 103) = .211, p = 0.976) (Ward, 2008). However, it was seen that faculty opposed to the use of the online environment for the conduct of general introductory science courses for science majors instead preferring its use with non-science majors only. Additionally, faculty felt that any laboratory component of these courses should be undertaken in a face-to-face on-campus environment (Ward, 2008).

The other significant study that dealt with online science learning explored the attitudes of faculty towards online science education within the Biology discipline. This research study investigated the "relationship between attitudes towards online teaching and various demographic characteristics among biology faculty members at colleges and universities" (Kopachena, 2018, p. 8) in northeast Texas. This study used the same research design as Ward's study however, an adaptation of the STOIC survey (Ward, 2008) was used in order to cater for biology faculty, specifically. Some key findings of that study revealed that the laboratory component of online biology courses was a major point of contention, with the majority faculty surveyed (over 90%) expressed their reservations about it and considered it an impediment to teaching biology online (Kopachena, 2018). Additionally, it was also seen that a positive outlook to teaching biology online was given by mainly female biology educators who hold MS or EdD degrees (Kopachena, 2018).

RESEARCH METHODS

RESEARCH QUESTIONS

The following research questions and hypotheses guided the quantitative section of the study:

RQ1: Is there a difference in the attitudes of faculty and administrators towards the introduction of a fully online chemistry course?

H_{01}: There is no statistically significant difference in the attitudes of faculty and administrators towards the implementation of a fully online chemistry course.

H_{1a}: There is a statistically significant difference in the attitudes of faculty and administrators towards the implementation of a fully online chemistry course.

RQ2: Is there a difference in the attitudes of faculty and administrators towards the introduction of a virtual chemistry laboratory exercise in a fully online chemistry course?

H_{02}: There is no statistically significant difference in the attitudes of faculty and administrators towards the implementation of virtual chemistry laboratory exercises in a fully online chemistry course.

H_{2a}: There is a statistically significant difference in the attitudes of faculty and administrators towards the implementation of virtual chemistry laboratory exercises in a fully online chemistry course.

The qualitative research questions that guided the study were:

RQ3: What are the prevalent faculty's and administrators' attitudes and perceptions towards the introduction of a fully online chemistry course?

RQ4: What are the prevalent faculty's and administrators' attitudes and perceptions towards the introduction of virtual chemistry laboratory exercises in a fully online chemistry course?

RQ5: What are the barriers that affect the introduction of a fully online? chemistry course as perceived by faculty and administrators?

RQ6: What are the barriers that affect the introduction of virtual laboratory exercises as perceived by faculty and administrators?

A mixed methodology approach using a modified sequential design (Creswell, 2014; Cohen et al., 2011) was selected to conduct this study. Ethical approval was obtained from the UWI Open Campus Research Ethics Committee as well as from each of the individual institutions involved in the study. The total target population comprised fifty-four faculty members and twenty-two administrators from the departments of chemistry of four different Caribbean universities within the English-speaking Caribbean. Faculty who participated in the study belonged to institutions that offered full time, face-to-face undergraduate and/or graduate degrees in chemistry and this was the main institutional criteria. The administrators were leaders of these departments and included university officials who were responsible for decision-making regarding curriculum, technology infusion and teaching and learning. Twenty-five faculty and 5 administrators agreed to participate in this research. Every effort was made not to identify specific departments or their locations to ensure confidentiality.

The Caribbean Higher Education Leaders were contacted via their public institutional email addresses that were found on each department of chemistry's website and institutional directories. Participants were informed via email of the background of the study, its benefits, voluntary participation, confidentiality and proposed completion date (Creswell, 2014). A link to Science Teachers and Online Instructional Concerns (STOIC) survey was also shared with faculty and administrators. Interests in follow-up interviews were to be expressed to researcher via email. Reminder emails were then sent one week later for two more weeks (Creswell, 2014). The responses were monitored periodically, with the last recorded chemistry faculty response received on June 28, 2019 whilst the last recorded response from an administrator was June 22, 2019.

Survey Instrument. Permission was granted for the use of a modified version of the STOIC survey instrument (Appendix A & B) was which was designed by Ward (2008). The original STOIC survey had a Cronbach alpha coefficient that was assessed to be .80 (Ward, 2008). The survey instrument was divided into two sections- the demographics section and the opinions section which utilized the Likert-type scale format where *a = strongly agree*, *b = agree*, *c = neutral*, *d = disagree*, and *e = strongly disagree*. These were then coded as 1 = *strongly agree*, 2 = *agree*, 3 = *neutral*, 4 = *disagree*, and 5 = *strongly disagree* for analysis purposes.

Interviews. In order to probe deeper into the attitudes and perceptions of faculty and administrators towards the introduction of fully online chemistry courses and virtual chemistry laboratory exercises, semi-structured, open-ended interviews were used. The lists of the questions for administrators and faculty have been included in Appendix C and D respectively.

Pilot study. A pilot study similar to that done by Ward (2008) was completed and involved piloting the STOIC survey instrument and interview questions via pilot interviews. These modified surveys were more culturally suited to the Caribbean participants and the Cronbach alpha for the STOIC Survey for Faculty and Administrators were estimated to be 0.962 and 0.968 respectively.

DATA SOURCES

Excel data sheets were used to organize the data that was obtained from each of the surveys. Anonymity was preserved for administrators and chemistry faculty completing the survey on Google Forms and by extension institutions. Quantitative methods were used to analyse the data using the Statistical Package for the Social Sciences (IBM SPSS Statistics v20). T-tests of independence were used in order to determine if there were any significant statistical difference between the attitudes of faculty and administrators with regard to the aspects of online chemistry learning. The survey questions that were based on opinions regarding online teaching and experience with virtual laboratories were organized into tables to show relative frequency data and sample percentages.

The qualitative data from the interviews as well as that obtained from item 34 on the STOIC survey for both faculty and administrator was analysed using Microsoft Excel. This data was analysed in order to answer research questions RQ3, RQ4, RQ5 and RQ6. The transcriptions of the interviews for both faculty members and administrators were done using Nvivo Transcription software. It was then read several times member checked, extracted and coded for similarities in responses that supported all the research questions.

RESULTS

RESPONSE RATE

The online STOIC survey link was distributed via email to 76 Caribbean Higher Education Leaders that included 22 administrators and 54 faculty members. Thirty Caribbean Higher Education Leaders actually participated in the survey this represented approximately seventeen percent were administrators and 83 percent were members of faculty. Table 1 shows a summary of the research sites and the response rate for each of the locations.

Table 1 Summary of Response Rate.

RESEARCH LOCATIONS-DEPARTMENT OF CHEMISTRY	ADMIN. SURVEYED	ADMIN. RESPONSE RATE %	FACULTY SURVEYED	FACULTY RESPONSE RATE %	OVERALL RESPONSE RATE BY INSTITUTION %
Barbados-University A	4	50	7	57	55
Jamaica-University B	5	20	21	33	31
Guyana-University C	8	25	10	70	50
Trinidad-University D	5	0	16	44	33

DEMOGRAPHICS

The demographics of Faculty and Administrators who participated in the study are shown in Figures 2 and 3 respectively.

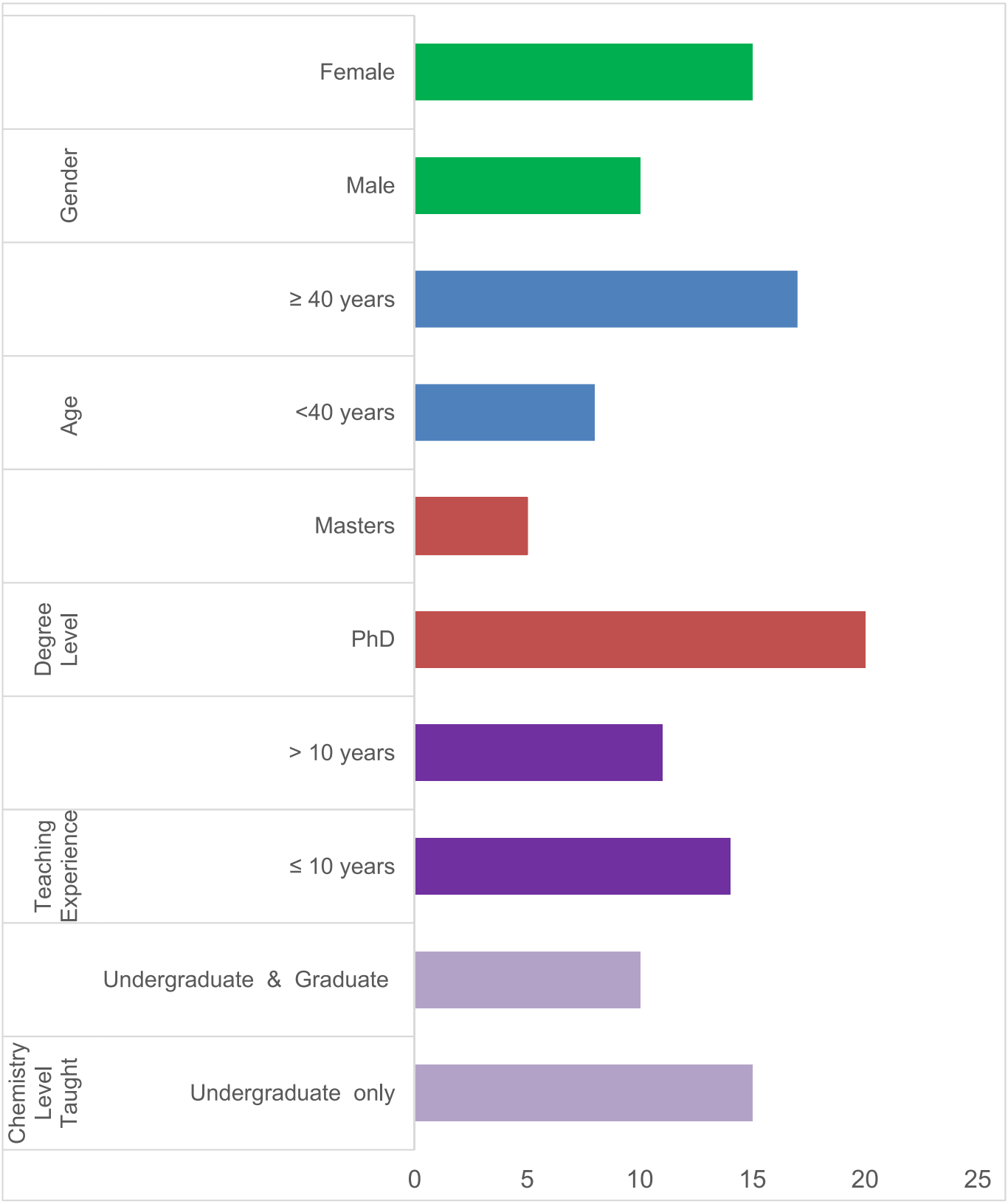

Figure 2 Demographics of Faculty (n = 25).

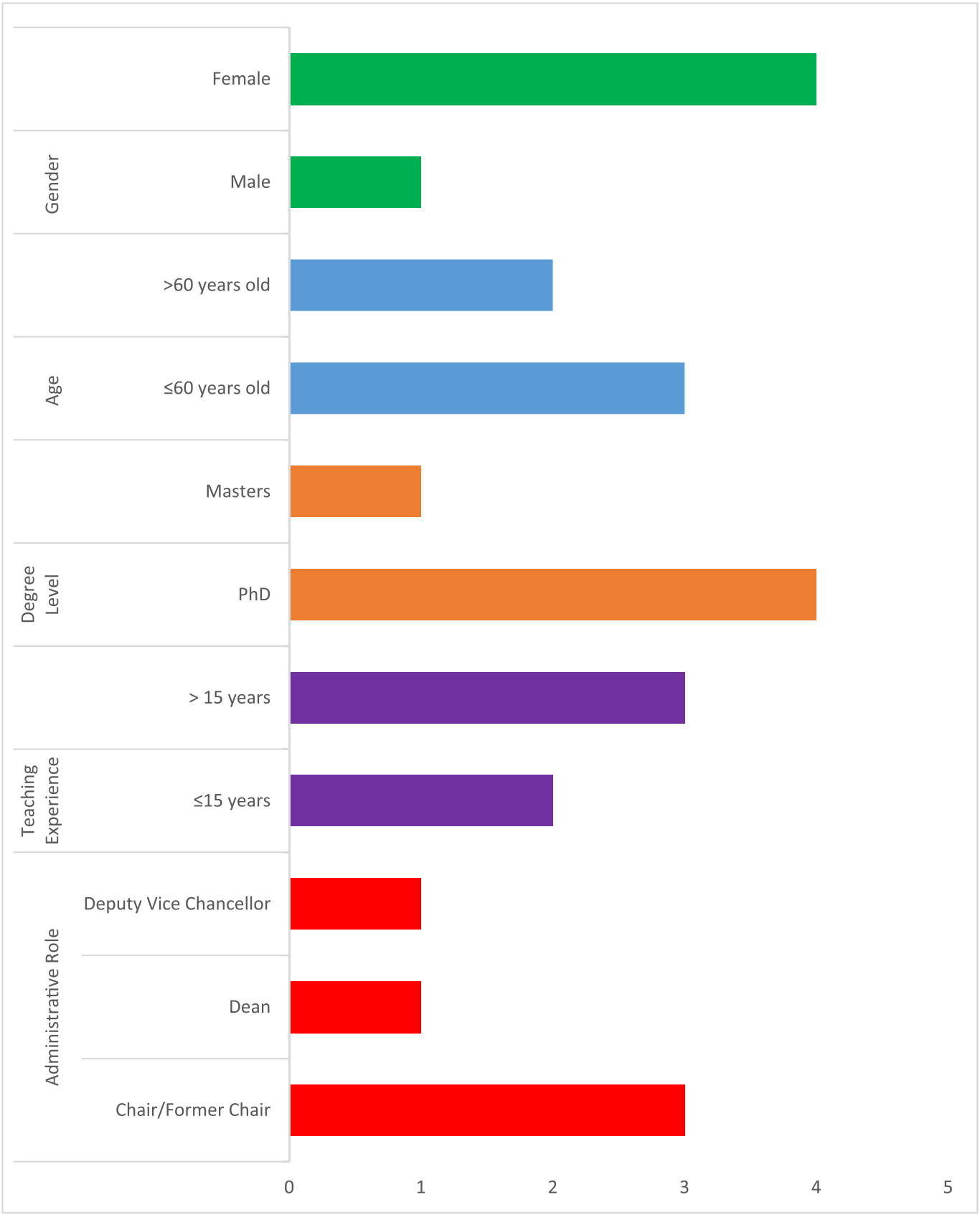

Figure 3 Demographics for Administrators (n = 5).

ANALYSIS

Quantitative Analysis

Parametric analysis was used for the quantitative data obtained to add a unique quality and richness to the study since each of the previous studies by Ward (2008) and Kopachena (2018) used non-parametric analysis. It is noteworthy that there is no significant difference if parametric or non-parametric analyses are done for quantitative analysis using Likert scales (Mircioiu & Atkinson, 2017) and that the data satisfied the assumptions of the independent t-test used for the analysis.

It was seen that there were no significant differences in attitudes of faculty and administrators towards the implementation of online chemistry courses with regard to these criteria except for items 23 and 25. The results of the Independent Samples t-Test analysis show that there was a significant difference in the faculty responses for Q23 (M = 2.40, SD = 1.080) compared to those of administrators (M = 3.80, SD = .447) conditions; t (28) = –2.818, p = .009. This means that the attitudes of faculty and administrators differ significantly with regard to the effectiveness of lectures delivered to students in a face-to- face chemistry class or in the online environment. It was also seen that there was a significant difference in the faculty responses for Q25 (M = 2.40, SD = .866) compared to those of administrators (M = 2.00, SD = .000) conditions; t (24) = 2.309, p = .030 (equal variances not assumed). This means that the attitudes of faculty and administrators differ significantly with regard to the effectiveness of the use of peer study groups and tutoring sessions in a face-to-face class as opposed to the online environment. Table 2 shows the statistical analysis of the survey items and highlights these important findings. It was found that there was no statistical significant difference in the attitudes of faculty and administrators towards the implementation of virtual chemistry laboratory in fully online chemistry courses this was determined from t- test analysis of Item 17.

QUESTION ITEM AND STATEMENT	GROUP	n	MEAN	MEAN DIFFERENCE	t	SIGNIFICANCE (2 TAILED)
17. An online chemistry course should include accompanying virtual chemistry laboratory exercises.	F	25	2.04	.440	.896	.378
	A	5	1.60			
23. Lectures by the instructor are just as effective to students whether delivered in a face-to- face chemistry class or in the online environment.	F	25	2.40	–1.400	–2.818	.009*
	A	5	3.80			
25. Peer study groups and tutoring sessions, comparable to those associated with a face-to-face course, could be provided effectively in the online environment.	F	25	2.40	.400	1.018	.030*†
	A	5	2.00			

Table 2 Comparison of Group Means obtained for Faculty and Administrators for Items 17, 23 and 25.

Note: F = Faculty, A = Admin
* Indicates significant difference; † Equal variances not assumed.

Faculty and Administrators' Opinions and Qualitative responses

Another interesting finding from this study was that the majority of the faculty and administrators, 68% and 60% respectively had not used virtual or simulated chemistry laboratories as seen in Table 3.

QUESTION	GROUP	n	FAMILIAR	NEUTRAL	UNFAMILIAR
Question 29: How would you describe your knowledge regarding the use of the online environment for course delivery?	Faculty	25	44% (11)	44% (11)	12% (3)
	Admin	5	40% (2)	40% (2)	20% (1)
Question 30: How would you describe your knowledge regarding the use of virtual chemistry laboratories/simulated laboratories for laboratory component delivery?	Faculty	25	12% (3)	40% (10)	48% (12)
	Admin	5	40% (2)	40% (2)	20% (1)
Question 31: How would you describe your use of virtual chemistry laboratories/simulated laboratories for laboratory component delivery?	Faculty	25	0	32%(8)	68% (17)
	Admin	5	20% (1)	20% (1)	60% (3)

Table 3 Familiarity of Faculty and Administrators with online environment including virtual laboratory.

Based on their recorded opinions in these open-ended section of the survey, the majority of faculty members surveyed, 64% were in favour for the introduction of a fully online chemistry course. However, both administrators and faculty were unanimous in their concerns about face-to-face laboratory experiences for students. Here are some sample comments by Faculty and Administrators:

> Faculty A: "A general introductory chemistry course could be offered online but laboratory exercises should also be done on campus."

> Faculty B: "I think it can be offered online but I personally believe that the laboratory component needs to be face-to-face."

Additionally, Faculty1 who participated in the Zoom interview was in agreement with the introduction of the online introductory chemistry course mainly because of the convenience it presented to many of the enrolled working students who would take this type of course. Faculty1 stated, "So yeah I think it would be useful if they can get the information that way just to meet their busy schedules." The faculty member also went on to add that the face-to-face lab component is required alongside the online course. It was stated, "Yeah I would still advocate that students come to the lab and do that practical course but the theoretical aspects I would advocate for that being online, I don't see anything wrong with that."

The above opinion also concurred with that of an administrator. A sample comment from Administrator A was in agreement for the introduction of the online course for it to cover the theory but indicated that laboratory component should be done face to face and not online. He stated, "I believe that the theoretical component can be offered fully online but laboratory time is required for the development of skills which I don't believe virtual presentations can provide."

In this study, it has been found that the top three concerns for both faculty and administrators in rank order were laboratory, student interactions and academic integrity as shown in Figures 4 and 5.

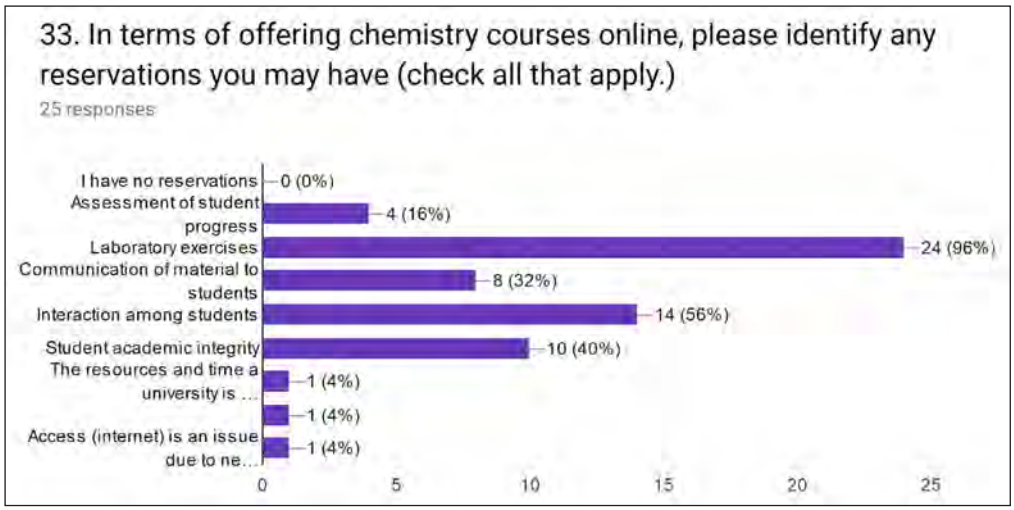

Figure 4 Faculty Reservations on offering Chemistry course online.

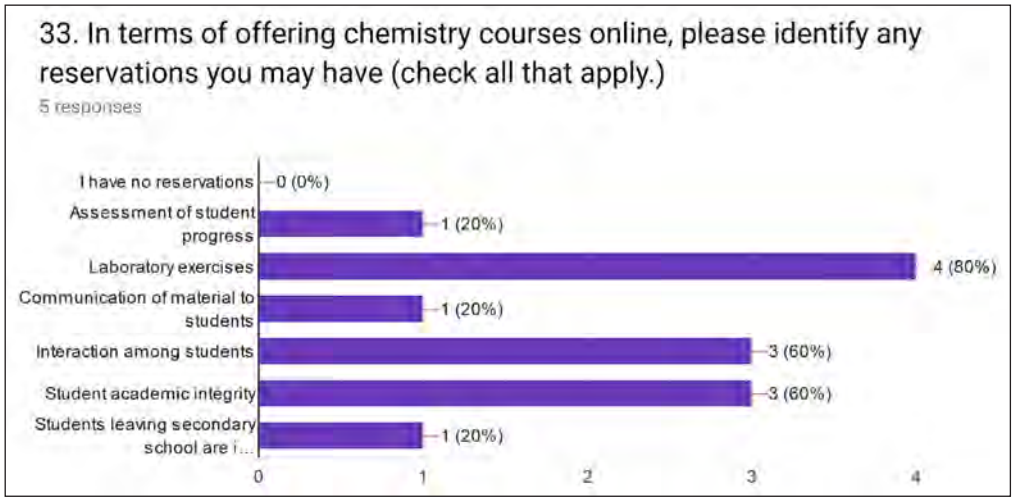

Figure 5 Administrators' reservations on offering Chemistry courses online.

With regard to faculty and administrators' views on online learning, it was found that the first choice of the majority of faculty and administrators (48% and 80%, respectively) was that of having students complete the tests using a home computer under a strict time limit as seen in Figures 6 and 7.

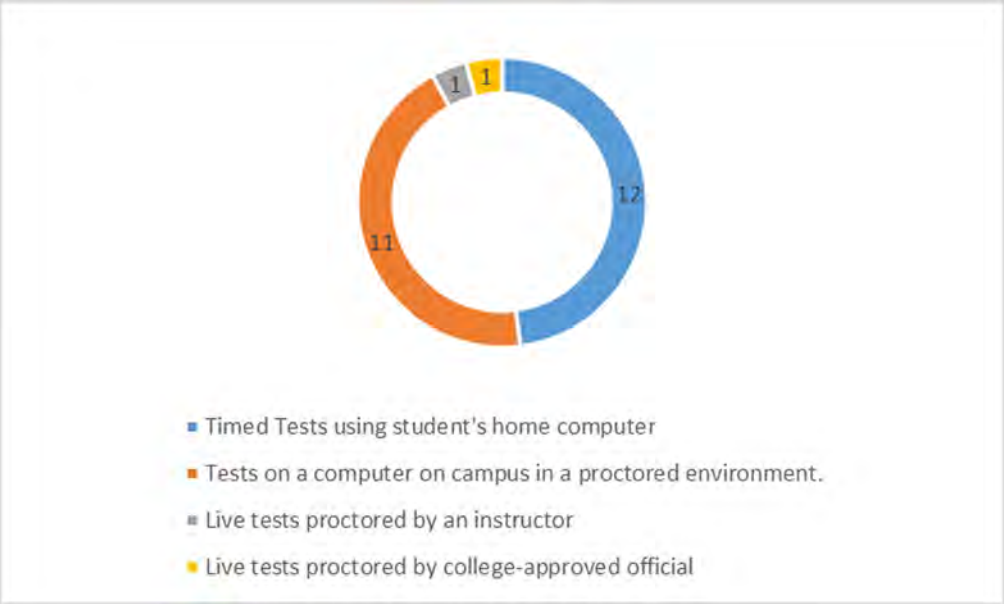

Figure 6 Faculty's views on online testing.

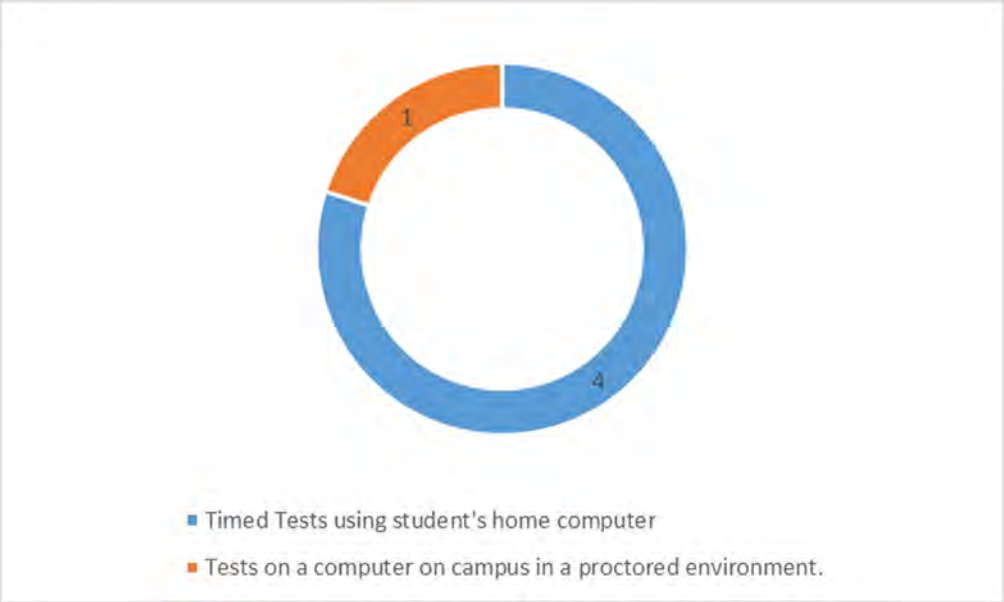

Figure 7 Administrators' views on online testing.

In terms of funding an online chemistry course it was the majority of faculty (40%) did not believe that their institutions will support such a move. However, Caribbean administrators (60%) believe that their institutions will provide the funding and training that are necessary for the implementation of such a course. Table 4 highlights the opinions of faculty and administrators with regard to funding an online chemistry course.

Table 4 Educational leaders view on Institutional Support for online chemistry course.

QUESTION	GROUP	n	AGREE/STRONGLY AGREE	NEUTRAL	DISAGREE/STRONGLY DISAGREE
Question 28: The university where you are employed would provide the necessary support (funding, training, etc.) to offer a chemistry course online.	Faculty	25	32% (8)	28% (7)	40% (10)
	Admin	5	60% (3)	20% (1)	20% (1)

INTERVIEW VIGNETTES

In examining the responses with respect to barriers perceived by faculty in the implementation of fully online chemistry course, Faculty1 gave a representative view of this issue from the perspective of her current institution. She indicated at her institution the main barriers included the reliability of internet service and electricity supply. She indicated, "So they would need more reliable internet because the students may have laptops, their iPads et cetera the internet is not very reliable so that is a challenge. I am ashamed to have this recorded but more reliable power supply definitely from an institutional level." Having to change the mind-set and philosophy of the faculty will also be a barrier as was indicated that, "In terms of the faculty point of

view, most staff seems be bit against online delivery. I would say that most of us seem to be an 'old school' and would prefer it to be face-to-face delivery. So that might require some reconditioning of the mind-sets for the faculty."

With respect to barriers towards the introduction of virtual chemistry laboratory, the common opinion was that 'practicals' (sic) should be hands on. Faculty1 stated, "Initially, I would have to say no because I don't know anything about it and I feel strongly that when it comes to practical things the learning is doing." She further explained, "So in this sense I am a bit 'more old' school and I feel like practicals (sic) have to be done in reality." When probed further about if this would be the perception and general consensus of the rest of her faculty members, Faculty1 indicated, "I think most persons will feel like the practicals (sic) should be hands on." However, further on in the interview, Faculty 1 when faced with a suggestion of having the younger students in year 1 and 2 become grounded in practical use of equipment and then later expose them later on to related virtual labs, Faculty 1 saw that there was value in its possible use. She stated. "So if it's something that they have already developed manipulation skills for, then sure we can do virtual labs in that area."

Adminstrator1 who was interviewed in the second phase on study via zoom was able to shed light on her rationale for not wanting to have an introductory course in chemistry fully online. She stated, "There's so many different models and manipulatives that we use in the classroom that bring a more meaningful learning experience that I wouldn't want to teach my first year online, even without a practical."

In terms of the barriers for the introduction of a fully online chemistry course Administrators 1 saw the lack of a face to face contact "which should be included in a fully online course." She stated, "For me it would have to be built in such a way there is some aspect of it face to face, online because the human aspect to teaching has a lot to in my opinion the learning of something." In addition, a barrier that was highlighted was the time management aspect of the course. It was stated, "The longer you are in the online course the longer the tutor has to be with you, and therefore, in my opinion it does not allow you as a tutor to manage your time as well as you would want to." The last barrier that Adminstrator1 saw that there would be learning that is more passive rather than active engagement due to the absence of manipulatives and use of techniques. She stated, "I think that it is divorced from the techniques and manipulatives that are necessary for active learning in a chemistry classroom that I think at first year you should be exposed to."

With regard to the introduction of virtual chemistry laboratory exercises the majority of administrators favour practical experience as opposed to virtual based on the responses. However, Administrator 1 held a different view having used virtual labs in her department. She was of the view that it can be useful and can be incorporated as "part of instructional strategy or learning tools." She went on to indicate that it could be used for preparation of actual lab work and even lab safety. She stated, "And so I think they are useful in terms of preparation for the lab. I just don't think it would or should replace a lab experience." In her estimation with regard laboratory safety she stated, "I personally believe that all our incoming students should be made to take an online course in laboratory safety before they come on campus."

These findings point to perceived technical, cultural, pedagogical, structural, interpersonal and epistemological barriers that exist with regard to the implementation of online chemistry courses and accompanying virtual chemistry laboratory exercises within the Caribbean context.

CONCLUSION

STRENGTHS AND WEAKNESSES OF THE STUDY

The study documented the diversity of views by Caribbean Higher Education faculty and administrators who participated. It employed a mixed method approach that had not been previously used for this type of study and despite not fully adhering to a sequential research design, quantitative and qualitative data were used to answer the research questions.

Additionally, no other study in this part of the world has been able to capture the attitudes and perceptions of faculty and administrators towards online science learning and phenomenon of online education which has become a part of the pedagogical strategies in Higher Education.

In order to ensure reliability and validity constructs within the use of both quantitative and qualitative methods, pilot testing, Cronbach alpha analysis, member checking, triangulation of data and declaration of the researcher's bias have all been employed. This also lends to the credibility in the study's findings.

Additionally, the study applied the strengths of each of the quantitative and qualitative methods in the execution of the study that ensured that the methodology was well aligned to accepted standards of this type of research.

Since only the chemistry faculty members and administrators from a specific population within a chosen grouping of Caribbean universities were qualified to participate, the findings that were based on this specific sample cannot be applied to the general population. This is one of the major weaknesses of the study. Further the small sample size of the population also is a major weakness of the study.

The study's findings are limited mainly to the efficiency of the survey instrument that was used for data collection and the study did not include any student perspective on the issue of online chemistry learning.

Finally, the participants limited online experience or even lack of thereof may have influenced their attitudes and perceptions of the use of fully online chemistry courses and virtual chemistry laboratory exercises and this would have been another weakness of the study.

APPLICATIONS

There are several applications that can be put forward based on this study and which would be impactful on all stakeholders in Higher Education in the Caribbean which can be grouped as theoretical applications, practical applications and future implications.

Theoretical Applications

There is clear evidence and support for e-leadership theory and its application in the Caribbean context. Caribbean Higher Education Leaders should be exposed to e-leadership skills especially the teaching and learning of chemistry in the online environment. Based on the findings there is a need to improve overall educational leadership skills with emphasis on e-leadership skills from the boardrooms and classrooms. This will further impact on students who would prefer to study chemistry in an online environment that may be more suitable to their circumstances and learning styles. Additionally, having educational leaders make data-driven, informed decisions with regard to technology can further strength the infusion of technology to enhance chemistry teaching and learning.

Practical Applications

Formalized training in e-leadership skills is necessary as part of the training and preparation of potential educational leaders who aspire for leadership roles in their institutions. It has been shown that by making the use of technology mandatory as well as through learning, that e-leadership can be effective in improving technology utilization (Hartman et al., 2017; Svalfors, 2017). Revised programs in educational leadership should be offered by Caribbean tertiary institutions.

Based on the findings of this study, Caribbean universities should offer blended offerings as part of their chemistry programs. This would be subject to addressing the pedagogical, technical, interpersonal and cultural barriers that currently exist among Caribbean Higher Education Institutions and leaders. Blended chemistry programs can attract more students and increase enrolment since the course offerings would become more academically attractive and more in alignment with 21st century teaching and learning methods.

Future Applications

Future studies should focus on the attitudes and perceptions Caribbean chemistry students towards the implementation of online chemistry courses and virtual laboratory exercises. The data obtained can then be analyzed and add value to administrative and curriculum decisions and how to best adapt and adopt the technology in creating student-centered curriculum.

Also future studies can examine the relationship between demographics of the chemistry faculty such as, the type or level of course taught, tenure, age, teaching experience, education level, gender,

ethnicity, and nationality and how this influences attitudes towards online chemistry teaching. This would be of benefit to the institutions as based on this data, institutions would be able to provide training for faculty accordingly based on their interest, motivation and capacity to participate in online chemistry training and then eventually implementation of online chemistry courses.

Also future studies can encompass correlational or comparative analysis of attitudes of Caribbean chemistry faculty to those in other parts of the world such as Europe or North America. This can add further insights into how Caribbean educational leaders perceive online chemistry learning and how this compares to the developed world. This can be of benefit to regional Ministries of Education and higher education institutions as a whole. In that, they will be able to analyze critically and determine the present the developmental stage of each of the institutions as well as how they compare to other institutions, in terms of faculty readiness for online chemistry learning.

Future studies can focus on the virtual laboratory component of the study and its effectiveness within the Caribbean setting. Finally, with the advent of COVID-19 future studies can examine within the same institutions the attitudes and perceptions of faculty and administrators now as compared to when this current study was completed.

ADDITIONAL FILES

The additional files for this article can be found as follows:

- **Appendix A.** Modified STOIC Survey – Administrators. DOI: https://doi.org/10.55982/openpraxis.14.1.143.s1
- **Appendix B.** Modified STOIC Survey for Chemistry Faculty. DOI: https://doi.org/10.55982/openpraxis.14.1.143.s2
- **Appendix C.** Interview Questions- Faculty. DOI: https://doi.org/10.55982/openpraxis.14.1.143.s3
- **Appendix D.** Interview Questions –Administrators. DOI: https://doi.org/10.55982/openpraxis.14.1.143.s4

COMPETING INTERESTS

The author has no competing interests to declare.

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