Australian Journal of Teacher Education

Volume 42 | Issue 10 Article 2

2017

Using ICT-based Instructional Technologies to Teach Science: Perspectives from Teachers in Trinidad and Tobago.

Rawatee Maharaj-Sharma
The University of the West Indies, St. Augustine, rmaharajsharma@gmail.com

Aarti Sharma
Imperial College, London

Aditi Sharma
University of Waterloo, Canada

Recommended Citation
Maharaj-Sharma, R., Sharma, A., & Sharma, A. (2017). Using ICT-based Instructional Technologies to Teach Science: Perspectives from Teachers in Trinidad and Tobago.. *Australian Journal of Teacher Education, 42*(10).
http://dx.doi.org/10.14221/ajte.2017v42n10.2

This Journal Article is posted at Research Online.
http://ro.ecu.edu.au/ajte/vol42/iss10/2

Using ICT-based Instructional Technologies to Teach Science: Perspectives from Teachers in Trinidad and Tobago.

Rawatee Maharaj-Sharma
The University of the West Indies, St. Augustine, Trinidad & Tobago
Aarti Sharma
Imperial College, London, UK
Aditi Sharma
University of Waterloo, Ontario, Canada.

Abstract: The purpose of this study was to investigate how science teachers in Trinidad and Tobago use ICT-based instructional technologies in classroom science teaching. The participants were 30 secondary school science teachers who completed their Postgraduate Diploma in Education within the last 2 years from the University of the West Indies in Trinidad and Tobago. The teachers were asked to prepare lesson plans which demonstrate their use of instructional technologies to teach science topics within their term's schemes of work. They were subsequently asked to explain their reasons for using the selected instructional technologies. The findings revealed that PowerPoint was the most widely used ICT-based instructional technology in the lesson plans analyzed. Animations and hands-on practical activities were the least used ICT-based instructional technologies. Virtual labs, computer-aided simulations and smartboards, were other ICT-based instructional technologies used by a few teachers. Textbooks and whiteboards were the non-ICT-based instructional technologies teachers used.

Introduction

The use of ICT-based instructional technologies in education has been widely discussed in light of the advancements in new technologies (Serin, 2011; Inan and Lowther, 2010; Ahuja, 2016). Governments all over the world have drafted policies on information and communication technology in education (Spector, Merrill, Merrienboer & Driscoll, 2008; Hogarty, Lang & Kromrey, 2003) and have made enormous investments in initiatives aimed at integrating information and communication technologies in schools. For example, in the United States, more than 95% of schools and 72% of classrooms were connected to the Internet in the year 2001 (Quality Education Data, 2000 as cited in Hogarty, Lang & Kromrey, 2003) at a total spending cost of $5.2 billion (Reed et. al., 2001, as cited in Hogarty, Lang & Kromrey, 2003). With the technology revolution, it seems that there are deliberate intentions, almost at the global level, to encourage teachers to include ICTs and ICT-based activities in the range of instructional technologies they adopt in their classroom teaching (Morris, 2012).

In keeping with this global technology thrust, Trinidad and Tobago formulated the Draft Policy for Information and Communication Technology in Schools in 2005 (Trinidad and Tobago, Ministry of Education, 2005) and this policy was formally introduced in schools one year later. Through this policy, educators and by extension schools, were encouraged to conceptualize educational experiences which ensured that "ICT is significantly integrated into the teaching and learning process." In order to facilitate this shift in mindset, tremendous efforts were made to ensure that schools were outfitted with computer rooms and/or laboratories which were equipped with modern ICT devices and that technical support in the form of ICT technicians were attached to schools. Later in 2010, the eConnect and Learn (eCAL) Programme (the teaching and learning aspect of the Draft ICT policy), was formally implemented in Trinidad and Tobago. The eCAL programme provided (i) for every student entering secondary school to be given a laptop as an instructional tool for use in school and at home for the period of his/her secondary education; and (ii) for teachers to have access to a laptop taken from the laptops assigned to schools for use as an instructional tool in school. As a result of the eCAL programme even greater investments in a range of ICT devices, resources, infrastructure and personnel were made in 2010 and beyond. The eCAL programme also included an aspect of training for teachers whereby the Ministry of Education undertook to provide training and professional development to teachers and administrators not only on technical skills but also on curriculum integration. The intention therefore was to place teachers in a position where they will be well poised to integrate ICT devices and ICT-based activities in their classroom teaching. Science teachers in particular were strongly encouraged to integrate ICTs in their classrooms because of the wide range of science-based software the eCAL programme made available at schools.

In spite of these progressive shifts in education, some scholars and educational theorists have raised concerns about maximization, efficiency and effectiveness of ICT resources in the context of teachers' beliefs, their proficiency levels and how prepared they are for the use of ICT-based instructional technologies in their classroom instruction (Tezci, 2011; Otten-Leftwich, Glazewski, Newby & Ertmer, 2010). They argue that not enough is known about the extent to which teachers are using ICTs in their classrooms, and if they are in fact using it, what are the specific ways in which teachers are using the technology to enhance teaching. Cox and Marshall (2007) have spoken specifically about the speed with which the technology revolution is unfolding and they have questioned if, as consumers of the technology, we really know what we should know about the transition that is occurring. They have asked further if, as consumers of the technology we are cognizant of the implications of technology for us at this time and of those implications it will have for us in the future. Concerns have been raised about value for money and about learning benefits to students. In science education for example, Kozma (2005), raised the concern that huge sums are invested in science-based software and application packages but science teachers are using these only rarely in their everyday teaching. More than a decade later, Maharaj-Sharma and Sharma (2017) have reported that in many jurisdictions, Kozma's concern remains valid and that there is urgent need to understand why this is so.

In Trinidad and Tobago, the eCAL programme, has made available at all secondary schools, a wide range of high quality, sophisticated science-based ICT resources but it is not known the extent to which science teachers are using these in their classroom teaching. Even less is known about what types of ICT-based instructional technologies science teachers use in their classrooms and about their levels of proficiency, competency and preparation for the use of these technologies. Science teachers in Trinidad and Tobago have never been surveyed to find out their views and dispositions on the use of ICT-based instructional strategies in science teaching,

and what are their reasons for choosing specific instructional technologies (ICT-based or otherwise). There are therefore obvious gaps in the knowledge available on science teachers' use of, and choice of, ICT-based instructional technologies to teach science in Trinidad and Tobago. It is these gaps in knowledge which motivated the current work. In addition, the researcher being a science educator was, curious to find out what kind of ICT-based instructional technologies science teachers are more likely to use to teach science and what are the reasons for their choice of ICT-based instructional technologies. Against that background therefore, the following research questions guided the focus of this work:

- What ICT-based instructional technologies are used by secondary school science teachers in their science teaching?
- What are teachers' reasons for the choice of ICT-based instructional technologies used in their science teaching?

Given the above stated research questions, this study is significant in the Trinidad and Tobago context as it will serve as an initial indicator of the extent to which ICT-based instructional technologies are used by science teachers to teach science. It will also provide valuable insights from science teachers' perspectives about how elements of practice impact on the way ICT-based instructional technologies are integrated into science teaching. The findings hereof will reveal the specific considerations which science teachers take into account when choosing ICT resources for use in their science classrooms. Understandings arising from this work therefore may provide useful information which can be used to assess, in some small way, the effectiveness of the ICT initiative in Trinidad and Tobago.

Underlying Theory

To effectively harness the power of effective use of ICTs in education, a number of essential conditions must be met. Among these are that (i) students and teachers must have sufficient access to digital technologies and to the Internet in their classrooms and schools, (ii) high quality meaningful and culturally responsive digital content must be available for teachers and learners and (iii) teachers must have the knowledge and skills to use the new digital tools and resources to help all students achieve high academic standards (Vikashkumar, 2005). In approaching this daunting task it is important to understand that accessibility and teachers' competence levels cannot be regarded in a casual way. In fact structured approaches to facilitate ready access of equipment and other ICT resources must be embedded into the guiding policies and procedures of schools in ways that will encourage and support teachers in their integration efforts. Furthermore, consistent and well managed continuous professional development programmes in the area of ICT integration must be an integral part of schools' schedule of activities (Haydn and Barton, 2008; Prensky, 2010).

In addition to the elements of accessibility and training articulated in the ICT integration framework described above, Keengwe, Onchwari and Wachira (2008) advice that teachers' personal beliefs and their general perceptions which includes comfort zones, levels of confidence and the nostalgia of traditional teaching and learning approaches have undeniable influence on teachers' ICT integration efforts. These softer elements are intuitively instructive for practice and therefore cannot be ignored; rather these must be enhanced or swayed, either through meaningful professional development or a mentoring system aimed at motivating teachers to integrate ICTs

into their teaching as a matter of habit (Maharaj-Sharma and Sharma, 2017). It seems therefore that the critical elements of any successful ICT integration initiative must include, but may not be limited to, focused considerations of the following:

- Ease of accessibility of ICT resources for teachers
- Meaningful and relevant training in the use of ICT resources for teachers
- Structure by way of established policies and procedures to facilitate access and training
- Teachers' beliefs/perceptions about the impact ICT has on the teaching and learning experience.

Literature

Zhang and Martinnovic (2009) suggest that access is a key issue in encouraging teachers to use ICT devices and ICT-based teaching and learning activities in their classrooms. Other researchers have reported that in addition to access, teachers' ICT proficiency, their perceptions and their attitudes toward ICT integration in the curriculum are instrumental in determining the extent to which teachers will use ICT in their teaching (Sasseville, 2004). In a 2009 study by Darling-Hammond, Wei, Andree, Richardson and Orphanos it was revealed that 'one of the key factors influencing teachers' decision to use ICT was a belief that such use made a difference to their lessons and their belief that students would respond positively to it.

Over the last decade or so, a number of studies on the topic of ICTs in science education have been conducted in different contexts around the globe. For example, a study done in Australia by Baskin and Williams (2006) suggested that not only curriculum factors but also personal factors such as attitude, motivation, and confidence are important considerations for teachers in their decision to integrate technology in their science classes. Other studies in the north American context have reported that science teachers are in fact very attracted to certain types of ICT resources such as virtual labs and computer simulations because these allow for easy and frequent repeat runs and have the potential to bring abstract concepts, some of which cannot be replicated in a traditional lab, to life for their students (Levin and Wadmany, 2008). In a study done in the Caribbean context, Maharaj-Sharma and Sharma (2017) found that ICT devices and ICT-based activities, when effectively integrated into science teaching facilitated greater learning in the science class, promoted high levels of student engagement and provided for students new avenues of knowledge accessibility. The researchers cautioned however, that a harmonious balance between ICT-based activities such as computer simulations and virtual experiments and real hands-on, practical activities including traditional collaborative group work must be established to ensure that the science classroom does not suffer technology overkill which can easily turn-off students.

Science teachers have recognized the versatility that ICT devices and ICT-based classroom activities offers in the science classroom and many have articulated a desire to see increased levels of ICT integration in science classes (Willshire, 2013). But having acknowledged the pedagogical utility ICTs offer, Hennessy, Deaney, Ruthven and Winterbottom (2007), reported that science teachers admit that they find themselves easily reverting their "old and secure" styles of teaching particularly because their training in ICT integration is limited and/or lacking. Many jurisdictions seem to have a model for teacher training in ICT integration which involves an initial overview phase followed by unstructured, random follow-up sessions

which do not focus on specific integration strategies but are rather general in nature (Goodwin, 2010). As a result skill development is not progressive and so teachers are not provided with meaningful opportunities to develop competence and confidence in ICT integration techniques in these follow-up sessions. Maharaj-Sharma and Sharma (2017) suggest that this lack of competence and confidence force teachers to revert to traditional practices.

In addition to the deterring factors mentioned above, Abdullahi (2014) has reported that the seeming reluctance on the part of many science teachers to integrate ICT-based teaching and learning activities into their everyday teaching may be linked to the unreliable and ineffective in-house technological support that is common at many schools. Administrative hassles too, to access equipment and schedule times to use computer labs often frustrate teachers. These issues are what Player-Koro (2012) suggests are among the main reasons for the observed reluctance by science teachers to use ICT-based instructional technologies in their lessons.

Zhang and Martinnovic (2009) suggest that if teachers efforts in ICT integration are to improve and increase, regular, structured and relevant training must be an integral part of any ICT integration initiative. Furthermore, efficient and reliable technical support must be at teachers' disposal at all times and every effort should be made on the part of administrators to minimize the bureaucracy which currently hampers teachers willingness and interest to integrate ICTs in their lessons.

Methodology

This study was conceptualized in the qualitative research paradigm and therefore adopts an exploratory approach in order to gauge elements of practice and to gain an understanding of underlying reasons, opinions, and motivations. Document analysis of written science lesson plans and researchers' notes obtained from observations of teachers' in their natural setting was employed to learn about teachers' classroom activities and hence to arrive at a determination of the types of instructional technologies science teachers use (DeWalt and DeWalt, 2002). The aim was to provide insights into the extent to which ICT-based instructional technologies are used by secondary school science teachers in Trinidad and Tobago. Open-ended questioning was used, in the first instance to uncover, at a practical level, the underlying reasoning which guides teachers' practice and therefore informs their choice of instructional technology, and secondly to interrogate teachers' general perceptions of the use of ICT-based instructional technologies. Both methods, document analysis and open-ended questioning, involved interactions with teachers in a very intimate way and hence facilitated breadth of exploration in an informal setting. In this study therefore, the observing researcher was an integral part of the investigation (Jacob 1988).

Participants

The participants were 30 secondary school science teachers (15 male, 15 female) all of whom had completed their Postgraduate Diploma in Education Programme (a 9-month in-service professional development programme) at the School of Education at the University of the West Indies in Trinidad. All participants completed the Information Technology module and the Teaching of Science course, both of which were necessary requirements to graduate from the programme and all participants have a B.Sc. degree in either biology, chemistry or physics. Among the 30 participants, 10 had a B.Sc. in physics, 10 had a B.Sc. in chemistry and 10 had a

B.Sc. in biology. All participants were serving as teachers in secondary schools in Trinidad and Tobago and were teaching science in the area in which they obtained their B.Sc. degree at the time the study was conducted. The participants were purposively selected by the researcher based on observations of their prior teaching practice for a period of at least 9 months which demonstrated a cautioned and sometimes hesitant willingness to use ICT-based instructional strategies in their teaching. The particular sampling technique used here is similar to the purposive sampling method described by Palys (2008).

Data Collection

Data from lesson plans, researcher's notes from classroom observations of taught lessons, and an open-ended questionnaire were collected over the period February 2016 - March 2016. Participants were asked to conceptualize science lessons and to develop science lesson plans based on the Danielson model for writing science lesson plans which is described and reported on by Jacobs, Martin and Otieno (2008). The teachers prepared lesson plans to teach the science topics they were scheduled to deliver to their respective science classes for the February-March 2016 period. They were not directed to use any specific ICT-based instructional technologies. The teachers were observed teaching the lessons they developed and careful notes of the types of instructional technologies used in the science lessons were taken. Each teacher was observed twice - once in February and once in March. .

The open-ended questionnaire was given to teachers after they taught the second lesson and they were asked to complete and return the questionnaire to the researcher one day later. The questionnaire was an adaptation of the instrument described by Patton (2005) which in this case sought to elicit from science teachers their reasons for the choice of instructional technology used and their general perceptions of the use of ICT-based instructional technologies in science teaching. The questionnaire consisted of ten items. The first six items were designed to prompt teachers to offer specific reasons for their choice of instructional technology while the latter four items were loosely worded in a deliberate attempt to provide teachers with opportunities to freely articulate their perceptions in relation to the use of the instructional technologies of their choice. The instrument's validity and reliability are described in detail in Patton (2005).

Data Analysis

Data were analyzed using a two-step inductive approach. In the first step, all lesson plans and corresponding researcher’s notes from classroom observations were numbered and analyzed in terms of instructional technologies used by the teachers (ICT-based and otherwise). Qualitative data analysis of classroom observation notes revealed that a range of instructional technologies were used by the science teachers and subsequent data coding for types of instructional technologies led to the emergence of six categories of instructional technologies used by the teachers. These were: PowerPoint presentations, virtual labs, computer simulations, animations and practical hands-on activities, boards (which included smart boards and white boards) and textbooks. Frequency analysis was conducted for each category. In the second step, teachers’ responses to the open-ended questionnaire were coded and analyzed to determine (i) their reasons for the selected ICT-based instructional technologies used in the delivery of science lessons and (ii) teachers’ general perceptions of the use of ICT-based instructional technologies.

Results

Types and frequency of Instructional Technologies used by Science Teachers

Most teachers used more than one instructional technology in their lessons but the overall findings of the study reveal that PowerPoint was the most widely used instructional technology in the documented lesson plans as well as in the corresponding classroom observations. It is to be noted that 24 teachers, which represented the majority of the participants in this study, used PowerPoint in the delivery of their science lessons, and that all 10 biology teachers observed used this instructional technology. Most of the biology teachers included in their PowerPoint presentations video clips or animations often to summarize their lessons but in some cases to demonstrate concepts or processes at the microscopic level during the execution of their lessons.

A slightly smaller number of chemistry teachers (8 teachers) used PowerPoint but physics teachers used this instructional technology the least. In contrast however, more physics teachers used computer aided laboratory work in the form of simulated experiments and virtual labs. With the exception of two, all the physics teachers in this study engaged their students in either simulated experiments and/or virtual labs in the lessons they taught. All teachers used whiteboards at some point in their lesson, but 5 teachers (3 chemistry and 2 physics) used the smartboard in very interactive ways to engage students in data plotting and data manipulation exercises during the delivery of their science lessons. In fact, the 2 physics teachers who used the smart boards were the same ones who did not use computer-aided laboratory work.

Animations and hands-on practical activities were used by only 5 of the teachers observed in this study, 3 of which were physics teachers. Among these 3 physics teachers, 2 used animation and 1 used hands-on practical activity. The other 2 teachers - 1 biology and 1 chemistry - used hands-on practical activity in their lessons, but no animation. All 30 teachers used the whiteboard several times in their lessons. In some of the lessons, the whiteboard was used by students to present solutions to problems or to explain concepts or processes using diagrams and flowcharts. A total of 16 teachers made explicit use of science textbooks in their lessons, but most of these teachers were observed to have used other instructional technologies as well. What was well-noted from the lessons observed, was the fact that in most instances teachers used more than two, and in some cases as many as 6, different instructional technologies in the delivery of their science lesson. Overall, all the instructional technologies (ICT-based or otherwise) used by all 30 teachers in their science teaching were noted and are captured in summary in Table 1.

Instructional Technology	Total no. Teachers	Biology Teachers	Chemistry Teachers	Physics Teachers
PowerPoint	23	10	8	5
Virtual Labs	12	4	2	6
Computer Simulations	11	1	2	8
Animations & Hands-on Practical Activity	5	1	1	3
Smart boards	5	0	3	2
Whiteboard	30	10	10	10
Textbook	16	9	5	2

Table1: Instructional Technologies used by Science Teachers

Teachers' Reasons for their Choice of Instructional Technology/gies

PowerPoint

Teachers' reasons for their frequent use of PowerPoint presentations were all linked to its ease of preparation, the very little technical skills required to execute a PowerPoint presentation in the classroom and the ability to present a lot of content very quickly and in a visually appealing way in a PowerPoint presentation. Most teachers in this study were comfortable using PowerPoint and indicated that it was their preferred ICT-based instructional technology for use in science teaching because a large part of the training aspect of the eCAL programme focused on developing PowerPoint presentations. As part of the eCAL training exercise, many teachers had hands-on opportunity to develop PowerPoint presentations in their subject area and as a result have acquired the skills necessary to prepare effective PowerPoint presentations. Many of the science teachers in this study admitted to having prepared a range of presentations which they continue to use in their science teaching. Sixteen of the 23 teachers who used PowerPoint in this study were in fact using *pre-prepared* PowerPoint presentations in their lessons. When asked if they are likely to prepare other presentations to teach topics for which they do not already have presentations, most of them said they would not. When asked further about why they would not, two-thirds of them said that in spite of the technology shift, they preferred to teach science 'in the traditional way … the way they were taught ….' The other one-third said that limited access to ICT resources at school and at home was the reason they would not prepare PowerPoint presentations for other topics. Seven of the teachers however, who also use *pre-prepared* presentations in their teaching, indicated that they have created many other presentations for several other topics using the knowledge and skills they developed in the eCAL training exercise.

Virtual Labs

Teachers in this study who used virtual labs believe firmly that virtual labs create enriching experiences for students by giving them the opportunity to behave and act like real scientists in a real lab. This was the main reason they offered for using virtual labs in their classrooms. In fact one teacher said "… virtual labs encourage even weak science students to participate in science activities with confidence ….." These teachers stated explicitly that they make deliberate attempts to use virtual labs in their science teaching especially because in the schools they are at, students do not get the opportunity to go to the science lab regularly. In some cases the science labs are underequipped, not up to safety standards or do not have the laboratory assistant and technicians to facilitate the practical activities teachers plan for the labs. The physics teachers in particular say that virtual labs to which they have access are relevant to many abstract concepts in the secondary school physics syllabus and that by using them students are able to grasp understandings of abstract concepts which would otherwise be difficult for them appreciate. Teachers cited "electrostatic charging by friction" as an example of one concept students have difficulty grasping but which is made vivid in virtual labs which show the movement of electrons when objects rub against each other.

Computer Simulations

As with virtual labs, this instructional technology was used most by physics teachers. These teachers explain that some physics processes like atomic fusion, atomic fission and radioactivity cannot be replicated in a traditional lab and that students usually learn these concepts simply by reading about them without getting a sense of what is involved in these processes. Computer simulations are extremely useful for processes like these and the physics teachers in this study say " … this is the main reason why … [we] use them in science teaching." The biology teacher who used computer simulation in her lesson said that she uses just one simulation – that of digestion – whenever she is teaching that topic. Concepts such as nutrient absorption and mineral exchanges which students do not grasp fully, (even though they understand digestion at a macroscopic level), are made much clearer to them when she uses this computer simulation. One chemistry teacher explained that "the factors that affect reaction rates computer simulation" is one she uses regularly because her students have said that it helps them understand the proportionality relationship between factors and rates.

Smartboards

Smart boards were used by chemistry and physics teachers in this study. These teachers say that their attraction to the smartboards is its "many interactive features" which they use to engage students, oftentimes getting students too to use the boards. The smartboard allows for easy correction of written text and makes it easy to use colors and fonts for additional emphasis. The memory feature of the smartboard is the most useful thing for these teachers – they say it is easy to go back to previously taught material for review or reinforcement when students are having difficulty understanding material in new lessons. Teachers who did not use the smartboards, even though they were available for use in their classrooms, cited lack of training in the smartboard features as the main reason for not using them in their science teaching. One teacher who described herself as a technophobe said "… learning to use the smart board could get me started on my technology journey …" but she laments "… no training opportunity in smart board use has been arranged by the school."

Animations and Hands-on Practical Activity

These were not used very frequently by the teachers in this study and when asked about reasons, those teachers who used hands-on practical activity said that in the past they would do many more practical activities in the lab with their students, but since the addition of virtual labs and computer simulations to their repertoire of teaching and learning resources that they have shifted away from traditional laboratory exercises. Some teachers admitted that laboratory exercises which focus on the development of specific manipulative skills, such as titration or dissection cannot be adequately developed with the technology and suggested that traditional laboratory practical activities must be employed during teaching in such cases. Interestingly though, it was noted that a few teachers in this study used no practical activities in their lessons and when probed about this observations the following were their responses:

- Underequipped, unsafe labs and non-availability of technical laboratory support
- Simple preference for the classroom-centric method of teaching and learning

The two physics teachers in this study who used animations explained that the "combined visual and auditory effects of animations" make them an attractive instructional technology either for introduction to a lesson, to capture students' attention when starting a lesson or for summarizing the main points in a lesson so that students exit the class with a memorable note of what was taught in the lesson. This they suggest is an excellent reason all teachers should use animation in their teaching, even more so if the topic is abstract or has scaffolding elements, as is the case with many science topics.

Whiteboard and Textbooks

All the reasons teachers offered for the widespread use of whiteboards in their science classrooms were linked either to the challenges they encounter in their attempts to use ICT-based approaches, or to aspects of their own learning experiences in which traditional methods were used. While most of the teachers in this study recognize the opportunities ICT-based technologies offer, many were adamant that in their own learning experiences, the whiteboard was extremely useful for reinforcement, emphasis and 'teacher body language teaching.' Textbooks too, more than half the teachers in this study say, are extremely useful reinforcement teaching tools which if effectively used can easily measure up to the benefits ICT-based instructional technologies can yield.

Discussion

It is clear form this work that even while science teachers in Trinidad and Tobago have embraced the idea of using ICT-based instructional technologies they have not abandoned traditional methods. There is a high instance of use of a range of ICT-based instructional technologies but PowerPoint is most popular among the teachers. Teachers still see considerable value in the use of non ICT-based instructional technologies and many have actually combined both in their science teaching. An interesting follow-up to the current work would be an exploration of the ways science teachers use a blend of ICT-based and traditional instructional technologies in their teaching.

What stood out from this work was the existence of a deficiency in capacity to facilitate science learning in a meaningful way at the schools in which the teachers taught. Whether they were referring to ICT-based instructional technologies or otherwise, teachers made it clear that not enough support systems are in place to support their efforts. Technical support for the execution of ICT-based lessons is limited in most instances and where they are available they are unreliable and inefficient. Structured, consistent training in skill and competence development to use ICT resources are minimal and haphazardly scheduled. Maintenance of computer hardware, upgrade of software and renewal of application packages licenses are not done in a timely and responsible manner in many cases. Matters like these impact negatively on teachers when they choose to use ICT-based instructional technologies and in fact the teachers spoke at length about these challenges when asked to elaborate on their perceptions of the use of ICT-based instructional technologies in their science classes. This might be one reason why such a large number of the teachers in this study have chosen to retain the traditional methods (whiteboards and textbooks) in their teaching - an observation that is worthy of further investigation.

But even with traditional, non-ICT-based instructional technologies such as practical hands-on activities in a traditional lab, deficiencies in the physical infrastructure and the poor supply and maintenance of laboratory equipment and reagents seem to be pushing teachers back into traditional teacher centric classrooms. Indeed, it is not hard to understand why some teachers would find it easy to abandon even their best intentions when confronted with challenges for which they feel solutions are not forthcoming.

The above having been said, it is important to note that this work focused on a deliberately selected group of science teachers in Trinidad and Tobago and therefore cannot be generalized for all science teachers in the entire country. In fact it might be that the findings herein are not what obtains in a general sense and that the frequency of use of ICT-based instructional technologies might be far less. Also the reasons for use or not, of these ICT-based instructional technologies, may be more wide-ranging than that revealed here. These speculations can best be clarified by a long term study of similar nature but which involves a larger number and a wider cross section of teachers (science and non-science). An instructive finding emerging from this work is the need for reliable and efficient support systems in schools to facilitate teachers' efforts in the use of ICT-based instructional technologies in science teaching and learning. Overall though, this study provides for the Trinidad and Tobago context, a glimpse into science teachers' use of instructional technologies in their classrooms and some explicit reasoning for their choice. Such insights were not known in a formal way prior to this work and in that context, this work adds instructive value to at least one other dimension of teachers' practice in Trinidad and Tobago.

References

Abdullahi, H. (2014). The role of ICT in teaching science education in schools. *International Letters of Social and Humanities Sciences*,19: 217-223. https://doi.org/10.18052/www.scipress.com/ILSHS.19.217

Ahuja, A. (2016). Integration of information and communication technology in school curriculum, *Learning Community: An International Journal of Educational and Social Development*, 7(1): 1-8. https://doi.org/10.5958/2231-458X.2016.00001.4

Baskin, C., & Williams, M. (2006). ICT integration in schools: where are we now and what comes next? *Australasian Journal of Educational Technology*, 22(4), 455-473. https://doi.org/10.14742/ajet.1280

Cox, M., & Marshall, D. (2007). Effects of ICTs: Do we know what we should know? *Education and Information Technologies*, 12(2): 59-70. https://doi.org/10.1007/s10639-007-9032-x

Darling-Hammond, L., Wei, R.C., Andree, A., Richardson, N., & Orphanos, S. (2009). Professional learning in the learning profession: A status report on teacher development in the United States and abroad. National Staff Development Council: USA.

DeWalt, K.M., & DeWalt, B.R. (2002). Participant observation: A guide for fieldworkers. Walnut Creek, CA: AltaMira Press.

Goodwin, N. (2010). ICT knowledge in the technology classroom - where to and why. 6th Biennial International Conference on Technology Education Research, Brisbane: Griffith University.

Haydn, T., & Barton, R. (2008). 'First do no harm': Factors influencing teachers'' ability and willingness to use ICT in their subject teaching, *Computers & Education*, 51(1): 439-447. https://doi.org/10.1016/j.compedu.2007.06.001

Hennessy, S., Deaney, R., Ruthven, K., & Winterbottom, M. (2007). Pedagogical strategies for using the interactive whiteboard to foster learner participation in school science. *Learning, Media and Technology*, 32(3): 283–301. https://doi.org/10.1080/17439880701511131

Hogarty, K.Y., Lang, T.R., & Kromrey, J.D. (2003). Another look at technology use in classrooms: The development and validation of an instrument to measure teachers' perceptions. *Educational and Psychological Measurement*, 63(1): 139-162. https://doi.org/10.1177/0013164402239322

Inan, F.A., & Lowther, D.L. (2010). Factors affecting technology integration in K-12 classrooms: A path model. *Educational Technology Research and Development*, 58(2): 137-154. https://doi.org/10.1007/s11423-009-9132-y

Jacob, E. (1989). Qualitative research: A defense of traditions. *Review of Educational Research*, 59(2): 229-235. https://doi.org/10.3102/00346543059002229

Jacobs, C.L., Martin, S.N., & Oteieno, T.C. (2008). A science lesson plan analysis instrument for formative and summative programme evaluation of a teacher education programme, *Science Education*, 92(6): 1096-1126. https://doi.org/10.1002/sce.20277

Keengwe, J., Onchwari, G., & Wachira, P. (2008). Computer Technology Integration and Student Learning: Barriers and Promise, *Journal of Science and Technology Education*, 17(6): 560-565. https://doi.org/10.1007/s10956-008-9123-5

Kozma, R. B. (2005). National Policies that Connect ICT-Based Education Reform to Economic and Social Development. Human Technology, Volume 1 (2), pp. 117-156. URN:NBN:fi:jyu-2005355. Retrieved from http://www.humantechnology.jyu.fi https://doi.org/10.17011/ht/urn.2005355

Levin, T., & Wadmany, R. (2008). Teachers' views on factors affecting effective integration of information technology in classroom: Developmental scenery. *Journal of Technology and Teacher Education*, 16(2):233-236.

Maharaj-Sharma, R., & Sharma, A. (2017). Using ICT in secondary school science teaching what students and teachers in Trinidad and Tobago say? *European Journal of Education Studies*, 3(2), 197-210.

Mishra, P. & Koehler, M.J. (2006). Technological pedagogical content knowledge: A framework for teacher knowledge. *Teachers College Record*, 180(6): 1017-1054. https://doi.org/10.1111/j.1467-9620.2006.00684.x

Morris, D. (2012). ICT and educational policy in the UK: Are we on the way towards e-maturity or on the road to digital disaster? *Research in Teacher Education*, 2(2): 3-8.

Ottenbreit-Leftwich, A. T., Glazewski, K. D., Newby, T. J., & Ertmer, P. A. (2010). Teacher value beliefs associated with using technology: Addressing professional and student needs. *Computers and Education*, 55(3), 1321-1335 https://doi.org/10.1016/j.compedu.2010.06.002

Palys, T. (2008). Purposive sampling. In L. M. Given (Ed.), The Sage Encyclopedia of Qualitative Research Methods, Volume 2, Sage: Los Angeles, pp. 697-8.

Patton, M. Q. (2005). Qualitative Research. Encyclopedia of Statistics in Behavioral Science. https://doi.org/10.1002/0470013192.bsa514

Player-Koro, C. (2012). Factors Influencing Teachers' Use of ICT in Education. *Education Inquiry*, 3(1): 93–108. https://doi.org/10.3402/edui.v3i1.22015

Prensky, M. (2010). Teaching digital natives: Partnering for real learning, London: Sage.

Sasseville, B. (2004). Integrating Information and Communication Technology in classroom: A comparative discourse analysis. *Canadian Journal of Learning and Technology,* 30(2), 527. https://doi.org/10.21432/T23P4B

Serin, O. (2011). The effects of the computer-based instruction on the achievement and problem solving skills of the science and technology students. *The Turkish Online Journal of Educational Technology*, 10(1), 183- 201.

Spector, J. M., Merrill, M. D., Merrienboer, J. V., & Driscoll, M. P. (2008). Handbook of research on educational communications and technology (3rd ed.). New York, London: Lawrence Erlbaum Associates.

Tezci, E. (2011). Turkish primary school teachers' perceptions of school culture regarding ICT integration. *Education Technology Research Development*, 59: 429-443. https://doi.org/10.1007/s11423-011-9205-6

Trinidad and Tobago. Ministry of Education. Draft Policy for Information and Communication Technology in Education. (2005). Policy for Information and Communication Technology. Port of Spain, Trinidad: Author.

Vikashkumar, J. (2005). Technology integration in education in developing countries: Guidelines to policy makers. *International Education Journal*, 694): 467-483.

Willshire, M. (2013). Interesting, cool and tantalizing? Or inappropriate, complicated and tedious? Student and teacher views on ICT in science teaching. *School Science Review*, 95(350), 127-133.

Zhang, Z., & Martinovic, D. (2009). ICT in teacher education: Examining needs, expectations and attitudes.*Canadian Journal of Learning and Technology / The Canadian Journal of Learning and Technology, 34* (2). doi: http://dx.doi.org/10.21432/T2WK5T