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Implementing Technology for Science Classrooms in São Tomé and Príncipe

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Abstract

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Abstract

This qualitative bounded case study was designed to understand how technology integration in schools could be addressed in a first-wave country. The integration of educational technology in São Tomé and Príncipe (STP), a first-wave agricultural civilization, can narrow the divide between STP and third-wave information age societies. The conceptual framework was based on theories of change, learning, and context. Toffler's wave theory described how societies changed while Fullan's change theory examined how the people might change. Roger's diffusion of innovations addressed how processes change. Bandura, Vygotsky, and Siemen provided the framework for the learning within the model of change. Finally, the context theories of Tessmer and Richey's instructional design, Lave and Wenger's situated learning, and Sticht's functional context theory were applied. Twenty five individuals from 5 schools, including teachers, school directors, key educational stakeholders, and the minister of education were involved in a pilot project to integrate technology into the science curriculum. The data were collected via interviews, reflective summaries, and confidential narratives. The resulting data were analyzed to find emerging patterns. The results of this analysis showed that a first-wave civilization can adopt a third-wave civilization's features in terms of technology integration, when there is the support of opinion leaders and most of the necessary contextual requirements are in place. The study contributes to social change by providing access to knowledge through technology integration, which empowers both teachers and students.

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Dedication

This research is dedicated to the development and integration of educational technology in the chemistry and physics classrooms in São Tomé and Príncipe. The study resulted from work done with teachers from São Tomé between 2010 and 2012.

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Chapter 1: Introduction to the Study

The purpose of the present case study was to understand how the integration of technology in schools, for teachers, could be addressed in a first-wave country. First wave civilizations are agricultural in nature, they replaced the hunter-gatherer cultures while second wave civilizations are industrial and essentially bureaucratic societies. The third wave civilizations are knowledge based, postindustrial or information age societies. A pilot educational program was implemented in São Tomé and Príncipe (STP) to train high school physics and chemistry teachers in technology integration. Studies have been conducted on the integration of technology in distance education programs and the use of specific technology, yet no past research has been conducted on the implementation of educational technology in the science classroom in first-wave countries. STP offered the ideal conditions to explore this issue because some teachers had recently participated in an educational program in which they had received training in the integration of technology in the science classroom. Broadband communication arrived in STP at the end of 2012, providing the country with the infrastructure to implement technology in the classroom. STP is a tiny country, and the integration of technology had the potential to be easy; however, teachers needed to be properly trained in its use (Bhatti, 2010). The integration of technology provided students with the opportunity to access resources, experiment, and collaborate in ways they otherwise would not have been able to. Technology also provided the teachers with resources and knowledge bases as well as learning opportunities that would not have been accessible without it.

Background

The Internet provided people with the opportunity to interact with each other quickly and efficiently (Rogers, 2003; Siemens, 2005). With the advent of the Internet, people around the world started to use technology to collaborate and share knowledge (Siemens, 2005). Human learning involves a combination of processes through which a person experiences a social situation that transforms him or her cognitively, emotionally, or practically (Jarvis, 2006; Siemens, 2005). Information technology enabled the restructuring of educational systems and facilitated a focus on teachers' as well as students' needs (Bhattacharya, 2008; Jumani & Rehman, 2011). The way teachers taught could change, and they could become facilitators of the learning process (Siemens, 2005; Stricht, 1997; Toffler, 1970). Student-centered learning could be done at any time and in any place (Jumain & Rehman, 2011).

Since the turn of the century, developing countries have been suffering pressure to modernize their education (Garrote, Petterson, & Christie, 2011; United Nations Educational, Scientific, and Cultural Organization [UNESCO], 2009). Although these countries faced economic and developmental constraints, there were advantages in technology implementation (Bhatti, 2010; Garrote et al., 2011; Ham & Cha, 2009). Countries such as Guyana and Botswana started to use radio technology in their instruction (Mackinnon & Mackinnon, 2011; Odera, 2011). In Bangladesh the government was interested in implementing technology in education but encountered barriers with the infrastructures and personnel; , "everyone should be aware of the importance of technology in developing students' learning and should strive to overcome the barriers which prevented the use of technology in classroom settings" (Khan, Hasan, & Clement, 2012, p. 73).

Distance education has provided adult learners with the opportunity to access quality education without the need to be present at the institution, as well as the ability to learn on their own time. Distance education technologies have been considered to be a cost-effective way of rescuing struggling schools in developing countries (Kamanja, 2007; Muhirwa, 2009; Rao & Giuli, 2010). In general, the attitude toward technology and distance education, as well as the adoption of innovations, was directly related to participation in distance learning programs (Birch, 2009; Tabata & Johnsrud, 2008). The implementation of educational technology requires commitment from all stakeholders, including the government, school administrators, teachers, students, and the community (Khan et al., 2011). In the social learning approach, the observer extracts the essential elements of an observed pattern or behavior and then performs in a similar way (Bandura, 1977; Rogers, 2003). No verbal exchange of information is needed for a person's behavior to be influenced; verbal and nonverbal communication can affect behavior change (Siemens, 2005). Social computing, wherein students are able to communicate with colleagues, family, and friends all over the world, has changed the way people talk and learn. Students have been able to participate in task-oriented activities in virtual environments (Garrett, 2009; Shana, 2009).

The use of educational technology in the science classroom has provided teachers and students with opportunities for experimentation, collaborative learning, and social development without needing to have laboratories because, for example, simulations and modulations provide students with experiences that otherwise would not be possible (Finkelstein et al., 2006; Stizman, as cited in Farrington, 2011; Toffler, 1970).

Teacher training in the use of educational technology, instructional procedures, and didactics is of paramount importance for the development of the new generation of students. The potential of computer mediation to foster knowledge depended less on what learners used than on how they used it (Thompson, as cited in Shana, 2009). In the teacher training programs, the trainees were expected to develop many technology-related skills. They used productivity tools, educational software, and other available resources, which they were expected to apply to teaching in their subject area (Duran, Brunvand, & Fossum, 2009). The implementation of educational technology required commitment from all stakeholders, which included the government, school administrators, teachers, students, and the community (Khan et al., 2011).

São Tomé and Príncipe

The integration of educational technology in the science classroom in the 21st century occurred naturally in third-wave countries. The same was not true for first-wave countries where, in many cases, information technology was not readily available and educational technology was simply nonexistent. In developing countries, science labs where students could learn through experimentation did not exist in most schools, nor were student-centered instructional strategies in place. This study examined the experiences and views of teachers, school directors and members of partnership institutions on the introduction and implementation of educational technology in the *Licenciatura* program for high school teachers in São Tomé and Príncipe. This program was designed to train high school teachers in STP as well as help them infuse technology into their classrooms. The teachers in the study participated in the program for the introduction of educational technology in physics and chemistry classrooms, which was part of the *Licenciatura* program that they pursued. If educational technology in the science classroom could be implemented successfully in STP, students would have widespread learning opportunities.

The country. STP is an island nation in the Gulf of Guinea with an area of 1,000 km^2 composed of two inhabited islands, the island of São Tomé and the island of Príncipe. STP has a tropical climate with temperatures that rarely rise beyond 32ºC, and it has an extensive rainy season that extends from October to May.

History/economy. STP was discovered by João de Santarém e Pedro Escobar in the late 15th century. The volcanic soil made it ideal for sugarcane production, which made STP one of Africa's foremost exporters of sugar. By 1908, STP had become the world's largest producer of cocoa with the production of 8,000 to 10,000 tons per year. When the sugar industry declined because of superior sugar production in the West, STP became engaged in the slave trade between Africa and the West. In the 19th century, coffee and cocoa plantations were initiated; these continue to be the country's primary production centers.

The educational system. Education has been a priority in the government budget; in 2010, approximately 40% of income was allocated to the sector, where scholarships for studies abroad took up 44.5% of the Ministry of Education, Culture and Training's (MECF) budget (MECF, 2012, p. 3). Eighty-six percent of the country's youth enter secondary education, but only 13% of these students conclude this level of education. There are too many students per classroom, and of the 1,885 teachers and educators in the educational system, 60% lack the necessary pedagogical training for teaching (MECF, 2012).

Attempts have been made to modernize the educational system, and the Minister of Education who was in office from 14 August 2010 to 12 December 2012 was interested in the introduction of technology into education in STP. In 2009, the program was developed to modernize the educational system and provide new curricula to be implemented at the local schools. The project aimed at education for all was organized by a Portuguese nongovernmental organization (NGO), Instituto Marquês Valle Flôr (IMVF). IMVF went to Sao Tomé and Príncipe to collaborate with the government and help update the school programs as well as train the STP teachers (IMVF, 2011).

The IMVF project for education in STP. Since its creation, the IMVF has been dedicated to serving underprivileged people all over the world but mainly in STP, where it created an educational project (Escola+). This project aimed to contribute to the socio-economic development of STP by upgrading the education of human capital by strengthening secondary education and promoting the Portuguese language in STP. Project Escola+'s activities were divided into four areas of intervention: physical improvement of the secondary schools, improvement of teachers' skills, management and monitoring systems, and integration of professional courses at the high school level to satisfy the country's needs in terms of human resources.

ESECS-IPL and its contribution to education in STP. To guarantee a high level of quality in teacher training, the Faculty of Education and Social Sciences at the Instituto Politécnico de Leiria (ESECS-IPL), through their department of education, collaborated in the preparation and implementation of training programs for teachers, school administrators and school inspectors. São Tomé had teachers with bachelor's degrees who were capable of teaching the final years of secondary education but needed to complement their training to do so. Instituto Superior Politécnico (ISP) in São Tomé did not have faculty to provide the postbachelor programs for these teachers; therefore, ESECS-IPL cooperated by providing faculty to complement the training that would be supplied at the ISP so that the teachers could pursue their postbachelor degrees in the areas of math, physics/chemistry, and biology/geology.

A learning management system (LMS) using EDU2.0 software was created to be used by ESECS-IPL faculty and trainee teachers for resources and communication within the different courses (www.teleformacao.edu20.org). "Introduction to Educational Technology in the Physics and Chemistry Classroom" was provided using the LMS as a complement to the daily lessons where the teachers learned to use the discussion board to participate in discussions, submit their applications, find their course materials, and see their evaluations. When the 10 teachers started the course, only one had a laptop, one did not know how to use a computer at all, two did not know how to use Word documents, and only two were familiar with Excel spreadsheets. The course syllabus included topics ranging from basic word processing to the use of simulations of experiments. At the end of the course, the participating teachers all bought laptops for themselves. When the teachers enrolled in “Research Project I and II,” they worked with technology on their individual projects, and these were applied to their students.

The educational reform program implemented in the middle and secondary school was developed by IMVF. The problem of teacher unpreparedness could not be resolved with a few training sessions. The ESECS-IPL’s support for the postbachelor programs filled the gap, yet only the program for the *Licenciatura* in chemistry and physics had a course to prepare the teachers to work with educational technology in their field of study. This program trained a limited number of teachers, and it was necessary to determine their perceptions of the program and the importance of the integration of educational technology in education in STP. The implications for social change of this study were significant, as the teachers’ training programs helped to prepare the teachers better. Training the teachers in the integration of technology in the classroom brought a different dimension into the class and consequently brought STP closer to the rest of the world.

Importance of Present Study

The study contributed to the body of knowledge by providing understanding of how the integration of educational technology in the science classroom for teachers in a first-wave country could be addressed. It was important to understand to which extent educational technology and distance education were useful to the development of STP’s educational system. The study revealed itself to be useful for teachers, school directors, ministry of education officials, and company managers interested in a more technology-efficient workforce for their enterprises. The study was also important for the IMVF and the ESECS-IPL in showcasing the work they have accomplished in STP.

Problem Statement

Although technology possesses the potential to improve education to a considerable degree, developing countries have encountered many barriers to its implementation (Khan et al., 2012). Developing countries lacked funding for the development of their educational systems "Effective implementation of technology into education systems involved substantial funding, that was very hard to manage in developing countries" (Khan et al., 2012, p. 68). Offerings of distance education courses have been growing throughout developing countries (Rao & Giuli, 2010). The integration of technology in developing countries has been essential to many (Bhatti, 2010; Lateh & Muniandy, 2011; Mackinnon & Mackinnon, 2010; Tedford, 2009). The focus of the project to develop the quality of information and communication technology (ICT) for rural schools has been the use of technology to deliver instruction to teachers or other professionals. In Thailand, a project for developing quality of information and communication technology for rural schools was conducted to implement technology in classrooms, and the teachers involved were trained in computer use (Chansiri, 2011). Simulations and modulations to enhance student understanding, participation, and motivation in the classroom had not been used in prior research in developing countries.

In STP, schools have been receiving donations of computers, and the telecommunications company in the country, Companhia Santomense de Telecomunicações (CST), provided basic Internet coverage for most schools that reduced the funding needed for the investment. The majority of the high schools did not have chemistry or physics laboratories, and therefore students did not have access to experimentation. The educational system was mainly oriented toward teacher-centered education instead of student-centered education. In STP, a pilot program was designed to provide teachers with better qualifications, specifically providing teachers who held bachelor's degrees with the *Licenciatura* in the same area. The partners in the program included ESECS-IPL, which provided most of the faculty for the courses in the program, and ISP, which provided the physical space and some faculty for the courses. The IMVF was responsible for financing the program, which was within their objectives for the development of education in STP.

There has been limited research on teachers training to implement technology in their classrooms, particularly in countries with limited resources. Thorough teacher training in the use of educational technology in particular sectors of knowledge would enhance teaching and would benefit students. Through the use of educational technology, future generations could have access to the same educational opportunities as have youngsters from developed countries, thus taking on third-wave features of development. No research was found regarding third-wave civilizations' features in terms of technology integration in schools in first-wave countries, and this constituted the gap for the research.

Purpose of the Study

The purpose of this qualitative case study was to understand how technology integration in schools, for teachers, could be addressed in a first-wave country. A pilot program was designed to train high school science teachers in STP to infuse technology into their classrooms. The perceptions and experiences of the teachers, the directors of the schools where these teachers worked, members of the partnership institutions (board members of IMVF, two IMVF teachers who worked with the teachers, the project leader of the teacher development program at ESECS-IPL, two ESECS-IPL faculty members who trained the teachers, the head of physics department at ISP, the head of the technology department at ISP, a faculty member at ISP), and the former minister of education were sought. The participants were asked to share barriers and supports related to the program and to make recommendations for further implementation and future programs.

Research Questions

What are the experiences and perceptions of the individuals involved with the integration of technology into a first-wave country?

1. What are the experiences of the teachers in STP during the implementation of the program?
2. What are the experiences of the representatives of the partner organizations and the directors of the schools during the implementation of the program?
3. What are the experiences of the former minister of education during the implementation of the program?

Conceptual Framework

The framework for this study was based on a combination of the theories of change, theories of learning, and context theories. People in a third-wave society would use simulations and students would be more reflective of what they really wanted to learn; this would occur in a social manner wherein they would learn in real-world situations as well as through games and simulations (Toffler, 1980). To implement change, a process of change that involved teacher motivation, capacity building, learning in context, social learning, reflection, trilevel engagement, and finally persistence and flexibility would be put into place (Fullan, 2006). This process of change would need to take into account the communication channel in the innovation process “Diffusion is the process by which the innovation is communicated through certain channels over time among the members of a social system” (Rogers, 2003, p. 11).

The process of change was based on the premise that people are able to adopt behaviors that they observe and that they are most likely to adopt those behaviors that people value most (Bandura, 1977). Social interaction is central to complex thinking, and students’ mental abilities develop through discovery and are influenced by social and cultural environments (Vygotsky, 1978). The majority of learning occurs in an informal manner, and learning is a lifelong process (Siemens, 2005). There is nonetheless too much information for one person to assimilate alone, so people need to join networks where they can learn from the experiences of others and where they can share their experiences (Siemens, 2006). In essence, people learn by observing others in their behaviors and adopting these practices according to their own capacities, which can be done with technology. As technology was included and connection learning was promoted, knowledge flow became too rapid for any other learning theory to interpret (Siemens, 2005).

Learning not only occurred through the application of learning theories; context factors also needed to be taken into account. Context could inhibit or facilitate learning, and there could be many contexts for one learning experience (Tessmer & Richey, 1997). Context factors that involved the locations where the teachers and students lived, their level of preparedness, their economic background, their culture, and their educational setting also influenced learning (Lave & Wenger, 1991; Stricht, 1997; Tessmer & Richey, 1997). Tessmer and Richey (1997) proposed an instructional design model to promote learning that involves the orienting context, the instructional context, and the transfer context. Situated learning depends on the activity; the context and culture in which learning occurred and social interaction was imperative (Lave & Wenger, 1991). Learning occurred within communities of practice where the learner had the opportunity to become immersed in the learning situation and had a chance to participate, similar to an apprenticeship (Lave & Wenger, 1991). Functional context theory suggested a need for the creation of courses to facilitate learning at the beginning of the process and throughout the process in order to indicate how to apply what had been learned (Stricht, 1997). The students needed to be well informed about what they were going to learn, why they were going to learn it, and its usefulness to them. Here, once again, the knowledge the student needed to acquire was built upon the learner's prior knowledge, and this knowledge was necessary for adult as well as youth education.

In STP, a first-wave country, the contextual framework, as well as the diffusion of educational technology, was analyzed, and the principles used to implement change were presented. These policies were based on a combination of theories of change, theories of learning, and context theories. The part played by the teachers, the school administrators, and Ministry of Education officials in the change process was presented and discussed. In STP, where teachers did not use computers at school and where most teachers did not understand the importance of technology in the classroom, the integration of technology was done in a way that motivated the teachers so that they could become the promoters and diffusers of the use of technology in the classroom. Teacher motivation was managed by providing training and creating learning opportunities whereby the teachers could experience, through hands-on activities, how technology worked in the classroom and by showing them how the use of technology in the classroom could enhance student learning. They also saw how they could prepare the students better for their integration into the country's workforce and how they could prepare them to work with technology, similarly to people in third-wave countries.

Nature of the Study

The study was a qualitative case study. The goal was to understand how technology integration in schools, for teachers, could be addressed in a first-wave country. A technology training program for physics and chemistry teachers was implemented in STP during 2010-2012. In qualitative research, researchers make philosophical assumptions about what the participants think and believe, the way they acquired knowledge, the role of values in the research, the language in the study, and the methods used (Creswell, 2007). Data were collected through interviews with the teachers who participated in the program, the directors of the schools where the teachers worked, board members of IMVF, two IMVF teachers who worked with the teachers, the project leader of the teacher development program at ESECS-IPL, two ESECS-IPL faculty members who trained the teachers, the head of physics department at ISP, the head of technology department at ISP, a faculty member at ISP, school directors, and the former minister of education. There were 25 people who participated in the study.

Participants invited to take part in the research received a consent form (Appendix A) in which they were informed about the objectives of the research. The same information was supplied at the time of the interview before it started. The participants were interviewed using Skype, and the interviews were recorded. The interviews were semistructured based on questionnaires (Appendix B, C, D, and E) and lasted less than 60 minutes each. Transcript (Appendix F, G, H, and I) review and member checking were used. The teacher participants were asked to complete additional narratives (Appendix J and K) to give them the opportunity to reveal information that they did not provide during the interviews. A coding system (Appendix L) was used to support data analysis. NVIVO's filing system was used for data storage and interpretation.

Definitions

Although there may be different meanings for different people of some of these concepts and terms, in this study they were identified as follows.

Educational technology: "Study and ethical practice of facilitating learning and improving performance by creating, using, and managing appropriate technological processes and resources" (Richey, 2008, p. 24). "Educational technology is the combination of instructional, learning, developmental, managerial, and other technologies as applied to the solution of educational problems" (Gentry, 1991, p. 8).

Developing country: A nonindustrialized poor country seeking to develop its resources through industrialization (Farlex, 2013).

Licenciatura: Four- to 6-year university programs that are confined mainly to some European countries and became extinct with the Bologna Treaty (1999), which aimed at converging the European higher education programs. It is a university degree that is intermediate between a bachelor's degree and a doctorate (Farlex, 2013).

Delimitations

The study was a case study that was limited to the science teachers who participated in the *Licenciatura* program in physics and chemistry and to the primary stakeholders in the educational forum in STP. Because the focus was on experiences and perceptions of teachers who participated in the program on integration of educational technology in the physics and chemistry classroom, the study excluded the perceptions of teachers who were not in the program. The stakeholders involved in the study all participated directly or indirectly in the project. The school directors chosen to participate were the directors of the schools where the teachers taught at the time. There were 25 participants in the study.

Potential Design and/or Methodological Weaknesses of the Study

The outcomes of a case study depend on a small number of participants and may only be meaningful to a particular case, not being generalizable (Hodkinson & Hodkinson, 2001). The fact that this study was not generalizable was one of the great limitations of the qualitative approach in comparison to the quantitative approach. The results could not be transferred or even extended to larger populations with any degree of certainty. Case studies are thought to produce a lot of data over time (Zainal, 2007) but are sometimes also accused of lack of rigor and objectivity (Hodkinson & Hodkinson, 2001). The current research is not representative of all physics and chemistry teachers, or of STP teachers in general.

Assumptions

The study focused on interviewing participants who were directly or indirectly involved in a pilot educational program that took place in STP. The study was based on physics and chemistry teachers who participated in the program, in an attempt to understand their thoughts and feelings on the successful integration of educational technology in the classroom. The participants who were chosen were knowledgeable about the program. Further, the study was based on the assumption that the teachers, school directors, members of the partnership institutions, and the minister of education participated willingly and responded honestly to the interview questions. It was assumed that the interview and narrative responses reflected the actual perceptions of the participants on the support provided.

Limitations

Because this was a case study, the results could not be generalized (Hodkinson & Hodkinson, 2001). In this case study, the greatest limitation was that the teacher participants were my students in three courses for physics and chemistry teachers in the Licenciatura program which took place between 2011 and 2012. Some of the participants could be reluctant to participate in the interviews or hesitant to answer questions in a way that could be perceived as negative. These teachers were former students whom I no longer have any power over. I could not exclude these individuals from the study because they were the only teacher participants in the program. In order to reduce the risks of feelings of coercion to participate, I assured the participants that their involvement in the study was confidential, that their participation was entirely voluntary, and that at any point in the study, they could withdraw their participation. The participants were assured that my role was that of a doctoral student and not of their instructor, and that it was not my role to judge; I simply needed to collect data (Patton, 2002). The purpose and benefits of the study were explained, and the interview was conducted to obtain the necessary information.

Significance of the Study

This study contributed to the body of knowledge on educational technology that is applied in countries with limited resources. By understanding and explaining the extent to which the teachers in STP were able to implement technology in the classroom and through the analysis of the data provided, a plan for the optimization of technology use in the science classrooms could be put into place. The study also contributed to the understanding of the importance of context in the implementation of educational technology in a developing country and the importance of having the different stakeholders involved in the process. The study was important for the interested parties in the educational system in STP. The case study provided data that could be used for other projects in developing countries with similar characteristics as STP.

The study was aimed at understanding and preparing a plan for the development of an educational system where students are able to use technology to learn and be connected to the rest of the world in terms of access to knowledge and technology use to support learning. Through the efficient and sustainable use of educational technology and distance education programs, students in remote areas are able to access quality education, and in so doing, they may advance the country's social capital to support its development.

Summary

Given the history, social context, economic situation, and educational system of São Tomé, it was easy to understand that change was needed. The change contemplated in this chapter was in the educational sector, where IMVF created a program called Escola+. The program Escola+ contributed to the socioeconomic development of STP by upgrading the education of the human capital, by strengthening secondary education and promoting the Portuguese language in STP. The present qualitative case study was designed in an effort to explore and understand the perceptions and experiences of teachers in the implementation of educational technology in the science classroom. A higher education Licenciatura program was set into place and implemented by faculty from the ESECS-IPL in Portugal and ISP in São Tomé. The prerequisite for the teachers to be part of the program was having a bachelor's degree. The case study focused on the chemistry and physics teachers in São Tomé who learned to use and apply educational technology in their classrooms. The program started in 2011, and it was completed by the end of 2012. It provided examples of how educational technology could be implemented in the country and in so doing promoted social change.

By reviewing many articles that focused the same problem in other developing countries, I found a gap in the research concerning teachers training in the introduction of educational technology into science classrooms. The study was a qualitative case study that aimed to understand the perceptions and experiences of those teachers who took part in the training and were willing to participate. Relevant stakeholders related to education in STP, the former minister of education, board members of IMVF, two IMVF teachers who worked with the teachers, the project leader of the teacher development program at ESECS-IPL, two ESECS-IPL faculty members who trained the teachers, the head of physics department at ISP, the head of the technology department at ISP, a faculty member at ISP, and directors of the schools where the teachers who participated in the course worked all participated in the study. All these people were contacted to determine whether they were willing to be part of the study. The research questions were formulated to understand the teachers' experiences during and after participation in the educational technology teacher training, as well as the thoughts of the main educational stakeholders about the integration and diffusion of technology in the educational system. The conceptual framework, which involved theories of change, theories of learning, and context theories, was presented. Through the literature review, I sought to acquire information on the research that had been done in developing countries in the area of educational technology, specifically the physics and chemistry classroom.

Chapter 2: Literature Review

The present literature review represents a synthesis of the literature concerning the integration of technology in developing countries. The focus of this literature was mainly on the integration of technology in education. Literature on teachers training in the use of technology was represented. The study was based on the assumption that thorough teacher training in the use of educational technology in the teachers' specific fields of knowledge as well as in new educational strategies would enhance their teaching and consequently benefit their students.

The problem to be addressed by this case study focused on science teachers and the lack of knowledge they had of educational technology that they could use to enhance student learning in their classrooms. The majority of the high schools did not have laboratories and therefore offered no opportunities for experimentation; alternatives such as simulations, modulations, videos, an interactive periodic table, and games had potential to help students gain a better understanding of the phenomena they needed to learn. Educational technology (in particular, simulations and modulations) to enhance student understanding, participation, and motivation in the classroom had not been used in prior research in developing countries. The educational systems in these countries were mainly oriented toward teacher-centered education instead of student-centered education. The purpose of this qualitative case study was to explore and to understand the perceptions and experiences of teachers and other stakeholders related to teacher training and implementation of educational technology in STP. The use of modulations, simulations, interactive periodic tables, multiuser virtual environments, cloud-based collaboration, and presentation tools could enhance student learning.

The theories and concepts that created a framework upon which the research could be set were represented at the beginning of the literature review. In this research project, theories of change, theories of learning, and theories of the importance of context in the implementation of change served as a framework. First, the focus was on the theories of change: Toffler's (1980) wave theory, Rogers's (2003) diffusions of innovations theory, and Fullan's (2006) change theory. Toffler's wave theory was the origin of the concept that developing countries could transition directly from a first-wave agricultural society directly to a third-wave technology-based society, as they had many social similarities. Rogers's diffusion of innovations theory was then used to address the process and time that were needed for an innovation to be adopted successfully. Fullan's change theory focused on the process to bring about change. Discussion then went to the theories of learning: Bandura's (1977) social learning theory, Vygotsky's (1978) social development theory, and Siemens's (2006) connectivism theory, which reflected on the world where people collaborated, ran businesses, shared ideas, and shaped a new world with people they would never meet personally. People develop their ability to function using different skills and become skilled at analyzing and interpreting meaning in the tone of voice or a lifted eyebrow in the physical and virtual environments (Siemens, 2006). Next, the context theories were scrutinized: Tessmer and Richey's (1997) role of context in learning and instructional design, Lave and Wenger's (1991) situated learning, and Sticht's (1997) functional context theory. Finally, articles on educational technology, distance education in developing countries, access to education, educational technology in the science classroom, and the context factors influencing the adoption of educational technology in developing countries were analyzed.

Search Strategy

I started to search for articles in the area of educational technology in developing countries in science classrooms and context factors that influenced the implementation of technology in education. The databases used were Education Research Complete Database, Eric, SocIndex, and Academic Search Complete. Google Scholar and Google search engines were also used to track articles in the field. The strategy was to access the most appropriate articles. In order to find these articles, the keywords were joined together using the Boolean operator AND in order to narrow down the research results and not come up with information that was too vague or not necessary. The date from which to start the research was specified as 2009, and peer-reviewed articles were selected. The search terms used for the articles that were analyzed were *educational technology*, *developing countries*, *distance education, virtual laboratories*, *science education*, *technology integration*, *principals*, *teacher training*, *diffusion of innovations*, *context*, and *social learning*.

Conceptual Framework

The phenomenon that was the topic of this research was a change process that involved teaching strategies and the use of technology to support these strategies. This phenomenon was studied from the perspective of the teachers who received the training and the educational stakeholders in the country. The stakeholders who participated were the past minister of education, personnel from the IMVF with the Escola+ project, the ESECS-IPL, ISP, and the school directors.

It was important to view Toffler's wave theory, Rogers's diffusion of innovations theory, and Fullan's change theory in order to formulate an idea of how change could be implemented and the channels that could be used. Before the change could be achieved, it was necessary to know how students learn best; Bandura's social learning theory, Vygotsky's social development theory, and Siemens's connectivism theory provided this information. These concepts of learning and change were not enough to help in implementing change because change and learning do not happen in the same way everywhere. Therefore, an understanding of context became increasingly necessary. The context theories viewed were Tessmer and Richey's (1997) "multilevel body of factors in which learning and performance are embedded"; Lave and Wenger's (1991) situated learning theory, which involves consideration of the activity, context, culture, and social interaction in which learning occurs; and Stricht's (1997) functional context theory, which suggests the creation of courses that facilitate learning on entry and throughout the course, and that enable the transfer of this knowledge to real-life situations.

Within every set of theories, there were several benefits of the framework for the current research. In the change theories, Toffler (1980) stated that the third wave had much more in common with the first wave than with the second wave, which made it easy for a first-wave country to transition to third-wave practices (p. 337). The integration of educational technology in the science classrooms in STP would provide validation. It was necessary to appreciate the importance of Rogers's opinion leaders and change agents in the change process because the government had changed at the end of 2012, and the new orientations were different from the previous ones. Fullan's steps to implement the change process were necessary for adjustment in the change process. In terms of the learning theories, Siemens's connectivism theory integrated Bandura's social learning and Vygotsky´s social development theories where people are connected to the knowledge sources. People not only learn from personal experiences, but also rely on the knowledge and experience available for all, which is in accordance with the integration of technology in education. These aspects needed to put into context "a multilevel body of factors in which learning and performance are embedded" (Tessmer & Richey, 1997. p. 87). Tessmer and Richey's instructional design model was divided into three parts: students' need to be motivated, students' need to learn, and students' need to transfer what they have learned into a professional context. It was also important to consider the cultural and developmental context where the learning process was going to be situated (Lave & Wenger, 1991), as well as the importance of the application of what was learned in order to increase motivation (Strucht, 1997).

The current study benefited from this multilevel framework because the situation was not a simple integration of technology in a place where technology had been implemented in the past; it constituted an innovation that had not been tried before in the country. The success of the continued implementation of technology in the classrooms in STP, specifically in physics and chemistry classes, depended on the careful consideration of all these factors. The current literature in this area focuses on globalization and educational technology, technology in developing countries, technology in science classrooms specifically, access to education through technology, context factors, teaching and learning, lifelong learning, and eacher training.

Theories of Change

Toffler's wave theory. Wave theory (Toffler, 1980) focuses on the phases of evolution that societies faced and compares them to waves that disappear when the new wave appeares. Initially people were hunters and agriculturists, followed by people who worked in the industry, and in turn followed by a small percentage of people of the future who belonged to the technological society (Toffler, 1980). The concept of family changes, and society changes with it; people would use simulated environments, such as computer games, for entertainment (Toffler, 1970). In this society, many jobs would be performed from home where people would be able to work collaboratively in an online environment. Women would have jobs and have less time for motherhood. Therefore, children would grow up in much less child-centered society. Many jobs would be substituted by automatic machinery. Companies could lure the best people away from other firms wherever these were resulting in their migration from one place to the another because they had been offered better work opportunities and had changed jobs (Toffler, 1980).

High-speed change would be due to factors such as population growth, urbanization, shifting proportions of young and old people, and most of all technology (Toffler, 1980). People would become so accustomed to using technology that it would become part of them: "the technology of tomorrow requires men with technology in their bones" (Toffler, 1970, p. 403). School structures and curriculum would become more focused, and parents would be able to choose the courses for their children to take for short periods of time (Toffler, 1970). Students could be far from the pressure caused by their colleagues and become higher achievers. Students would move to game-based learning. They would not all study the same courses nor do the same things. Yet, they should have a common ground where they could learn everyday skills, so that they could communicate which is necessary for their social integration (Toffler, 1970). More students learning would occur in the real world, and they would interact with people of other generations, transforming education into a mesh of different experiences. Students would become more reflective of what they wanted for themselves in the future and how they see themselves as well as those around them (Toffler, 1970).

Fullan's change theory. "Having a 'theory in use' is not sufficient, of itself. The people involved must also push to the next level, to make their theory of action explicit" (Fullan, 2006, p. 3). The change theory can be powerful when used by people who have deep knowledge of the dynamics of how to operate to get certain results in educational reform (Fullan, 2006). Teachers, who intend to help students develop skills and competencies of knowledge creation, would need to acquire experience in this area. There are seven core premises that need to be taken into account when attempting to implement change. The first premise focuses on motivation where teachers need to feel motivated and engaged in the change process. The second premise focuses on capacity building that involves helping develop knowledge, competencies, resources, and motivation. The third premise involves the creation of opportunities for learning in context, where the teachers have the chance to learn about their practice in actual work settings. The fourth premise involves changing the context, providing the opportunity for the teachers to interact and learn from teachers in other schools, promoting a knowledge flow and identification with a larger part of the system. The fifth premise involves reflective action, where purposeful thinking is encouraged. The sixth premise involves tri-level engagement that is the involvement with the school, the community, the district, and with the state. The seventh and last premise requires persistence and flexibility in staying on course. It is necessary to be among the people promoting educational reform instead of waiting for it to happen (Fullan, 2006, p. 14).

Rogers's diffusion of innovations. Diffusion is the process in which an innovation is communicated through different channels over time among the members of a society, and communication is the process in which people created and share information in order to understand each other (Rogers, 2003, p. 5). Most of the innovations analyzed are technological innovations that benefit the potential users. Young scientists are attracted to fields of study that have a new paradigms either because of the gaps that exist or because they want to be part of the diffusion of the innovation. Technology contributes significantly to the change of paradigms and mass media has been shown to be the best way to create awareness about an innovation (Rogers, 2003).

The diffusion of innovations is controlled by four principal elements which are the innovation itself, the ways in which it transmits to society, the medium through which it is communicated, the time that it takes to be implemented, and the members of the society in which the innovation is transmitted (Rogers, 2003). The time the innovation takes to be implemented depends on the people to whom the innovation is spread and the advantages that it brings to their lives. There are individual communication channels which may or may not support the implementation of the innovation. The first step is the innovation itself followed by the person who has knowledge in using the innovation, the people that need the innovation, and then the communication channel. There are mass media communication channels which are the fastest and most efficient, the interpersonal channels, and an interactive communication channel which is the Internet.

The structure of a social system can either make the diffusion of an innovation easier or more difficult (Rogers, 2003). If the opinion leaders and the change agents of a society do not see the advantages of the innovation for them, they will likely ignore it and therefore make the diffusion process more difficult. On the contrary if the opinion leaders of the society think that the innovation will benefit to them, they will influence the diffusion of the innovation, narrowing the time to implementation and adoption of the innovation (Rogers, 2003).

The opinion leaders and the change agents are usually the most innovative people in a society. They need to be credible in order to influence the attitudes or behaviors of the society in the way that they plan. An opinion leader is normally the person that influences other peoples' opinions frequently. When a society is oriented to change, the opinion leaders are more innovative, but when a society's customs oppose change, the behavior of the opinion leaders reflects this. Factors that greatly influence the rate at which an innovation can be adopted in a society is the quantity of publicity behind the innovation. Rogers believed that those with lower income need more communication with change agents. "It is as unthinkable to study diffusion without some knowledge of the social structures in which potential adopters are located as it is to study blood circulations without adequate knowledge of veins and arteries" (Katz, 1961 cited in Rogers, 2003, p. 25).

Theories of Learning

Bandura's social learning theory. People learn social behaviors mostly by observing others. They follow the success that each of these behaviors have as well as the consequences. Therefore, they are most likely to adopt practices that have the approval and were more successful instead of those that did not. Social learning does not require external reinforcement. A lot of it happens from casual and direct observation of other people's everyday behaviors where the observers form their ideas of how these actions are performed. These behaviors then serve as a guide for future actions that these people could perform. The social learning theory explains human interaction as being a reciprocal interaction between cognitive, behavioral, and environmental influences (Bandura, 1977). Actions performed in substitution of others and self-regulatory activities play a valuable part in social learning. People's responses to various situations can only be evaluated adequately when a range of environmental values are included (Bandura, 1977). Social learning is self-regulatory. By providing cognitive support and knowledge of the consequences, people are able to control their behavior. Modeling is influential in spreading new ideas and practices in a society and between societies. When behaviors result in outcomes that people value, they are more likely to be adopted in modeling than behaviors that have results that people do not value. "The process by which someone develops interest in activities in which they initially lack interest is very important" (Bandura, 1982, p. 133).

Self-evaluation is a meaningful part of social learning as it serves as an incentive for conduct. The people's levels of self-satisfaction or dissatisfaction are not only measured by accomplishments but by comparing them against standards set by the individual (Bandura, 1977). After people set standards for themselves, such standards influence their behavior and provide them with a sense of self-direction.

Vygotsky's social development theory. Vygotsky (1978) characterized aspects of human behavior and offered responses to their formation over the centuries and throughout a person's life. He questioned relationships between people and their environment, the forms of activity that established labor as the means of relating people to nature, and the relationship between the use of tools and the development of speech. Social interaction is central to the development of complex thinking. Vygotsky's theory is the foundations of constructivism. According to Vygotsky student's mental abilities develop through discovery and are greatly influenced by their cultural and social environments. "Human learning presupposes a specific social nature and the process by which children grow into the intellectual life of those around them" (Vygotsky, 1978, p. 88).

Siemens's connectivism theory. Informal learning plays an important part in the learning process and the majority of learning occurs in an informal manner (Siemens, 2005). Learning is a lifelong process which is not separate from work activities; they are similar in many situations with rapidly shifting core elements and connection making.

Developmental and formative learning occurs in the form of courses where the students can explore new ideas. Exploratory and inquiry-based learning provides depth of learning and understanding through research. Learning is constructed from cognition and reflection where the learner acquires knowledge and uses this knowledge to innovate and develop higher level thinking. Learning theories are concerned with the learning process and not with the value of what is learned (Siemens, 2006). People need to evaluate the worthiness of learning even before the learning process begins. Learning through experience is considered the best way to acquire knowledge. Since people cannot experience everything, other people's experiences serve to collect knowledge (Siemens, 2005).

Learning and knowledge occur in networks. In a networked society, even the simple form of getting information is significant and worth investigating. The filtering agent is the person who connects to the networks that work best for them, instead of having anybody else in society choose for them. Learning becomes a lifelong process which occurs continuously in people's daily lives. People have moved from a society where learning was done separately, to a society where learning occurs during the people's daily normal activities.

According to Siemens, technology makes people's brains work differently, and a lot of the information that was handled by learning theories started being supported by technology. Theorists have revised and evolved theories because the conditions have changed, and that has happened substantially due to technology. By including technology and activities that promote connection learning, theories have moved into the digital age

(Siemens, 2005). People save time by having technology manage some of the content while they take more time interacting.

In learning and knowledge ecologies, the knowledge flow is so rapid and complex that no other learning theory is able to process or interpret it. Some of the processing and interpretation functions of knowledge flow can be offloaded to nodes within the learning network. Instead of the person needing to evaluate every piece of information they create a personal network of trusted nodes: with people and content enhanced by technology. These ecologies possess characteristics that need to be seen during the design process. An efficient network is required to allow space for professionals and beginners. There needs to be a space for interaction, for debate and dialogue. There is also the need for locations to search for archived knowledge, to learn in a structured manner, communicate new information and knowledge and a space to nurture ideas. Finally there needs to be a place to test new approaches, prepare for new competition, and to develop pilot processes. Innovation requirs trust, openness, and experimentation to enhance creativity and re-create. Learners possess personal learning network's and the networks health depends on the suitability of ecology in which the learner exists. Healthy knowledge ecology allows individuals to enhance their existing learning, enabling them to make better decisions and perform better (Siemens, 2006).

Technology opens doors to communication and conversation between people from totally different places in the world. People are able to connect and share knowledge and information with family and friends they had in other countries. People have learned to see that there is not only one point of view on any one subject, nor is there any certainty. The separation between the physical and digital world has become blurry. People collaborate, run businesses, share ideas, and shape a new world with people they may have never seen. People develop their ability to function using different skills and have become skilled at analyzing and interpreting meaning from the tone of voice to a lifted eyebrow in the physical and virtual environments (Siemens, 2006).

Context Theories

Role of context in learning and instructional design theory. Context theories consider learning as being influenced by the whole environment or background situation in which the learner is found. "Context is then a multilevel body of factors in which learning and performance are embedded" (Tessmer & Richey, 1997, p. 87). There are a variety of underlying assumptions in the role of context: it is an inevitable part of learning; it can inhibit or facilitate learning; there can be multiple contexts for one learning experience; successful learning is applied in its intended environment; there is accommodation of instructional design to fit context and adjust contextual factors to facilitate instruction; successful instructional design should be specific to the situation in which it applies; and finally that approaches to instructional design related to the system are more effective than standardized approaches (Tessmer & Richey, 1997).

Tessmer and Richey (1997) proposed an instructional design model which influences learning and performance. It is divided into three different parts: the orienting context, the instructional context, and the transfer context. The orienting context precedes learning and influences student motivation, setting goals and preparing students for the learning experience. The instructional context is directly involved in the process of instruction while the transfer context relates to the setting where the knowledge is acquired and skills will be applied. There are different levels of orienting, instructional, and transfer contexts which depend on learner factors, immediate environmental factors, and organizational factors.

Situated learning theory. Situated learning depends on the activity, context, and culture in which it occurs. Social interaction is a crucial part of this type of learning (Lave & Wenger, 1991). This theory is based on the principle that knowledge needs to be presented in an authentic context, and it requires social interaction and collaboration. Learners participate in communities of practitioners, learning within the community by participating and discovering all the intricacies of the community. Legitimate peripheral participation provides relations between pupils and members of the community.

Situated learning depends on the observation, repetition, and reproduction of what is done in the community, having at its core Bandura's social learning theory. Lave and Wenger believed that communities of practice evolve because the learners become specialists within the community and are able to teach others what they have learned themselves, all within the situated learning concept which is from peripheral learning to full participation.

Functional context theory. The application of this framework to instructional development suggests the creation of courses that facilitate learning on entry and throughout, and that also enables the transfer of this learning to real life situations where it is meant to be applied (Stricht, 1997). The implementation is through explanation of what the student will learn, the reason why, and the usefulness this knowledge will have to them. Students' prior knowledge should be used as a basis on which to build the new knowledge, facilitating the students' entry into the learning situation, followed by lessons which always build upon knowledge already attained by the pupils. All tools used in the learning process should be contextualized, using as much as possible situations, materials, and procedures taken from future work situations which facilitate the students' transfer into these tasks and situations (Stricht, 1997).

Functional context education is necessary for adult education as well as youth education because it focuses on providing relationships between what the students learned and its application in their lives after the program, providing increased motivation as well as the capacity to transfer what is learned (Stricht, 1997).

Technology in Education

McLuhan, M. (1964), Rogers, E. (2003) and Toffler, A. (1970), predicted that learning would occur in different ways where students would use educational technology and play an active role in their own learning process. Education leads to discovery, probing, and exploration (McLuhan, 1964; Rogers, 2003; Toffler, 1970). Students learn through constructive development of knowledge (Vygotsky, 1978). Teachers change the way they teach (Siemens, 2005; Stricht, 1997; Toffler, 1970). They become more involved as facilitators of the learning process to be undertaken by the students. The more teachers use technology in education the more they realize the benefits it brings to their teaching practice (Cakiroglu, Akkan & Guven, 2012; Fullan, 2006). Cakiroglu et al. performed a case study using a mixed method approach which considers the integration of technology at school and uses interviews, observations, and surveys as their data collection tools. In the teacher preparation programs at most higher education institutions, educational technology courses are provided in order to introduce fundamental technology concepts because stand-alone technology courses are no longer considered sufficient for preparing teachers to use technology for educational purposes in their classrooms (Duran et al., 2009). A constructionist approach to learning where the teachers act as facilitators is coherent with the use of the Web 2.0 technologies and has proven to be advantageous in educational projects (Brunello, 2010). Students become self-learners as they use more and more information technology in their learning (Tavakol, 2009). The introduction of educational technology in schools enables the restructuring that is necessary to meet higher educational goals, and it has a stronger impact if it is complemented with educational reform (Bhattacharya, 2008; Jumani & Rehman, 2011). Jumani and Rehman's study focused on the use of educational technology for teaching purposes at the Allama Iqbal Open University in Pakistan, which they studied through the use of questionnaires. "Educational technology helped focus on both teacher and learners needs and assisted in identifying the application of modern techniques in the teaching/learning process" (Jumani & Rehman, 2011, p.763). On the other hand, Bhattacharya informed that there is considerable progress in information technology in general and in the opportunities it provides for generation, use, and implementation of materials for educational purposes. A virtual classroom and laboratory were built at the center for educational technology that aimed at "reproducing hands-on laboratory experiments through advanced modeling and simulation techniques" (Bhattacharya, 2008, p. 95).

Globalization and Educational Technology

Toffler (1980) believed that while countries fight to maintain their identities, borders have become less important in the world of technology that brings with it globalization and diversity. In high technology, world countries are no longer significant although they can maintain their identities (Toffler, 1980). Societies offer a great variety of goods that contrast with the standardized products that are currently distributed around the world (Toffler, 1970). Society is an open network of relationships between "global" and "local" where the local fights for its place in the "global" (Jarvis, 2006). Globalization has generated new conditions for ideals to change and makes people think beyond their society (Jarvis, 2006). The internet gives people the opportunity to interact with each other very quickly and efficiently (Rogers, 2003; Siemens, 2005). Emails have revolutionized the communication system because people can send emails to each other anywhere in the world instantaneously (Rogers, 2003).

Information technology dilutes the barriers between countries, creating a global village. Globalization is responsible for economic, political, and cultural changes (Watkins, 2006). These statements are in accordance with Toffler’s (1970) perception of the global economy which renders individual nations a less influential role. Some problems that were too large for individual countries to cope with can be resolved collaboratively by a group of nations.

Human learning is a combination of processes through which the whole person, body and mind, experiences a social situation which transforms them cognitively, emotionally, or practically (Jarvis, 2006; Siemens, 2005). The shift in the economy and the political structure implies a change in knowledge and global world knowledge can be exchanged easily and very quickly (Siemens, 2005; Watkins, 2006). Decentralization provides possibilities for greater regional diversity in education by creating curricula that is more motivating and necessary to the region. Child-centered pedagogy becomes the preferred method for learning. The learning society is composed of growth, globalization, knowledge types, and learning.

The more evolved the technology in the country, the greater the literary diversity is. According to Rogers people link to each other through closed networks that do not require much effort, although he also believed that these networks were of limited value as they do not provide information about innovations. On the other hand, networks with socially and spatially distant people would be productive in providing information about innovations (Rogers, 2003). Rogers advised that if people wish to receive information effectively they need to break loose from the closed networks and move toward the distant networks where they can interact with people who are spatially remote as well as socially distant. People will belong to networks of practice, where the members have the same interests as they do, and this provides them with access to a greater quantity of knowledge (Siemens, 2005). "Effective and efficient teaching-learning process was potentially possible at any time and any place in any discipline. It promoted a shift from teacher-centered education to student-centered learning" (Jumani & Rehman, 2011, p.763). In Nepal education became more modern mainly due to the integration of technology, although the rapid succession of governments and the political instability provided the opportunity for less investment with poor technology policies (Shields, 2011). Globalization in higher education entails commercial knowledge transfer and international study offers (Jumani & Rehman, 2011).

Educational Technology in Developing Countries

Progressive education became a tool that enabled students to become active participants in a democratic society, while authoritarian education undermined a democratic and equal society (Andersson & Hatakka, 2010; Dewey, 1916). The developing countries were suffering pressure to provide a higher quality education for a larger population (UNESCO, 2009; Garrote, Petterson & Christie, 2011). There were nevertheless problems for these countries to meet the demands because of economic constraints even though the advantages of a more efficient and modernized higher education with the incorporation of technology were evident (Bhatti, 2010; Garrote et. al., 2011; Ham & Cha, 2009). "The fundamental objective of the Plan was to ensure that everyone had the necessary skills to benefit fully from the fruits of the information society" (Minister of Education [Kenya] 2006 in Ham & Cha, 2009, p.538). In Kenya, Botswana, and Guyana research was done on the effectiveness of particular educational technology which had been implemented in these countries. In Kenya the impact of information technology in schools was analyzed (Khan et al., 2012). In Kenya, radio technology, implemented in primary and secondary schools, was researched (Odera, 2011). The research design used was a descriptive survey that included quantitative and qualitative methods of data analysis. The participants were 40 head teachers, 40 English teachers, and 400 pupils. Interviews were used to collect information from head teachers while surveys were used by English teachers and students. The research findings showed that 50% of the schools had purchased the radio sets, 10% had radio sets which did not function, and 40% did not have radio sets (Odera, 2011, p. 964). Kabanoki (2008) focused on distance education students at the University of Botswana. In Kabonaki's study, questionnaires were used, and they had a return rate of approximately 54%. The learner readiness to use particular technology in learning showed that students enjoyed audiocassettes mainly to make written modules clearer, and these were used during their day-to-day activities (Kabanoki, 2008). Mackinnon and Mackinnon (2010) studied the implementation of educational technology in grades 1 to 3 in Guyana where the SuccessMaker software was evaluated through visits to the schools and through surveys. This software was revealed to be an excellent resource, yet the participants had mixed feelings as to the improvement this technology had on literacy and numeracy (Mackinnon and Mackinnon, 2010).

Research focused on the use of educational technology by the students in developing countries. The studies were done by students at different levels of instruction, which included higher education and different technology. The concern was to provide an opportunity for a more efficient and effective education for the students in these countries. Economic growth was directly linked to the performance of the students on standardized tests (Hanushek & Wößmann in Mackinnon and Mackinnon, 2010).

Student’s language and mathematics concepts and skills were enhanced through the use of radio technology in Guyana and Botswana (Mackinnon & Mackinnon, 2011; Odera, 2011). The student’s imagination and listening skills were enhanced through the use of radio technology in the schools (Heinrich, Russell, Molenda, and Smaldino in

Odera, 2011). When support materials and instruction were supplied to the teachers in order to help them work with the technology, the possibility of adopting these technologies increased the use of these technologies. Through observation, the interactive radio instruction (IRI) had a very strong impact on math, local language literacy, and English language skills for grade 1 students while a little weaker, yet positive for the grade 2 and grade 3 students (MacKinnon & Mackinnon, 2010). The technology to be used by teachers should be selected taking into account the comfort levels and interests of the students with the technology used. In Kabonoki's study, students preferred the technology with which they were more comfortable instead of increasing their knowledge in terms of computer technology.

Educational technology was nonetheless necessary to enhance students' motivation, content knowledge, and skills, and it provided the opportunities for an education model centered on the pupil. Some teachers received training and support materials for the use of the technology, and this promoted its utilization and success in student outcomes (MacKinnon & Mackinnon, 2010; Odera, 2011). Educational technology, in Kabonoki's study, was the medium that the distance education students used and they preferred the technology with which they were more comfortable. In Mackinnon and Mackinnon's research, grade 1 to 3 students were getting better scores with the use of the technology. In Odera's study, the technology employed by the teachers was the same for primary and secondary education, and teachers were comfortable with its utilization in the classrooms with the students.

The practice of technology showed no substantial change and its importance was due to its power as a symbol of modernization (Chansiri, 2011). “Everyone should be aware of the importance of technology in developing student’s learning and should strive to overcome the barriers which prevent the use of technology in classroom settings” (Khan et al., 2012, p.73). Although the technology had the potential to improve education to a considerable degree, developing countries were encountering first-order barriers which included lack and unreliability of equipment, lack of technical support, and other resource-related issues. Limited access to computers, unstable internet connectivity, lack of knowledge of computer use by students and teachers alike, and ineffective technical support were some of the barriers encountered. All these factors contributed to the decision that the African Virtual University revert to radio and video technologies for the developing countries (Muhirwa, 2009).

Second-order barriers included both school-level factors, such as organizational culture and teacher-level factors, beliefs about teaching and technology, and openness to change (Howie, 2010; Khan et al., 2012). Many educational technology projects in developing countries failed due to management practices, bureaucracies, costs, sustainability concerns, and a mechanistic mindset (Brunello, 2010). The process used to implement educational technology in the schools was crucial to determine the success of its implementation. According to Howie (2010), a comparison of the strategies used demonstrates the difference between South African and Chilean experiences in the application of educational technology. In the Chilean case, they used both a “top-down” and a “bottom-up” approach while South Africa only used a “top-down” strategy with much less success. In the “bottom-up” approach, the Chilean schools needed to take ownership of their interest in receiving computers. They needed to develop well-organized projects to receive the computers. In the “top-down” approach used in South Africa, schools received the computers whether they planned to use them or not. The South African Educational Department had great interest in the implementation of educational technology in the classroom but admitted that the “degree of implementation varied from province to province depending largely on the leadership, skills base, and human resource capability available in the Provincial Departments of Education” (Isaacs, 2007).

Educational Technology in the Science Classroom

Natural sciences lost their attractiveness to students in developed countries. Therefore, the primary goals for teachers were to change their procedures and develop teaching/learning processes using different technologies and learning strategies (Lamanauskas, 2009). The use of educational technology in education and specifically in the science classrooms enhanced education quality and made the educational process more versatile (Lamanauskas, 2009).

Many intentional relationships became virtual relationships, where students used cameras and other geospatial tools to create the idea of being in other places and with other people with whom they established relationships. There were 3-D applications for teaching and learning, among which Quest Atlantis, Skolaborate, and Teen Second Life appeared (Lloyd, 2010). In science lessons the technology was able to stimulate all the students’ senses, transforming the learning experience and making the acquisition of new knowledge much richer and motivating. When the students did not have the possibility of using a laboratory at school, technology was the only way to provide them with the experience they need. Using simulations enhanced learning, although it was important to remember that the methods used facilitated learning, not the delivery systems (Stizman, 2010). Toffler (1970) predicted that the game-based learning would be integrated into the new educational paradigm.

Integrated science was valuable in education and engaged a greater variety of students (Holley, 2009). Students were able to reflect on, integrate, and develop comprehensive thinking about the world. Project-based problem-solving encouraged students to investigate based on their curiosity and design-based education involved pupils in the process and methods of creating engineering artifacts. Science education has changed throughout the years. In 1990, scientific and technological literacy (STL) for all students was promoted through the creation of a protocol between the International Council of Associations for Science Education (ICASE), and UNESCO. ICASE and UNESCO initiated a project called 2000+ to promote STL for all students. Science education needed to change its philosophy, research, approach, and the way in which it was taught (Holbrook, 2009). The school curriculum should be aimed at the acquisition of knowledge, skills, and capacities. Project 2000+ was intended to promote science and technology literacy for all students; to produce formal and informal educational programs to prepare students for the increasing technological society; to promote continuous development training for teachers; and to support the projects which aimed at improving quality and productivity in society (www.unesco.org).

In science education students had the opportunity to simulate experiments in cases where it was expensive, time consuming, or even impossible to do in the classroom. Students who would otherwise not have a chance to do the experiments because of lack of resources could also have the experience without being penalized in terms of experiencing the phenomenon that needed to be understood. Holbrook (2009) presented a model for science and technology education, curriculum orientation, and teacher education or continued professional development (CPD). The purpose of science education was scientific literacy; to enhance and sustain student motivation in and about science; to promote professional development for science and technology education; for sustainable development; to emphasise student learning with the understanding of the nature of science and scientific inquiry; to promote partnerships with organizations within the community in order to increase student knowledge, skills, and understanding; and finally to develop attitudes needed for developmental change (Holbrook, 2009). The educational structure would become more focused and the curriculum orientation would be transformed (Toffler, 1970).

Physics Education Technology (PhET) simulations could be as productive or even more productive in the development of student conceptual framework than real experiments. The simulations promoted an interactive working place (Finkelstein et. al., 2006). All PhET simulations were free, and could be used online or downloaded. The simulations were interactive, and open learning was physically accurate, representations of physics principles sought to build bridges between everyday life and the underlying physical principles (Finkelstein et al., 2006). In their study, Finkelstein et al., demonstrate that the simulations are just as effective as or even more effective than real life demonstrations.

Students can acquire new knowledge through games that supplied the learner with life challenges. Serious games enhance learning and retention significantly (Farrington, 2011). The drawback to this type of education is that the student needs to have the foundations before starting the games (Siemens, 2006).

Access to Education Through Technology

Faculty's attitudes toward technology, distance education, and innovation in general are essential for the development and implementation of technology in education (Johnsrud & Tabata, 2008). Through the use of the internet, people were able to reach other people anywhere in the world in the same time and at the same cost as with someone next door (Rogers, 2003). Institutions around the world designed online courses with sophisticated materials for students who did not have access to education any other way (Baggaley, 2008).

Distance education. Faculty members understood the advantages of the use technology in education. As they became more knowledgeable about technology they started integrating it into their practices and became more open to adhere to distance learning (Tabata & Johnsrud, 2008). The attitude toward technology and distance education is directly related to the participation in these (Birch, 2009; Tabata & Johnsrud, 2008). In the Bangladesh virtual classroom project, the addition of mobile technology made interactivity possible within these classes (Anderson & Hatakka, 2010).

Although there was a high demand for higher education institutions in Africa, some countries could not do so due to lack of financial means to develop these institutions (Kamanja, 2007). Distance learning filled a gap by providing an opportunity for a high-quality education for learners that otherwise would not have had a chance to study because of time or physical location limitations. Distance learning institutions were more affordable, and the courses were able to cope with a larger number of students than the brick and mortar universities. Advances in educational technology placed pressure on the distance education sector to expand the e-learning environment (Birch, 2009). The redesign of the learning program involved: the purpose, educational approach, assessment strategy, materials developed, improvement of academic student support, and support systems to facilitate and enhance student learning (Fresen & Hendrikz, 2009; Garrett, 2009).

Humans have different abilities and capabilities and through appropriate educational systems they could discover their strengths and be oriented to the best career path for them (Tuomi, 2007). Educational technology would address student disabilities and weaknesses, where through the use of a variety of educational tools, technology would be reorganized to fit each student (Tuomi, 2007). Education would progress toward game based learning, and parents would be able to choose their children's curriculum (Toffler, 1970; Tuomi, 2007).

The research was related to the relevance of traditional educational aims in the changing world, and to the capacity of the learning institutions to adapt or be substituted by new forms of learning management. At New Zealand's Massey University 60% of the students were online students and some students that were not online students enrolled in some online courses because these provided better materials (Baggaley, 2008). The Advanced Certificate in Education, distance education program offered by the University of Pretoria was developed for teachers who lived in rural areas in South Africa. The program aimed to provide better access, support, and quality of the teachers in the program. (Fresen & Hendrikz, 2009).

The distance education students pursuing a degree in the primary education at the University of Botswana participated in the research that showed that the students had not increased their use of computer technology significantly. These students preferred television, telephones, cassette players and CDs to audio MP3 digital audio devices and computers which only few students had acquired by 2006 (Kabonoki, 2008).

The Regional Education Master's Online Training in Evaluation accepted 19 students from nine different pacific islands for a two-year course-based program. The courses were online with the exception of the first session which was a face-to-face meeting during the summer semester where students had the opportunity to meet their instructors. Throughout the program, the course instructors convened periodically with their students through web conferencing (Rao & Giuli, 2010).

The structure of the social systems could either facilitate or complicate the diffusions of the innovations (Rogers, 2003). The teachers, as agents of social change, should integrate technology into their educational practices in order to prepare the students for a society in which technology would be integrated. Distance education technologies were considered to be a cost effective way of rescuing struggling educational institutions in developing countries (Muhirwa, 2009). E-learning environments with discussion boards provided learning experiences for the students that participated in these situations. Therefore, they required careful preparation so that opportunities to construct new knowledge and develop higher order thinking could occur (Shana, 2009).

Context factors influencing adoption of educational technology. Literacy and a literate population were essential elements in economic development, personal achievement, and social well-being anywhere in the world (Dorner & Gorman, 2011). Inadequate and inappropriate educational systems resulted in the inability to support information literacy programs resulting in information illiteracy. These systems led to a lack of knowledge, skills, awareness, self-confidence, innovation and dependency thinking (Burkey, 1996; Dorner & Gorman, 2011).

Research findings in developed countries could not be applied to developing countries without a study of the context of the settings and tendencies. Developing countries often relied on the experience of specialists who came from developed countries to help advance education, on the basis of technical cooperation (Kuroda, 1998).

Adoption and maintenance of technology. The implementation of educational technology requires commitment from all the stakeholders which includes the government, school administrators, teachers, students and the community itself (Khan et al., 2011). The authors investigate factors that affect business employees' behavioral intentions. They want to use the e-learning system and in so doing combine Rogers's diffusion of innovation theory with the technology acceptance model to propose an extended technology acceptance model. The extended technology acceptance model had already been tested in Taiwan using 552 business employees. The study validates the extended technology acceptance model in the organizational context and provides a better understanding of the employee's perceptions of this model of learning (Khan et al., 2011).

Teaching and Learning

Social learning. The social learning theory approach to learning looks outside the person for the information change that occurs and promotes behavioral change (Rogers, 2003). In the social learning approach, the observer extracts the essential elements of an observed pattern or behavior and then performs in a similar way. There does not need to be a verbal exchange of information for the person's behavior to be influenced; therefore, verbal and nonverbal communication can affect behavioral change. Roger believed that social modeling usually occurs through interpersonal networks or by a social display of someone with whom the person is not acquainted, for example in a television show.

Social computing, where students were able to communicate with colleagues, family, and friends all over the world, changed the way they taught and learned. These students were able to participate in task-oriented activities in virtual environments (Garrett, 2009). Students needed to develop the competencies for their lives, to learn and work successfully in a rapidly changing world (Shana, 2009). It was nevertheless important to prepare the students to work in the learning environments in which they needed to work. Through the social experiences that occurred in these learning environments, knowledge could be constructed (Shana, 2009).

Lifelong learning. Learning systems evolved to serve the needs of lifelong learners (Henderson & Provo, 2006). As soon as technology was integrated into face-to-face education, distance learning emerged to provide education through the use of technology to students who otherwise would not have access to this education. Instructors created class environments for which they were responsible, and pupils had more opportunities to participate creatively (Schoenacher, 2008). Students gained trust and solidarity toward one another, and cooperated with each other, even though they could never come to meet one another. There were usually very few signs of conflict between students in these learning environments, and the students gained a sense of empowerment. Students who were quiet and timid usually did very well in distance education programs.

In Malaysia people believed that in order to develop their full potential and produce a population of intellectually, spiritually, emotionally, and physically balanced people, the learner should learn to be responsible for their own learning (Fauzan, 2007). Schools were technologically equipped, and learning was constructivist, creative, and stimulating. The modification of the educational paradigm toward a more individualized and technology-rich education agreed with Toffler's third wave theory where improvements in computer technology, videos, and other technology resources became common in school.

Teachers' training. In teachers training courses, the trainees were expected to develop many technology-related skills, use productivity tools, educational software, and other available resources which they were expected to apply when teaching content in their subject area (Duran et al., 2009).

> It cannot be assumed that simply providing teachers with appropriate tools and task materials will result in their spontaneous engagement with contextual thinking … the potential of computer mediation to foster knowledge depends less on what learners use, than on how they use it. (Thompson, as cited in Shana, 2009, p. 227)

Education and Educational Technology in STP

In order to reduce poverty and attain the Millenium Development Goals, the United Nations Educational, Scientific and Cultural Organization (UNESCO). Participation provided assistance to initiatives that included improving formal and informal education through the use of radio transmissions to animate interactions between the school and the community (Fall, 2007). The educational system had shortage of classrooms, unprepared teachers, lack of resources, poor educational planning, high repetition rates, and was highly dependent on foreign financing (Researching Virtual Initiatives in Education, 2013). The Education for All-Fast Track Initiative Program started in 2009 and aimed at improving the delivery of primary education, promoting equal access to all (The World Bank, 2013). With this program primary school completion rate rose from 44.2% to 80% while repetition rate fell from 24% to 15 %, and the number of untrained teachers at this level of education fell from 75 %to 45 % (The World Bank, 2013).

The Center for Migrations and Intercultural Relations (CEMRI) proceeded to the evaluation of Project Escola+, using a mixed method study. They observed the schools and interviewed people from the various educational institutions in the country and handed out questionnaires to students from grades nine through 12. Triangulation of the qualitative versus quantitative data were done. The data were organized according to the four different areas of focus. IMVF's project, Escola+ intervention was at the secondary school level and involved partial to full rehabilitation of eight schools, constructed and rehabilitated some classrooms into workshops, installed computer labs, spaces for physical education, and administrative areas (Ferreira et.al., 2013). This goal was partially reached. Project Escola+ also developed professional education at the secondary school level with the creation of some professional courses: Sports, Computer Science, Management Accounting and Administration, Industrial Technology, Tourism and Social Communication, Humanities and Law, Carpentry, and Sewing and Tailoring (Ferreira et. al., 2013). The goal for the creation of these courses was reached. Materials for these courses were provided by the project, and it also provided some equipment for the science labs at the main high school in STP and the Secondary school of Santo António (Ferreira et.al., 2013). The final objective involved the higher number of students within the educational system, and this goal was also reached with significant growth rates (Table 1). During the three years of the program, the number of students raised from 8.900 students to 15.291 students that corresponded to the growth of 71.

Table 1

School Population, 2007 to 2013

2008/2009		2009/2010		2010/2011		2011/2012		2012/2013	
7th	Total	7th	Total	7th	Total	7th	Total	7th	Total
3,179	8,024	3,650	8,900	4,122	10,059	4,912	12,289	4,239	15,291
4.8%	10.4%	14.8%	10.9%	30.9%	13.0%	19.2%	22.2%	- 13.5%	24.3%

Note. Number of students and growth rates % in seventh grade and total number and growth rate percentages of students in each school year before and after the implementation of the program. Adapted from "Relatório Final de Avaliação Externa," in *Projeto Escola + Dinamização do Ensino Secundário em São Tomé e Príncipe*, by M. M. Ferreira et al., 2013, CEMRI-UAb.

Teachers training was provided in three different areas of intervention. Firstly the secondary school teachers received support from the Portuguese cooperation teachers who worked in the Escola+ Program. Curricular Management and Pedagogical Supervision was provided by ESECS-IPL, and the completion of training program for secondary teachers was provided by ISP with the collaboration of ESECS-IPL (Ferreira et al., 2013). The technical sustainability of the educational system was promoted by strengthening the endogenous capacities of the local teachers, and through the implementation of an adequate educational model for the country's reality (Ferreira et al., 2013).

ICT in education was not considered a priority by the country's leadership although technology was essential for knowledge acquisition and information research (Fall, 2007). The list of factors that helped and hindered the implementation of technology in education included strategic government objectives to transform ICT into an instrument to reduce poverty and to reach the Millennium Development Goals (Fall, 2007). Among the factors that hindered were the weak internet access, the limited number of computers, and high taxes (Fall, 2007).

There were some virtual initiatives in postsecondary education, mainly from universities in Sao Paulo, Brazil (Researching Virtual Initiatives, 2013). There was also a local consulting and training firm which provided face-to-face and virtual training opportunities, some of which were free of charge (Instituto Globus Virtual, n.d.).

São Tomé and Príncipe. An explanation of STP's geographical, historical, economic and educational settings was provided in order to contextualize the research that was to be done in STP. An example of IMVF's program and ESECS-IPL's contribution was also offered to portray its impact on education in STP.

Geography. STP is an island nation in the Gulf of Guinea with an area: 1,000 km2 that is composed of two inhabited islands, the island of São Tomé and the island of Príncipe. Just south of the Island of São Tomé is the isle of Rolas that is on the equator. These islands are part of the Cameroon volcanic mountain line. STP has a tropical climate with temperatures that rarely rise above 32ºC, and it has an extensive rainy season which extends from October through May. The country has a large number of endemic plants and birds.

History. STP was uninhabited when discovered by the Portuguese in the late fifteenth century. They found the volcanic soil suitable for agriculture and started sugar cane plantations. Slaves were brought to STP from the neighboring countries to work on the lands, and the sugar cane industry became one of Africa's foremost exporters of sugar. Due to unions between landlords and slaves who had come from several African countries, a new race called Forros appeared. In the mid-seventeenth century, some of these Forros were already slave owners themselves, and they took control of the church, the local administration, and the lands (Seibert, 2002).

Figure 1. Map of STP. Retrieved from http://www.saotome.st.

As the sugar industry declined because of superior sugar production in the West, STP became engaged in the slave trade between Africa and the West (Figure 2). In the nineteenth century coffee and cocoa plantations were initiated, and as the local Forro people did not want to work the lands, workers were shipped in from Angola, Mozambique, and Cabo Verde (Seibert, 2002).

Economy. By 1908, STP had become the world's largest producer of cocoa with the production of 8.000 to 10.000 tons per year. Portuguese families settled in STP and created the large plantations which were called Roças (Directel, 2012). Although at this time slavery had been abolished, the workers continued to be treated as slaves. Due to rising tension, the Comity for the Liberation of STP (CLSTP) and the Movement for the Liberation of STP (MLSTP) were formed. STP was a Portuguese colony until 1975, and when the country gained its independence, the MLSTP went into power (Directel, 2012).

Figure 2. Map of Portuguese colonies from which people were brought to work in the plantations in STP. Retrieved from https://maps.google.com.

The Forro people considered themselves the rightful owners of the lands although there was a lot of rivalry among them passed down through the centuries (Seibert, 2002). As they were the governing people of São Tomé, this competition made the country a very unstable one in political and economic terms. By the end of 2012, the majority government was thrown down due to a no-confidence vote by the combination of three opposition parties. The new government was entirely composed of the opposition party members, some who have limited experience in governance (CIA, 2013).

The educational system. Education was the first priority of the government budget, and approximately 40% of the income was allocated to the sector. “However, the distribution of this slice by education cycle was quite unbalanced in favor of the single cycle of Higher Education, more specifically, the scholarships for studies abroad” (MECF, 2012, p. 3). Of the country’s youth, 86% enter secondary education while only 13% of the youth conclude secondary education. There were too many students per classroom and of the 1,885 teachers and educators in the current educational system, 60% lack the necessary pedagogical training for teaching (MECF, 2012). Table 2 provides the STP student/teacher ratio, number of students per class, dropout rates and the previsions for 2022.

Table 2

Overall Picture of Education in STP

Educational level	*N*º of students	Dropout rate	*N*º teachers		Students per classroom	Prevision of number of new classrooms needed until 2022
			Total	Trained		
Preschool	8.591	----	348	38%	50,5	+171
Primary education	35.250	1%	1.037	42,5%	79	+39
Secondary education	11.618	24%	440	40%	80	+228
University education	1.570	---	28	20%	25/30	+1 University

Note. From *Carta de política educativa de São Tomé e Príncipe* (p. 61), by Ministério da Educação, Cultura e Formação, 2012.

The IMVF project for education in STP. In 2009, the program was developed to modernize the educational system and provide new curricula to be implemented at the local schools. The project, aiming at education for all, was organized by the IMVF that was in STP to provide assistance through educational and health programs. Since its creation the IMVF has been dedicated to serve underprivileged people all over the world, but mainly in STP where they participated in the educational project and created a program called Escola+ which aimed to contribute to the socio-economic development of STP by upgrading the education of the human capital, by strengthening secondary education and promoting the Portuguese language in STP. This project had the duration of four years, September 2009 to August 2013, and was run by the IMVF in partnership with the Ministry of Education of STP. The program benefited from co-financing from the Portuguese Institute for Development Support (IPAD) (IMVF, 2011). Project Escola+'s activities were divided into four different areas of intervention.

- Physical improvement of the secondary schools;
- Improvement of the teacher's skills;
- Management and monitoring systems;
- Professional courses at the secondary school level to satisfy needs of the country in terms of human resources.

The project dedicated its resources to modernizing the middle and high schools throughout the country (Escola+, 2009). They have built a new curriculum for middle and secondary education and have started implementing it through phases, starting with the 7th and 10th grades which are the beginning of each cycle. The following year they started the new programs in the 8th and 11th grades and in the third year the 9th and 12th grades started with the new curriculum.

ESECS-IPL and its contribution to education in STP. To guarantee a high level of quality in the teachers training ESECS-IPL, through their department of education, supported the project in the preparation and implementation of training programs. These programs were developed for the teachers, school administrators, and school inspectors. São Tomé had teachers with bachelor degrees who were capable of teaching the final years of the secondary education, but needed to complement their training in order to do so. Instituto Superior Politécnico (ISP) in São Tomé did not have faculty to provide the post-bachelor programs for these teachers, therefore ESECS-IPL cooperated by providing faculty to complement the training supplied by ISP so that the teachers could pursue their

Licenciatura in the areas of math, physics/chemistry, and biology/geology. The first group of teachers started this program in 2011 with some courses being provided by local faculty at the ISP while most courses were offered by faculty from or contracted by ESECS-IPL. The post-graduate program in chemistry/physics consisted of 14 classes (Table 3).

The courses that the ISP faculty were not able to provide were offered on an intensive basis by faculty members from the ESECS-IPL, who went to STP for periods of two weeks at a time. Some of the lessons were provided locally at the ISP, and the rest were provided at a distance, using the WebEx software in synchronous sessions. A learning management system (LMS) using the EDU2.0 software was created to be utilized by the ESECS-IPL faculty and the trainee teachers, for resources and communication in the different courses (www.teleformacao.edu20.org).

The course "Introduction to Educational Technology in the Physics and Chemistry Classroom" was provided using the LMS to complement the daily lessons where the teachers learned to use the discussion board to participate in their discussions, submit their applications, find their course materials and see their evaluations. The syllabus (Table 3) included basic word processing through the use of simulations. There were 10 teachers in the program and when they started the course only one had a laptop, one did not know how to use a computer at all, two did not know how to use word documents and only two were familiar with excel spreadsheets. At the end of the course, the teachers all bought laptops for themselves. When the teachers were enrolled in

“Research Project I and II” (Table 4), they worked on their individual projects (Table 5), using the technology, which they eventually applied to their students at their schools.

Table 3

Courses for the "Licenciaturas" in math, Chemistry/Physics, and Geology/Biology Lectured at the ISP With the Collaboration of Lecturers From the ESECS-IPL.

Year/Semester	Courses	Hours	Institution that provided the course
1/1	Nuclear and Atomic Physics	60	ESECS-IPL
1/1	Educational Research Methodology	60	ESECS-IPL
1/1	Environmental Inorganic Chemistry	60	ISP
1/1	Quantum Mechanics	60	ISP
1/1	Physics and Chemistry Didactics I	60	ESECS-IPL
1/2	History of Physics and Chemistry	60	ESECS-IPL
1/2	Introduction of Technology in the Physics and Chemistry Classroom	60	ESECS-IPL
1/2	Physics and Chemistry Didactics II	60	ESECS-IPL
1/2	Research Project I	60	ESECS-IPL
2/2	Physics and Chemistry in Context	60	ESECS-IPL
2/2	Research Project II	60	ESECS-IPL
2/2	Physics Laboratory	60	ISP
2/2	Chemistry Laboratory	60	ISP
2/2	Pedagogical Practice	90	ISP

Note. Information from http://teleformacao.webs.com/fsicaqumica.htm.

Table 4

Introduction of Educational Technology in the Physics and Chemistry Classroom Course Syllabus

Content	Software
Introduction to ICT in education	
Instructional strategies to develop creativity and become innovative, communicate and collaborate	
Overview the different categories in the ICT	
Text processing software	Microsoft Word, OpenOffice writer
Presentation software	Moviemaker, Microsoft PowerPoint, OpenOffice.org
Spreadsheets	Microsoft Excel, Open Office.org, Engrade
Brainstorming and organizational software	webspiration
Interactive periodic tables	
Chemistry and physics databases	
Simulation and modulation software	
Interact in multiuser virtual environments	
Use of different search engines	
Preparation of web quests	
Use of communication software	

The former minister of education, who left office at the end of 2012, was determined to integrate technology into the educational system and promote its use in the schools around the country. He was interested in developing an intranet system for the school administration service, where students' records could be filed and where all the data could be accessed centrally (MECF, 2012). The Board of Education wanted to equip all schools with computer labs where students would be able to learn to use technology to do their research and collaborative projects. As they did not have the means to equip all the schools with computers, they counted on the support from foreign institutions that supported this initiative. Some schools received computers donated by several international and national entities, United Nations Development Programme (UNDP), *Companhia Santomense de Telecomunicações* (CST) and others.

Table 5

Each Teacher's Individual Project

Title of project	
Capturing rainwater for domestic use and irrigation.	Social learning project.
Construction of an Inclined Plane Equipment for physics Classes.	Construction of materials for science lessons.
Noise as a disturbing factor during class.	
Metal corrosion.	Project-based learning.
De Olho nas Galáxias.	Use of simulations to support instruction.
Different inteligences learning the same physics.	Differentiated instruction.
Some interesting ideas for building science. materials to support physics teaching.	Construction of materials for science lessons.
Implementation of some of the applications of elements of the periodic table in real life.	Bring science closer to the students' daily lives.
The importance of historical context in science education.	
Effects of simulations on acid-base learning.	Use of simulations to stimulate student learning.

CST had an agreement with the Ministry of Education where they provided free basic internet connectivity for the schools. Most schools already had internet connections and at least one or two working computers. The cable and broadband fiber connections were already active which would improve the internet connectivity in the country. Having the equipment did not mean they would use it or even know how to. In STP in some areas, computers seem to stay stacked away because nobody used them, or saw any advantage in their use.

The problem of teacher unpreparedness could not be solved with a few training sessions. The ESECS-IPL's support for the post-bachelor programs filled that gap. On the other hand, only the program for the *Licenciatura* in chemistry and physics had a course to prepare the teachers to work with educational technology in their field of study. This program trained a limited number of teachers, and it was necessary to determine the importance of integration of educational technology in education in STP. In training, the teachers in the integration of technology in the classroom could bring a different dimension to the class, and consequently bring STP closer to the rest of the world.

Summary

The change theories complemented each other as Toffler spoke of how the third wave society would be, without attempting to implement the change himself. Rogers spoke of the innovation process and the importance of the change agent and opinion leaders in the diffusion of an innovation. Fullan supplied the steps to implement change through teacher's training. Within the learning theories, Bandura saw learning as a social process with which Vygotsky agreed. Vygotsky also believed in a constructivist view of education where students learned through discovery and new knowledge was built upon prior knowledge. Siemens included these two theories into his connectivism theory. In the context theories, Tessmer and Richey proposed an instructional design model that promoted learning by contemplating three different contexts. Lave and Wenger suggested that people learned from observing experts in their working place and in Stricht's functional context theory, the creation of courses that would facilitate learning in the beginning, throughout and how it was transferred were essential for learning to occur.

The context theories were of great importance when trying to implement educational technology in a developing country as was the case of STP.

The view that the implementation of educational technology had changed the world and the way people learned was shared by many of the researchers and theorists. The use of technology enabled many educational institutions and countries to restructure their educational systems and start concentrating on the needs of the students and teachers alike. Technology in the science classroom was considered to be effective (Finkelstein et al., 2006; Siemens, 2005; Sitzman, 2011; Toffler, 1970). Students were able to use simulations, modulations, games, collaborative tools and other technology that would support the development of knowledge. Developing countries had more challenges towardtoward the adoption and implementation of this technology because they had more economic and structural challenges. They also had challenges in terms of teacher preparedness, not only in technology but in their educational practice in general. Teachers training courses in the use of educational technology were suggested by some researchers (Duran et al., 2009; Thompson, 1999 in Shana 2009). “Everyone should be aware of the importance of technology in developing student’s learning and should strive to overcome the barriers which prevent the use of technology in classroom settings” (Khan et al., 2012, p.73).

Not only were the theories of learning and the change theories critical to the implementation of educational technology in developing countries, but context theories provided the information on the strategies to break the barriers that prevented technology from being implemented. It was important to understand the various contexts that affected the educational system and then work upon these in order to find a way to apply the change. It was necessary to overcome the contextual barriers to work towardtoward the use of educational technology in the classroom in the schools of these developing countries. The understanding of what was already researched and the results that the researchers acquired from their research as well as the theories of learning, of change and the context theories would support the development of a research plan for the implementation of educational technology in schools in STP.

Chapter 3: Research Method

Some research has been done in developing countries involving the integration of technology into education. Nevertheless, no one has studied the phenomenon in terms of Toffler's wave theory and the possibility of a first-wave country taking on third-wave features with the integration of technology. STP is a first-wave country where the integration of educational technology into teachers' practices could be the first step to taking on third-wave civilization features. STP possesses the ideal conditions to test Toffler's wave theory because it is a small island country where most of the people are isolated from other cultures. The only contact most have with the exterior occurs through phone calls, by watching TV, and by listening to the radio. First- and third-wave civilizations have much more in common with each other than they have with second-wave civilizations, and it would be easier for first-wave civilizations to take on some of the features of third-wave civilizations without going through the second-wave stage of development (Toffler, 1980, p. 337).

In this chapter, the central concept of the study, the research tradition, and the rationale for the tradition are identified. My role as a researcher is explained. An in-depth description of the research methodology with the participation selection logic, the instrumentation, data collection instruments, researcher-developed instruments, procedures for recruitment, and data analysis plan is presented. Issues of trustworthiness, as well as the ethical procedures, are discussed.

Research Design

Research Questions

What are the experiences and perceptions of the individuals involved with the integration of technology into a first-wave country?

1. What are the experiences of the teachers in STP during the implementation of the program?
2. What are the experiences of the representatives of the partner organizations and the directors of the schools during the implementation of the program?
3. What are the experiences of the former minister of education during the implementation of the program?

Central Concepts/Phenomenon of the Study

The central phenomenon of the study was how technology integration in schools, for teachers, could be addressed in the physics and chemistry classrooms in STP. The perception that the teachers who participated in the program had of educational technology and the power they felt it had to enhance student learning in their classrooms were examined. The perceptions of the directors of the schools where these teachers taught and of members of the partnership institutions concerning the implementation of educational technology in the physics and chemistry classrooms in STP were also examined.

Research Tradition

Philosophical worldviews or knowledge claims consist of a selected set of beliefs about how research should be done (Yin, 2011). Qualitative research involves the collection of a variety of materials from and about the object of study. Qualitative research is different from quantitative research in that they involve distinct worldviews, strategies of inquiry, data collection methods, and types of analysis. The qualitative researcher uses a broad range of ways to make sense of and interpret the meaning of the phenomenon or case for the people involved (Denzin & Lincoln, 2005, p. 3). A qualitative researcher is able to gain an in-depth view of the environment in which the research is done as well as the participant's views and opinions. Qualitative research questions are open ended, and the researcher is aware of adjustments that need to be made during the research in order to adapt and provide the most efficient research conditions. The researcher concentrates on specific data and makes interpretations regarding the specific data without generalizations (Creswell, 2009). A qualitative study tends to situate the researcher in the world, with interviews, observations, field notes, photographs, audio, video, and other artifacts that the researcher acquires during the research. Qualitative research involves the close attention of the researcher to contextual factors that include economic, cultural, social, and political factors.

A qualitative approach was determined to be more adequate than a quantitative approach for this study, as I intended to understand the integration of educational technology from the perspective of the people who, directly or indirectly, participated in a project. Context, social, and political factors were crucial to the understanding of the implementation of technology in schools. Open-ended interviewing with teachers who participated in the training program; the former minister of education; head representatives from IMVF, ESECS-IPL, and ISP; and school directors was the preferred way to collect data. Teacher participants were also asked to complete confidential narratives that provided them with the opportunity to reveal information that they were not comfortable providing during the interviews.

Narrative approach and theory. The narrative approach is derived from the social sciences. In this approach, the researcher studies the life of the research subject thoroughly, then provides a detailed picture of the subjects, their culture, and their lives (Patton, 2002). A combination of the researcher's views with those of the research subjects follows in the transformation of the data into a narrative chronology. The primary mode of data collection is open-ended interviews, observations, casual chatting, subject journaling, and archival document review. The data analysis in this approach includes the creation and organization of data files, historical content, and the description of stories (Creswell, 2009).

Ethnographic approach and theory. The ethnographic approach involves the description of the cultural behavior of a group of individuals or an individual in a natural setting. It derives from sociology and is aimed at understanding people´s perceptions and social behavior (Patton, 2002). The ethnographic approach entails describing and interpreting cultural or social groups and involves data collection during extended periods of time through interviews, observations, and the collection of artifacts. An ethnographic study may involve thick description and analysis for themes and patterns or interpretation in order to make sense of the information provided.

Phenomenological approach and theory. Researchers using the phenomenological approach describe the essence of an experience for the people who live it (Patton, 2002). This approach is aimed at understanding the nature of experiences concerning an individual phenomenon. Data collection is commonly based on lengthy and sometimes multiple interviews with a tiny number of people. The information is usually transcribed and stored in computer files. In the phenomenological approach, personal experiences and the essence of a phenomenon are described, classification is made through statements, and then interpretation follows. The presentation may be done through tables, figures, or narrative (Creswell, 2009).

Grounded theory approach and theory. A grounded theory approach is theoretical or represents a theoretical model and has its roots in sociology. In this approach, the participants in the study experience the development of a theory that needs to be supported by data. The researcher uses thick description and concentrates on all the details before making any generalizations. There is continual comparison of data to maximize differences and similarities of information (Creswell, 2009; Patton, 2002). In the data analysis, open coding, axial coding, selective coding, and conditional matrixes are used.

Case study approach and theory. Case study is a strategy in which the researcher develops an in-depth analysis of a case or cases within a bounded system through thorough collection and analysis of data from multiple sources (Yin, 2009). The case study has its roots in anthropology and sociology and can be used in both qualitative and quantitative research. Case studies are distinguished by the size and intent of the bounded case. The researcher determines the boundaries of the study in terms of time, events, processes, beginning points, and end points in order to surround the case (Yin, 2009). The researcher collects information from multiple sources that include documents, archival records, interviews, observations, and artifacts (Yin, 2009).

Why case study was the best approach. After having viewed and analyzed the different approaches to the qualitative study and the possibilities that each approach provided for the study, I identified the case study as the approach which was most fit to satisfy the needs of the study. The narrative approach could not be used in the study because the focus of this study was not the narration of the experiences and lives of the participants in the study, but on their experiences and thoughts about the case at hand. The phenomenological approach could be used to examine the phenomenon of the integration of educational technology into the science classrooms, but the case study would be more efficient in the analysis of its integration into the classrooms, how the various stakeholders could influence change. The ethnographical approach considered the people in their natural setting, and the researcher needed to be with the participants for a long period of time, observing their behaviors; therefore the introduction of educational technology in the physics and chemistry classrooms was not part of an ethnographical study. The ground theory would be the study of an entirely new concept, where the researcher would need to concentrate on the details and then generalize. In the current research this was not the best procedure because the training of teachers in the use of technology in the classroom was not groundbreaking; it was only new in STP.

The research would, therefore, be a qualitative case study where all the participants involved would have, directly or indirectly, participated in the pilot program which was to be examined. This case study was bound by the period during which the program was executed, by the program itself, and by the people who participated in it. The particular design was chosen because the program could only be examined and evaluated by the people who took part in it and knew what its objectives were and why it was implemented.

Role of the Researcher

Role as Observer-Participant

In the research, my role was that of conducting and transcribing the interviews. I was an instructor in the introduction to educational technology and in the research projects of the teachers who participated in the study. I also participated in the Educational Forum – STP 2012, where I spoke about the implementation of educational technology in the 21st century education and exemplified by work produced by my students who were teachers in São Tomé.

Having been a participant in the process of the instruction, I reminded the participants of the voluntary nature of the study, of its objectives, and of the value their sincere participation would have on its validity. Triangulation in qualitative research increased validity and reliability and through triangulation of the data from the teachers' interviews with those of the school directors, the members from the partnership institutions, and the Minister of Education, it would be possible to validate the data through cross verification. Another method to ensure validity was to ask the participants to provide confidential narratives sharing information they failed to share during the interview.

Relationships With Participants

My relationship with the participants was that of an instructor, to the teachers who had a bachelor's degree and were pursuing the *Licenciatura* in Chemistry and Physics, in a course called "Information Technology in Chemistry and Physics Education" as well as with their research projects. I left STP in July 2013, and do not have any control over these teachers, and our relationship was one of mutual respect and sincerity. I was an instructor for a course that was called "Introduction to Word and Excel" in which some of the directors of the schools at which these teachers worked. At the Ministry of Education, I had contact with the former Minister of Education who invited me to participate in the Educational Forum. My participation in this forum provided the government officials with examples of the work that these teachers had done and with the knowledge that technology in education was not necessarily something only developed countries could use; it had been done in STP.

Management of Researcher Bias and Power Relationships

I tried to eliminate the threats to the validity of the research by attempting to control the preconceptions I had of the results of the research findings and all the bias I could have in terms of selecting data that seemed more adequate. I did not have any power relationships with any of the participants in the study, as I am not their instructor anymore, and they were all in STP while I was in Portugal, also eliminateing social contact. The participants were interviewed and provided confidential narratives (Appendix J) to complement the interviews with extra information they wanted to share.

During the research, I interviewed all the participants in the study. Most interviews were with Skype video call, and the interviewees were asked for permission for the call to be recorded. The interviews were done after two years of implementation so that the teachers could have time to test the technology if they wanted to do so. I would also collect the results from the teachers who did not use technology at all during this period and see the reasons why they did not use the technology. The results from the different sources which were the teachers who participated in the pilot program, the directors of the schools where they worked, former minister of education, and members of the partnership institutions (the head of physics department and technology departments at the ISP, the project leader of the teacher development program and 2 instructors who had lessons with these teachers before and after they had contact with technology of ESECS-IPL, and members of the board of directors from IMVF), related to teacher training and implementation of educational technology in the physics and chemistry classrooms in STP would provide the opportunity for triangulation.

The interviews were all done in Portuguese; that was the official language in STP and Portugal. I prepared transcripts in Portuguese for the participants. The transcripts were translated into English (Appendices F, G, H and I) by the translators (Appendix M). I analyzed the results of the interviews and triangulated the results of the interviews from the different groups. The confidential narratives were also included and analyzed (Appendix K).

Methodology

The study was a bounded case study where the participants were people who were directly involved in the pilot project which involved the introduction of educational technology in the physics and chemistry classroom in STP. The data collection was managed through interviews and confidential narratives. The data were stored on the computer and using NVivo software for storage and analysis. The data analysis involved the triangulation, thick description of data, peer review, member checks, by the interviewees, and reflective summaries.

Participants

The research focused on chemistry and physics teachers who learned to use educational technology in chemistry and the physics classroom. Training in the use of technology in chemistry and physics class was provided during the 2011/2012 school year. Ten teachers participated in the training, and they were all be invited to participate in the study. These teachers were all from STP, had always lived there and taught there. The participants' thoughts about the implementation of technology in the classroom and their use of technology in their training, as well as the diffusion of this innovation throughout STP, were the focal points of the study. It was important to find out how technology influenced the way the teachers taught. During the Research Projects I and II, the teachers had supervised lessons and the school directors were informed about the program. The former minister of education was aware of the implementation of educational technology and the programs that were being implemented. Information about the program became public knowledge at the Educational Forum on 17 May 2012.

People from the entities who implemented the program were also interviewed. Therefore, members of the board of IMVF who were involved in the program were interviewed; some people involved in the teachers training program from the ESECS-IPL in Portugal as well as some involved in the program at the ISP in STP were interviewed to understand their views on the integration of technology in education in general and in the physics and chemistry classrooms specifically. The interviews with the various people were done mainly virtually using Skype.

The data were collected through interviews with the teachers who participated in the project, the directors of the schools where the teachers taught at the time of the implementation of the project, the government officials, the head executives of the IMVF, of ESECS-IPL and ISP. The burdens put upon the participants corresponded to about 2 hours of their time. There were no financial risks as the participants received internet charge that covered their expenses with the internet for the Skype interviews.

A complete chart of the interviews was set up with the dates and hours of the interviews. There was more data that could be viewed to understand what the teachers had done on their projects throughout their program. I was the instructor in 3 of the courses taken by the physics and chemistry teachers “Integration of Technology in the Physics and Chemistry Classroom”, “Research Project I” and “Research Project II.” In the research projects each teacher developed a project in the area of chemistry or physics education and implemented these with their students at their schools where I was able to see how they prepared, developed, and implemented their projects (Appendix N).

Sampling. When the researcher chose a sampling strategy, usually it depended on the research problem and central phenomenon, where a limited number of participants were selected from a large group. The researcher decided who or what should be sampled, the form and the number of people or sites to be sampled (Creswell, 2007). The researcher needed to determine if the sampling would be consistent with the information necessary for the approach of inquiry that the researcher would use.

In this study, the sample was constituted by the accessible population. The reason for my choice was that the teacher population that had participated the teachers training program for the physics and chemistry teachers was composed of ten teachers. The school directors that knew about the program were those that had teachers from their schools in the program. The board members of IMVF developed and implemented the program, while the faculty members at ISP and at ESECS-IPL that knew about the program were those that were in some way involved in the program. The former minister of education was also informed about the program. The teachers, the school directors, the partnership institutions and former minister of education constitute the different groups that were analyzed to understand the perceptions of these various groups and to understand the impact of the use of educational technology (teachers, school directors, the partnership institution officials and the former minister of education).

The sample size depended on the purpose of the study as well as on the expectations of the people who required the information and the available resources (Taylor-Powell, 1988). In qualitative research, the researcher started with a small sample size and worked up until informational redundancy was achieved. This informational redundancy determined the moment beyond which the extra data would not alter the information which was extracted, which is the moment when saturation of information was reached. In the present case, all the teachers who participated in the program for the *Licenciatura* in Physics and Chemistry Education which was developed in STP were invited to participate. The reason the whole group was invited was because the total number of people was very small and diverse, so it was important to interview as many teachers as were available to be interviewed. The head of the training program at ESECS-IPL, and two instructors who had provided instruction before and after the teachers started using technology from the ESECS-IPL were invited to participate. The heads of the physics department and the technology department at ISP, as well as the vice president, were invited to participate. The board members of the Escola + program as well as chemistry and physics teachers from IMVF who had contact with the teachers were also invited to participate. The principals of the schools where these teachers were lecturing at the time the training took place and the former minister of education were also invited to participate (Appendix C, D and E). The number of participants was estimated to be approximately 30, with up to 10 teachers, up to five school directors, former minister of education, up to two members of the ISP, up to four of ESECS-IPL and three of IMVF. The number of participants that did accept to participate was 26, but due to personal reasons one had to withdraw his participation before being interviewed. The teachers who participated in the program, and in the research, also supplied confidential narratives of their thoughts and feelings (Appendix K) toward the implementation of educational technology in the physics and chemistry classrooms.

Procedures for recruitment. For recruitment of the participants to be interviewed a letter explaining the objectives and the use of the interview was sent to each member, and assurance that a transcript of the interview would be sent to them was provided. In the letter, the procedures of the interview were explained, and participation was confidential. The participants received the consent forms (Appendix A) to participate in the research. The consent forms were sent via email and the participants needed to respond “I agree” when they agreed to take part in the study. The participants could download a copy of the consent form to keep.

Instrumentation

Interviews were the primary source of data collection, and most interviews were done through Skype calls because the participants were in STP, and I was not there at the time. I asked for permission to record the interviews. All the interview schedules/guides and questions (Appendices B, C, D and E), confidential narratives (Appendix J), transcripts (Appendices F, G, H and I), reflective summaries (Appendices O, P, Q and R), confidentiality agreements (Appendix M), letters of consent (Appendix S), were available be viewed. The data collection instruments were developed and tested on colleagues. The reason why these devices were tested on these colleagues was to determine if they would be efficient in collecting the data that I required for the research. The person who provided the most valuable information was a faculty member at the ESECS-IPL and a specialist in African educational affairs. She holds a Ph.D. in Education provided by the University of Bordeaux in France. The confidentiality agreements and letters of consent were based on those supplied by Walden University. Some colleagues stated that the confidentiality agreements should be shorter. The interviews were tested on colleagues, and I learned that I should use the questions more as conversational guides and let the interviewees express themselves more freely. The data collection instruments were all translated into Portuguese by English language teachers and translators (Appendix M), who have translated books for McGraw-Hill. Most of the participants in the study did not understand English. After the data were collected, it would be translated back to English. These data collection instruments helped me answer the research questions.

Data Collection

Data was the foundation for research studies and derived from the following data collection activities: interviewing, observing, collecting, examining and feeling (Yin, 2011). The participants were interviewed using interview protocols. All interviews were recorded, and NVivo was used for data storage and analysis.

Interviewing. Interviews provided the researcher with valuable information that could not be acquired through observation. Interviewing was chosen as the preferred data collection instrument because the aim of the study was to understand the perceptions and experiences of the teachers who participated in the pilot program. The perceptions of the principals of the schools where these teachers worked, members of the partnership institutions, and of the former minister of education were also sought. The interviews needed to be semistructured, or open-ended so that the participants could share their perceptions and experiences freely. The interviewer needed to moderate the amount of speech and be nondirective so that the interviewee could voice their opinions freely. I provided the participants with the objectives of the interviews, stipulating the time that the interviews would take and providing them with a reflective summary of the interviews. The summaries were provided so that the participants could choose to add or remove anything in the interview. These member checks were crucial to providing validity to the study and to establish a relationship of trust between interviewer and interviewee. Before the interview started, the participants were informed that they could leave at any moment during the interview, and they were asked if the interview could be recorded. On the occasion of the interview the information that had been provided by the first contact with the participant was provided again, and the person was made to feel as comfortable as possible so that the interview could run smoothly. The participants were informed that at any time during the interview they could feel free to terminate the interview. The interviews lasted at most one hour. The participants were interviewed with a semistructured interview model, so they could also have the opportunity to speak freely about their feelings and thoughts on the implementation of educational technology in the physics and chemistry classes (Appendices B, C, D and E). The teacher participants also had the opportunity to provide confidential narratives where they expressed their thoughts and feelings without the pressure of the interview (Appendix K).

Data Recording and Data Management

The interviews were the primary instruments in the research; transcripts and translations (Appendices F, G, H and I) were prepared for each of the interviews and these were uploaded to NVivo software and coded (Appendix L) for analysis. These instruments were also saved in computer files. The documents created would be transformed into pdf files and attached to the research project as picture attachments. The documents in paper format were saved in files that were organized in the same order as the attachments. Confidential narratives (Appendix K) were also uploaded to NVivo.

Interview transcriptions. I transcribed the interviews and summarized them. I then sent these to be reviewed by the participants. These procedures were done via email, and the participants were asked to respond within one week. The transcribed interviews were translated into English by a translator (Appendix M) and the translations were all made available (Appendices F, G, H and I). The interview process took longer than planned due to the fact that it was near the end of the school year and the participants asked for the interviews to be done after the exam period. All the data were translated and analyzed before uploading the data to NVivo and coding it (Appendix L). The total time per person during the interview stage was approximately 48 hours..

Confidential narratives. After the interviews, and in order to increase validity of the study, the teachers prepared confidential narratives (Appendix J) where they supplemented the information provided during the interview and that they did not feel comfortable with sharing, or did not remember to share during the interview. These narratives were sent to me by the interviewees through the mail, using stamped envelopes with my address on, which had been provided to them. After the interviews, I thanked the participants for the time they took to help the research and informed them that they would receive transcripts of their interviews. The interviews with the teachers were different to the interviews with the other participants so that the particular opinions of each group would be as complete as possible.

Data Analysis and Interpretation Plan

In the data analysis, the objective was to know the effectiveness of the plan for diffusion of technology in the chemistry and physics classrooms of the teachers who took part in the research. The process of the construction of the case study involved the assembling of raw data, the development of a case record with the summaries in order to make it more manageable, followed by the narrative where all the information was provided for the reader to understand all the aspects of the case (Patton, 2002, p. 450). NVivo software was ideal for importing data from interviews and confidential narratives, opening and exploring this data, coding this data through the use of nodes, making sense of the information that was collected, visualizing the data by displaying a word tree, and finally recording the insights and using the memo to write up the project (QSR, 2008). I, therefore, imported all the documents, including the audio sources, explored the data and created nodes, free nodes and tree nodes. This process took a couple of weeks.

Compiling. The data were collected and organized according to Creswell's (2007) analysis spiral (p. 151). The data analysis phase started with the uploading and organization of the data to NVivo software for storage, coding organization, and linking of data. A coding system (Appendix L) was prepared with codes at various levels for the questions, adapted (Miles and Huberman, 1994, pp. 59, 60), which served to organize the data and facilitate its interpretation. There was a detailed description of the case, and then the data were aggregated into categories, establishing themes and patterns with NVivo software.

Reflective summaries. I summarized the interviews after each interview and reflected on the participant's body language relative to the interview questions to see if it coincided with what was said. The reflective summaries were subject to peer review (Appendices O, P, Q and R) in order to confirm that there was no bias in the interpretation. The selection of the summaries subject to review was random. There were summaries of the interviews selected from each group of interviews, two from the teacher interviews and two from the educational stakeholders. These summaries (Appendices O, P, Q and R) were also uploaded to NVivo to be analyzed with the rest of the data.

Disassembling. The coding system used was composed of numbers and letters (Appendix L). Coding was made easier by breaking the text into sections before compiling and analyzing the data (Janesick, 2011). The data were separated into different sections. The participant identities were protected by allocating a number, which in the coding system was represented as n, to each member and their institution or post in order to separately determine if there was any pattern that emerged from the different groups. The interviews with the teachers were coded with #nT. The interviews with the school principals were coded with SP#n. The members of the partner institutions had S#n followed by the initials of the organization, IMVF, ISP and ESECS-IPL. On the teachers' interviews there was the possibility to put the locator of the director of the respective school which would make it easier to detect if there were any correlation between the teachers' use of technology and the directors' opinions on technology. On the directors' interviews, there was a possibility to put the various teachers' locators. The teacher narratives were coded as #nTN.

Reassembling. I started to look for patterns that could emerge when reassembling the data and how this data could reveal valuable information about the research questions (Yin, 2011). Hierarchical arrays were used to organize the data into the different classes, and matricial arrays helped work the data within the same category. To minimize biases I made comparisons, looked out for negative cases, and engaged in rival thinking (Yin, 2011). For the reassembling process, I also used NVivo software.

The data obtained from the teachers was analyzed together. The data obtained from the school directors, the teachers at the ESECS-IPL (Portugal), and the head of the chemistry and physics departments at the ISP were analyzed and compared. The information from the government officials, the IMVF, and other stakeholders were analyzed, compared, and contrasted. It was important to view that data carefully. A preparedness checklist matrix for teachers, school administrators, prior minister of education and other stakeholders which analyzed the level of commitment, materials, training, skills, planning time, implementation, and evaluation was presented (Miles & Huberman, 1994, p. 95). A role-ordered matrix was also prepared to view the first reactions toward the innovation (Miles & Huberman, 194, p. 124). Instead of organizing the teachers according to the subject areas they teach, they were divided into the subject (chemistry or physics) and into the years they taught. The information provided by the principals, the ministry of education officials, the members of IMVF, ESECS-IPL and ISP were separated.

Interpreting. I organized all the findings in order to interpret them and provide significance to the study. This was done in chapter 4 of the research and depending on the results, I needed to go back to the reassembling phase to revise data arrays or even the disassembling phase to recode items (Yin, 2011).

The emerging patterns were triangulated within the groups. A Folk Taxonomy was built up to formulate a hierarchical network display and to see the influence that the opinion leaders and stakeholders had on the implementation of the technology in the physics and chemistry classroom (Miles & Huberman, 1994, p. 133). The participant's perceptions of the educational technology applied in the project was analyzed to determine if, according to them, it was adequate for the teachers in this country, and to see if this made sense (Miles & Huberman, 1994).

In order to have a comprehensive and sound interpretation I needed to strive for the following attributes: completeness where the interpretation had a beginning, a middle, and an end; fairness where everyone with the same stance could arrive at the same understanding; empirical accuracy where the research represented the data accurately; added value where new data were presented; and credibility where the interpretation was accepted by esteemed peers in the field (Yin, 2011). I used the literature from my literature review to develop an argument.

The conclusion was connected to the interpretative stage and to the data from the interviews. In the end, I needed to see what was learned from the research and the implications for the future in terms of integration of educational technology in a first wave country like STP. The conclusions could point toward the outline for future research, or to the "need for and usefulness of new concepts or theories" (Yin, 2011, p. 223).

Issues of Trustworthiness

The issues of trustworthiness are very important in research studies, whether they are qualitative or quantitative. “From the conceptualization of the research project to its completion, the researcher needs to be direct in terms of identifying bias, ideology, stance, and intent” (Janesick, 2011, p. 176). My planned strategies aimed at ensuring credibility, transferability, dependability, and confirmability.

Credibility/Internal Validity

To provide credibility to the case, the interviews were semistructured so that it was easier to compare them, and at the same time allow for the interviewee to provide their own thoughts as well as complement these with their confidential narratives (Appendix K). There were different interview protocols for each group so that the most important questions for each group could be asked. The data from the confidential narratives was made for a richer description of the participant’s thoughts in the case. Triangulation of data to determine the convergence of data from the different data sources was also used. “Triangulation strengthens a study by combining methods. Triangulation could mean using several kinds of methods or data, including using both qualitative and quantitative approaches” (Patton, 2002, p. 247). In the current study, triangulation was between data from different sources in the educational system. Participants who were selected had various functions in the educational setting, and it was important to get the opinions of all the stakeholders in the educational scene in order to provide credibility and dependability of the study. After the data were organized numerically using codes to keep sources from being identified, the data, the interpretations, and the conclusions were analyzed by peer reviewers (Appendix M) who viewed the data, the interpretations, and conclusions to determine if the findings were credible, coherent, and if they were understandable. The peer reviewers were a specialist in technology integration in developing countries and a school chemistry and physics teacher who used technology in education. They were in no way involved in the project in STP, and did not have contact with people who were involved in it. It was important to create an authentic picture of the case (Patton, 2002). So that an authentic picture of the case could be made, the research described what the program meant to the participants involved.

Transferability/External Validity

The study involved educational stakeholders in all the organizations which had anything to do with the project in STP. The characteristics of the participants, the work methodology, and the context in which the program was executed as well as the thoughts of the participants in relation to the project were thoroughly described in order to ensure transferability. The results of the research were analyzed to determine if they were consistent with prior experience and theory. It was important to provide all the data and to determine whether the results from the study would permit adequate comparisons with other studies in countries with similar characteristics to STP or if there were many threats to the generalizability of the research. In order to guarantee transferability, there was a thorough description of all the data provided. The selected participants were from different professions within the educational system of STP. Their thoughts and opinions on the introduction of educational technology in the educational system in STP were diverse, rendering it essential to have thorough descriptions of each participant's thoughts and views. The processes and outcomes were described in the conclusions in a generic manner to determine the applicability to similar cases in different places or contexts. The study, therefore, reports the process and outcomes thoroughly, enabling replication of the research results. Readers are able to assess the extent to which proper research practices were followed in order to allow the readers to develop a thorough understanding of the methods and their effectiveness (Shenton, 2004).

IMVF and ESECS-IPL were based in Portugal while all the other stakeholders were in STP. Each interview took less than one hour, and the time necessary to prepare for another interview took approximately another hour. About four interviews could be done per day. Context was crucial in trying to determine transferability of research studies, although the idea of producing transferable results from one study was questioned (Shenton, 2004). The study could not disregard the importance of context that is essential to qualitative research.

Dependability/Reliability

The dependability of the research relates to the clarity of the research questions, and the features of the study should be congruent with them. An evaluation of the effectiveness of the inquiry was done. The data were collected across the full range of participants in the educational setting in STP. Data collection protocols for each group were specific. The interview transcripts and the confidential narratives supplied by the teachers were reviewed. Coding checks were made to ensure adequate agreement. Data quality checks were also made by analyzing convergence of accounts in terms of timings, settings, and activities. The researcher's role was described, and meaningful parallelism was sought from the data sources through triangulation. The research results were connected to the conceptual framework in order to specify paradigms and analytical constructs which could be drawn from the data.

Confirmability

The concept of confirmability is the qualitative investigator's comparable concern for objectivity. Here steps were taken to help ensure as far as possible that the work's findings were the result of the experiences and ideas of the participants, rather than the characteristics and preferences of the researcher. The role of triangulation in promoting confirmability was emphasized, in this context to reduce the effect of investigator bias. Confirmability is the extent to which the researchers admitted their predispositions (Miles & Huberman, 1994). One way to provide confirmability to the research was to explain decisions made as well as methods adopted in the research report and the reasons for having chosen a particular approach instead of other approaches.

Ethical Procedures

In qualitative research, potential ethical conflicts can exist regarding how a researcher gains access to a community group and in the effects the researcher has on participants (Orb, Eisenhauer, & Wynaden, 2001). I had a professional relationship with the teachers who participated in the research. I was an instructor for the courses "Introducing Educational Technology in the Physics and Chemistry Classrooms," "Research Project I" and "Research Project II" which ended in July 2012. To minimize the impact that my contact with the teachers had, I asked them to produce confidential narratives where they could express thoughts and opinions that they did not feel comfortable sharing during the interviews. Because STP is a small country, I know all the stakeholders in the educational setting. People of STP tend to shy away from participating in interviews with strangers or people they do not trust. Nevertheless, I informed them of the importance of being truthful when involved in the study regardless of what they felt I thought of their responses. The objective of the study was precisely to get their thoughts and opinions in order to evaluate the effect that the introduction of educational technology in the pilot program had on the teachers and on the other stakeholders. This allowed trustworthy conclusions to be drawn from the project.

The participants' identities were not revealed in the research; therefore, there were no personal risks to the participants in the study. The consent forms were sent to the participants in a language understandable to them. The consent forms included an understandable description of the research purpose, data collection procedures, and voluntary aspect of the participation (Appendix A). The consent form informed the participants that they had the right to decline or discontinue participation at any time. The consent form included written assurance that declining or terminating the interview would not negatively impact the participant's relationship with the researcher. The consent form included a description of compensation for internet usage during the Skype interview, privacy settings, preservation of legal rights, and contact information for the researcher and the university's Research Participant Advocate.

The participants were informed of every step of their collaboration with the study: the interview, the interview transcripts which were based on the interview recordings, the reflective summaries that they would receive shortly after the interview, and the confidential narratives.

During the data collection, all the information was stored in my computer, computer files, and NVivo software, and a copy was stored in an external drive that I never transported around with me. All the data with information were password protected at all times. All the personal information was, therefore, only available to me and would not be shared with anyone. The data would be stored for at least five years. I stored the personal information of the participants such as their names, consent forms, and other documents in a safe in my study at home. I had on my personal computer a list where I had their names and attributed numbers/letters as locators to each one for my own control. Nobody else had access to this information; it was also in a password protected file. The data were organized according to the participant's functions to understand the level of influence they had on the diffusion of the innovation in their country. The translator and peer reviewer only had access to the process with the locators. The codes for the participants all had a number which in the coding system was represented as n: teachers had #nT, the school directors had SP#n, the minister of education Yves, and the other educational stakeholders had S#n followed by the institution to which they belonged (IMVF, ESECS-IPL or ISP). The translators translated the consent forms, confidentiality agreements, and questionnaires for the teachers, school directors, partner institutions members, and minister of education. After I prepared the interview transcripts and the confidential narratives with the coded locators and without any personal information, the translator translated them into English. Summaries were made of the interviews, and these were also translated. The translator and peer reviewer both signed confidentiality agreements (Appendix M). After the data were separated and organized the peer reviewer reviewed the data to confirm that it was organized appropriately.

I contributed to current research in educational technology with my research. I conduct my research using professionally accepted guidelines and procedures, including those that protected participants from harm or discrimination. I uphold the principles of ethical conduct and research policies expected by a researcher and scholar-practitioner in Educational Technology.

Summary

The research procedures involved interviews with the participants in the study. The teachers also provided confidential narratives in order to augment the trustworthiness of the data supplied by them. The data were collected through interviews with the teachers who participated in the project, the principals of the schools where the teachers taught at the time of the implementation of the project, the prior minister of education, the head executives of the IMVF, of ESECS-IPL, and of ISP. After the data collection phase, all the data were uploaded to the NVivo software and was coded to be analyzed. The data were then analyzed and interpreted. All professionally accepted guidelines and procedures, including those that protected participants from harm or discrimination, were used. All the procedures to ensure trustworthiness were used, and the procedures to ensure credibility, transferability, dependability and confirmability were specified.

The integration of educational technology in education in STP would better the level of education considerably. Teachers would be able to prepare and develop experiments that facilitate and motivate learning, help develop student creativity, and help develop twenty-first century citizenship. The teachers also learned to communicate and collaborate using technology, learned to do research and develop critical thinking, as well as a sense of digital citizenship.

Chapter 4: Results

The purpose of this qualitative case study was to understand how technology integration in schools, for teachers, could be addressed in a first-wave country. Due to the fact that STP possesses the ideal conditions to test Toffler's (1980) wave theory, being a small isolated island, the implementation of a pilot program designed to train high school science teachers in STP to infuse technology into their classrooms was used to test the theory. The perceptions and experiences of the teachers, the directors of the schools where these teachers worked, members of the partnership institutions (members of IMVF, project leader and teachers of the teacher development program at ESECS-IPL, head of physics department and lecturers at ISP), and the former minister of education were sought.

Research Questions

What are the experiences and perceptions of the individuals involved with the integration of technology into a first-wave country?

1. What are the experiences of the teachers in STP during the implementation of the program?
2. What are the experiences of the representatives of the partner organizations and the directors of the schools during the implementation of the program?
3. What are the experiences of the former minister of education during the implementation of the program?

In this chapter, I begin by reviewing the setting where the study took place and the personal and organizational conditions that influenced the participants at the time of the research. I then present the participant demographics, after which I address the data collection process, explaining the type of data collected. I describe the location and duration of the data collection. The data analysis follows, with the data coding under a number of themes. The evidence of trustworthiness is also referred to, where issues of credibility, transferability, dependability, and confirmability are described. The results are presented by research question, with the data that supported them, and finally the answers to the research question are provided.

Setting

The setting was the town of São Tomé on the Island of São Tomé and Príncipe, which was the first-wave country of interest in this research. The educational system was very outdated, and the IMVF created the 4-year Project *Escola+* and implemented a new curriculum for the middle and secondary levels that is similar to the curriculum used in Portugal yet has been adapted to the context in São Tomé and Príncipe. It was detected that for the new curriculum to be applied, teachers needed to be trained, and therefore IMVF promoted teachers' training courses where teachers who held bachelor's degrees in physics, chemistry, biology, geology, and math were invited to participate in a program where they would be able to pursue their *Licenciatura* in those areas. The physics and chemistry teachers from São Tomé who took part in the program completed their *Licenciatura* in chemistry, or physics at a local university (ISP). These programs were promoted by IMVF and executed by faculty from the ESECS-IPL and some faculty from ISP.

Participant Profiles

Two years after the end of the program, the participants in the research were interviewed to find out their thoughts and feelings about the integration of educational technology in their professional practices. The total number of participants in the interviews was 25 (Table 6). All the participants possessed university degrees. All the teachers who participated in the training program agreed to participate in the study. These teachers lectured at five different schools in São Tomé. The schools were atributed pseudonyms which were the names of STP writers. Seven teachers taught at Alda Espírito Santo school, which was the main high school in the country. Of these seven teachers, only three taught there on a full-time basis; the other four supplemented their work at Alda Espírito Santo school with work at other schools. The two teachers who taught at Conceição Lima school lectured there on a full-time basis. Both teachers who taught at Costa Alegre school also lectured at Alda Espírito Santo school, so did both teachers who worked at Albertino Bragança school. One of the teachers who had lectured at Alda Espírito Santo school was in Angola and taught at a school created there by his church. One teacher lectured at Sara Pinto Coelho school, which was a private middle and high school. After obtaining his licenciatura, this last teacher was invited to lecture at the ISP. The principals of four of the secondary schools (Conceição Lima school, Costa Alegre school, Albertino Bragança school, and Sara Pinto Coelho school) participated in the study, and so did the head of the physics department at Alda Espírito Santo school, who also acted as the physics methodologist for STP. Methodologists are the people who are responsible nationwide for the programs that should be lectured and the execution of the programs by the teachers. A methodologist should also be responsible for the final exams nationwide. Because the physics methodologist was in different functions, the position was delegated to the head of the physics department at Alda Espírito Santo school. The other three heads of the physics departments (Conceição Lima school, Costa Alegre school, Albertino Bragança school) and the head of the chemistry department (Conceição Lima school) were among the teachers who participated in the study. They were promoted to these positions because they had completed their studies at the ISP. The teachers who participated in the program also counted on the support of the head of the physics department at the ISP, who was a very respected person in STP. The head of the physics department was aware of the technology that had been used by the teachers and was one of the defenders of technology integration in the physics classroom, especially simulations and modulations. Among the teachers who participated in the study were also two vice principals. The opinions and thoughts of these teachers in their dual roles were noted.

The stakeholders who participated in the study were from the IMVF, ESECS-IPL, and ISP. The participants from the IMVF were people directly involved with the program in STP (Project Escola+). The Project Escola+ coordinator, who was also the chemistry methodologist for STP, and the person in Project Escola+ which was responsible for the training (excluding the *Licenciatura* programs at the ISP) participated in the study. The two Portuguese teachers in charge of implementing the new physics and chemistry programs in STP (who worked directly with some of the physics and chemistry teachers) were the other two IMVF participants. These two teachers returned to Portugal when the first phase of the program ended. ESECS-IPL participated with the person in charge of the development of teachers' training programs (for the *Licenciatura* programs, for school inspectors, for school administrators, for heads of departments) and with the preparation of the new curriculum in STP's educational system. Two ESECS-IPL faculty members provided training to the teachers in STP before and after the introduction of educational technology for the physics and chemistry classroom program. The person in charge of the development of the training programs and one of these lecturers lived in Portugal, and the other lecturer was in East Timor training teachers. From the ISP, the study counted on the participation of the head of the physics department and that of the chief of the department of technology. The vice principal of the ISP who had agreed to participate was later not able to participate due to personal reasons that were beyond his control. One of the teachers involved in the study was invited to become a lecturer in the physics department at the ISP, and his dual role was noted. These three people all live in STP on a permanent basis. The minister of education at the time of the program also participated in the study. Table 6 indicates 36 participants, but five teachers worked at two places at the same time, and six teachers had dual roles; therefore, the number of participants was 25.

After I had interviewed the first people, it occurred to me that the heads of the physics and chemistry departments at the schools and the methodologists should also be included in the study, because they had been mentioned by some of the interviewees. Each school had a head of the physics department and a head of the chemistry department. Of these people, the chief of the physics department of Alda Espírito Santo school participated in the study. Another three heads of the departments were the teachers who participated in the study, and the head of the chemistry department of Conceição Lima school was also one of the teachers who was involved in the study. The teachers had been promoted to these positions as a consequence of the training through which they had received their *Licenciatura* degree.

Table 6

List of Participants in the Interview Roles

	High schools										
	A	B	C	D	E	Angola	IMVF	IPL	ISP	MIN	Total
Teachers	7	2	2	2	1	1			1		16
School principals		1	1	1	1						4
Head of department	1	2	1	1							5
Vice principals	1	1									2
Stakeholders							3	3	3		9
Minister of education										1	1

Note. Although the listed number of participants in the table is 36, some of the participants had dual roles. There were 25 participants in the study.

In the interviews, the methodologists were also mentioned; there was one methodologist nationwide for chemistry and one for physics. The chemistry methodologist was also the head of the project Escola+ who participated in the study, and the physics methodologist was not available because he was not pursuing his teaching profession at the time of the interviews. The methodologists had different positions relative to the other teachers, their positions were decreed through governmental gazette, and their wages were much higher than those of the other teachers. Some of these methodologists did not eteach anymore but continued to be the methodologists, and their salaries continued to be those of methodologists.

Data Collection

Interview Process

The current minister of education provided permission to conduct the study in the secondary schools of São Tomé and as part of the study, authorized contact with the participants in the study (Appendix S). Among the participants chosen to take part in the study were the ten teachers who participated in the program for the introduction of technology in the science classroom, the principals of the five schools in which these teachers worked in at the time, members from the relevant educational stakeholders in STP (IMVF, ESECS-IPL, and ISP) as well as the former minister of education at the date of the implementation of this program.

I contacted the participants via email having attached the letters of consent (Appendix A) which they needed to read and then answer the mail with the words “I consent” or “I accept” if they agreed to participate in the study. The participants sent emails to confirm their participation. The members of the IMVF delegated their participation to the members who were working on and and were in charge of the Project Escola+ in São Tomé and Príncipe. One of the members of the board of the ISP, who had initially agreed to participate in the study, was not able to participate later for personal reasons. The chief of the chemistry department at the ESECS-IPL delegated her participation on the chemistry instructors who had been involved in the training program, and had both provided training before and then again, after the teachers had learned to use technology.

The participants who agreed to participate in the study were informed of the objectives of the study, during the one on one recorded interview through Skype and they were informed that they would get a summary or transcript of the interview to review. The participants were thanked for their participation in the study as it was of a voluntary nature and they were free to refrain from responding to any question they felt uncomfortable with or even terminate the interview at any moment during the interview. They were informed of the minimal risks and benefits of the study, on the integration of technology in the classroom in STP. The names of the participants were not included in the study, nor was any other document that would identify them included in the study. The interviews were set up according to the participant's availability and they were set up through video conferencing Skype calls with the exception of one participant who did not have a computer and his interview was set up via recorded phone call. Most interviews were near the end of July and during the first week of August, after the school holidays started. A couple of participants did not have availability before nor during the summer break, so their interviews were conducted at the beginning of September. One hour was the anticipated time for the interviews, although no interview took more than 50 minutes. Creating the transcripts took many hours each in order to understand the exact words that had been employed, and there were many repetitions of the recordings. The translations took one month to get ready and then the summaries were done within two weeks of the completion of the translated transcripts. The summaries were translated back into Portuguese and sent to the participants.

After the first interviews, the importance of the heads of the physics and chemistry departments in the educational process became evident due to the responses of some of the interviewees, and these were consequently included in the study, and so were the methodologists. Some of the teachers that had participated in the program had been promoted to head of the chemistry or physics departments of their schools since the program. Other than the teachers who had been involved in the program that were heads of department, only the head of the physics department at Alda Espírito Santo school agreed to participate in the study. All the participants were given pseudonyms, which were chosen alphabetically according to the order in which each participant was interviewed within the group to which they belonged (Table 7). Pseudonyms were also provided for the teachers' narratives. In this case all the names chosen were male because male to female ratio of the teachers interviewed was 9:1.

The coordinator of Project Escola+ was also the chemistry methodologist. The physics methodologist did not participate in the study, although the chief of the physics department at Alda Espírito Santo school acted as the physics methodologist. One of the teachers who had been involved in the program was invited to become a lecturer at the ISP, and there were two vice principals among the teachers who participated in the program. The dual roles of all these teachers were noted and their comments outside that of their teacher role were coded accordingly with a distinctive suffix to distinguish them

Table 7

Participant Pseudonym, Gender, and Position

Participant Pseudonym	Current Position	Gender	Code
Anthony	Teacher	Male	T#1
Bernard	Teacher	Male	T#2
Charles	Teacher	Male	T#3
Daniel	Teacher	Male	T#4
Edward	Teacher	Male	T#5
Francis	Teacher	Male	T#6
Gerald	Teacher	Male	T#7
Hunter	Teacher	Male	T#8
Isabelle	Teacher	Female	T#9
Jack	Teacher	Male	T#10
Kim	Principal at Sara Pinto Coelho school	Female	SP#1
Louis	Principal at Conceição Lima school	Male	SP#2
Michael	Principal at Costa Alegre school	Male	SP#3
Nelson	Principal at Albertino Bragança school	Male	SP#4
Oscar	Head of Physics Department at Alda Espírito Santo school	Male	SP#5CPD
Patrick	Stakeholder ISP	Male	S#1ISP
Quinn	StakeholderISP	Female	S#2ISP
Rebecca	Stakeholder ESECS-IPL	Female	S#1IPL
Sharon	Stakeholder ESECS-IPL	Female	S#2IPL
Theresa	Stakeholder ESECS-IPL	Female	S#3IPL
Ursula	Stakeholder IMVF	Female	S#1IMVF
Vincent	Stakeholder IMVF	Male	S#2IMVF
William	Stakeholder IMVF	Male	S#3IMVF
Xana	Stakeholder IMVF	Female	S#4IMVF
Yves	Minister of Education	Male	ME
Andrew	Teacher narrative 1	Unknown	TN#1
Barry	Teacher narrative 2	Unknown	TN#2
Christopher	Teacher narrative 3	Unknown	TN#3
Dean	Teacher narrative 4	Unknown	TN#4
Ethan	Teacher narrative 5	Unknown	TN#5
Frederick	Teacher narrative 6	Unknown	TN#6
Gabriel	Teacher narrative 7	Unknown	TN#7
Henry	Teacher narrative 8	Unknown	TN#8

from the other stakeholders so that it could be easier to identify their comments from those of the other participants.

The interviews were conducted in Portuguese. They were recorded using Audacity software, and were transcribed by me using Express Scribe from NCH software. The transcripts were translated into English by the translators, they were summarized, and these summaries were sent to the participants so that they could validate the information provided. The summaries (Appendices O, P, Q and R) and confidential narratives (Appendix K) were translated by the translators.

Data Analysis

Categories and Themes

All the data, including audio recordings, transcripts, summaries, and teacher narratives, were uploaded to NVivo software where the coding process started, and the data were separated into different categories and themes. The data from the different sources were divided into different groups: the teachers, the prior minister of education, and the stakeholders which included the school principals, heads of chemistry and physics departments at the schools, and the stakeholders from IMVF, ESECS-IPL and ISP. There were five main themes which were the following: *roles, experiences, perceptions, recommendations, and other projects*. These items were created in an attempt to facilitate the response to the research question. Each of these themes had subthemes thus creating a hierarchy (Table 8).

Coding

Codes were determined for the participants, for their roles, their experiences, their perceptions, their recommendations and other projects (Appendix L). The codes for the participants all had a number which in the coding system represented the order in which they were interviewed within their group. This number is here represented as n. The teachers codes were #nT. The school principals codes were SP#n followed by VP, CQD or CPD when instead of the principal it was a vice principal, head of the chemistry or physics departments. When at the same time the person was one of the teachers who participated in the program the code was followed by the teacher code. The stakeholders codes were S#n followed by the initials of the organization which were IMVF, ESECS-IPL and ISP. The code for the prior minister of education was ME. The coding of the narratives was done in the order that they were received and opened. There was no correspondence between the numbering of the teacher interviews and the confidential narratives. These codes were used for the organization and analysis of the data. In the text pseudonyms were used for the participants instead of the codes.

Table 8

Themes, Audience, and Subnodes

Themes	Audience	Subnodes
Roles	Minister of Education School Directors Stakeholders	Minister of education, school directors and stakeholders
Experiences	Teachers	Dissemination, distance education, further education, implementation, important, most difficult, most useful, satisfaction
Perceptions	Teachers Minister of Education School Directors Stakeholders	Benefits, challenges/constraints, change, context Knowledge, likelihood to continue using technology, student behavior, student motivation, student performance, teacher investment, technology use
Recommendations	Teachers Minister of Education School Directors Stakeholders	consolidation, continuation or expansion, distance education, future of educational technology, sustainability
Other Projects	Teachers Minister of Education School Directors Stakeholders	Curricular development, laboratory project, resource center, technological plan, World Bank

The themes arose from the research question and the interview questions. The five themes had subthemes associated with them. The first theme was associated with the roles that the participants played in the project; the second was mainly related to the teachers experiences; the third considered the participant’s perceptions; the fourth covered the recommendations; the last theme had to do with other projects that directly or indirectly could influence the project (Table 8).

Evidence of Trustworthiness

Credibility

In order to ensure internal validity the data from the different sources was used to determine the convergence of data. The reflective summaries of the interviews were sent to the participants in order to see if these reflected their thoughts or if they intended on changing anything in these summaries (Appendices O, P, Q and R). The summaries were included in the study and served as member checks. The teachers' interviews were complemented with confidential narratives that were also included in the study. The data were organized numerically using codes to keep the sources from being identified. Peer review was another aspect of the study where I sent my results to two specialists who reviewed my results (Appendix M). The study described what the program meant to the participants. The data of the teacher interviews and the teacher narratives were analyzed for similarity to see that they did not contradict each other. The narratives (Appendix K) served to complement and validate the data from the interviews (Appendices B, C, D and E). The data from the three different groups of sources (Appendix T) were compared to verify the patterns that developed from them in order to respond to the research question and validate the data collected.

Transferability

In order to ensure external validity, I included and described thoroughly all the data provided. During the interviews, as a response to the reflections of the participants on the importance of the heads of the physics and chemistry departments as well as the physics and chemistry methodologist, I also contacted these people in order to include them in the study, and interview them as well. I was able to interview one extra person; the others were not available and some of the teachers themselves had become heads of chemistry or physics departments at their schools, therefore, had already been included. The considerations and thoughts of the teachers in these positions were included when they were provided. One teacher had also become a lecturer at the ISP, and two more were vice directors at their schools. One of the teachers was currently working in Angola also participated in the study. The methodologists were the people that were nationwide responsible for the subject. The chemistry methodologist was one of the educational stakeholders in the study while the physics methodologist was not available and head of the physics department at the ISP had provided that support to the teachers who participated in the program.

The results of the research were analyzed to determine if they were consistent with prior experience and theory in order to determine whether the results from the study permitted adequate comparisons with other studies in countries with similar characteristics to STP and threats to the generalizability of the study. The processes and outcomes were described in the conclusions generically in order to determine the probability of applicability in similar cases in different places or contexts. The study was, therefore, reported in detail to enable the replication of the research results.

Dependability

The research questions were clear, and the different features of the study were congruent with them. The interview questions were effective in providing the answers to the research questions. The data were collected across the full range of participants in the educational setting in STP that in some way were linked to the program and the data collection protocols for each group were specific. The interview recordings, transcripts, confidential narratives supplied by the teachers, and reflective summaries were reviewed and coded. Coding checks were made to ensure adequate agreement. Data quality checks were also made by analyzing convergence of accounts in terms of timings, settings, and activities. The researcher's role was described, and parallelism was sought from the data sources through triangulation. The research results were connected to the conceptual framework in order to specify paradigms and analytical constructs to be drawn from this data.

Confirmability

In order to help ensure that the research findings were the result of each participant's experiences and ideas, the research questions were answered using many quotations from the interviews. The research findings were based on the information retrieved from the participants either through the interviews or from the confidential narratives. The triangulation of the data from the different sources was emphasized in order to ensure confirmability and reduce researcher bias. All the decisions made, all the methods adopted in the research report, and the reasons for the particular approaches instead of others were explained.

Results

After the compilation of the data into NVivo to facilitate interpretation and the description of the case, the data were aggregated into the categories and themes. The disassembling of the data followed, and finally the data were reassembled in order to reveal relevant information to answer the research questions.

Reflective Summaries

The reflective summaries of the interviews (Appendices O, P, Q and R) with the participants in the study provided a global idea of the participants' thoughts regarding the implementation of technology in the physics and chemistry classes. The coding for the reflective summaries followed the same order as the interviews. Pseudonyms following the alphabetical order from A to Y were assigned to the codes for better understanding (Table 8). The reflective summaries for the teachers (Appendix O), for the school principals (Appendix P), for the educational stakeholders (Appendix Q), and for the minister of education (Appendix R) were sent to the participants for approval.

Confidential Narratives

Ten teachers participated in the interviews, but only eight narratives were received. The narratives were sent to me by the interviewees through the mail without any indication of the author of the letter. None of the narratives received had any personal indicator or signature on them. The teachers' narratives (Appendix K) were translated and disassembled according to the questions answered.

Degree of satisfaction. Andrew considered the program to be "very good with excellent results." The program made him reflect on how schools would be in the future, the activities they would use as well as the technology resources needed. The program made him realize that education had changed.

> This allowed me to understand that the classroom where the teacher talks all the time and the student listens, the student "receives" content and "returns" during the tests, in which almost no one uses the computer, tablets, etc, is no longer possible

Barry was very pleased with the program and considered the results encouraging. There was no laboratory at his school, and he used simulations that helped overcome the difficulties the students encountered. He realized that innovation in education was needed. “We face a new century with a new format for receiving and transferring knowledge, as well as an endless quest for knowledge.” He did nevertheless show his concern for the necessity of having electricity to be able to use this technology in the classroom. Christopher was satisfied with the program because he realized that there was a need to master new skills as a teacher, and the program provided “a technological culture in the school context.” As a response to his level of satisfaction with the program, Dean referred to all he had learned in the program. The program provided him with the knowledge and mastery of technology which helped him organize the data, plan lessons, prepare presentations, and use simulations. Ethan was very satisfied with his participation in the program. He considered it to be the basis for the opening of opportunities to have more access to information and “there has been a satisfactory growth in commitment and assimilation by the students.” Frederick was satisfied with the program, but he considered it to be too early to view immediate results. However, he found the students’ “general educational objectives” slightly improved. Gabriel was very satisfied with the program because it was his “first contact with the new educational technology for teaching in chemistry and physics lessons. The results were honestly satisfactory." Henry viewed technology applied to physics as "extremely important" as it allowed the students to interact with the technology for interactive activities as well as support with problem-solving. He does nevertheless think that STP may still take a while to start applying educational technology "due to profound shortage experienced in the country."

Probability of using educational technology in the future. Andrew had no doubt that he would continue to use technology and showed what he had achieved thanks to technology. He used technology to "develop more dynamic, creative and interactive activities. Students learn to use simulations, perform WebQuests, view videos, and animations, participate in school Moodle platform, etc." He felt that these interactive activities developed student creativity and willingness to participate. Barry also intended to continue using technology, especially simulations that facilitate understanding of certain concepts: "the use of technologyis changing work patterns to help achieve individual goals." Christopher believed that it improved access and efficiency of education and training and that it was essential for the development. It provided interactive activities and learning experiences "where students can experiment and apply knowledge as well as construct knowledge individually. Interacting with the world around him." The student could take on an active role in his education, and "emphasizes motivation with activities that stimulate student interest, curiosity, and appreciation for the topic under study." Gabriel believed he would continue to use technology in the future because it promotes learning, provides more interesting ways to teach the subject, and allows students to have the opportunity to interact with the course content and "assume the role of the builder of his own knowledge."

Barry referred to the schools being equipped with technology, but said that not all teachers used technology. Christopher also found that technology facilitated education but that there was a wide gap between what had been learned and what was done. "There is hardly another area where the gap between the imaginable benefits and the reality is as significant as in education and training." Dean referred to the fact that the teachers and students did not have the means to acquire computers. Frederick emphasized the need for the creation of support materials and dynamic activities as well as create "recycling sessions" for the people that had already been trained. He believed that "meetings, planning, and methodological preparation, which is usually fortnightly, could be alternated with presentations of topics and technical work practices for classroom use for more dynamic practices." He believed that with fortnightly sessions the integration of technology in the classroom would be of about 75% versus the 25% which he thought would happen if this support did not exist. Henry believed that due to the educational reform many students have transitioned into middle and high schools that "were not accompanied by the infrastructure, the equipment of these infrastructures, equipment, laboratories, etc." He felt that although some teachers had pedagogical-didactic training, the integration of technology would be difficult.

Christopher believed that the continuation of the use of technology in the classroom "depended on the country's leaders who needed to review the importance of teacher training for proper integration of technology for teaching and learning." Dean believed that in the future all teachers and students would use technology and that it "will be an integral part of the system where new technologies are used in the education system if it is within the framework of the programs under the guidance of subject delegates, methodologists, and senior educational managers." According to Ethan there was an 80% probability of using educational technology in the future, where students would develop "the spirit of research, present research data, and connect the theory to practice through simulators, games, and observation."

Other comments shared in the narratives. Christopher praised the program that was "essential for the development of a country by training better-prepared citizens for a world in constant change." He believed that people with in-depth knowledge in education were needed: "This program promises to play a significant role in enhancing teachers and students." Ethan wished "there was a book with guidelines to orient the teacher" and that the program would be extended to all secondary level teachers. Frederick was optimistic about the future of the program: "The thought of the education technology comes in good time, when the challenges of globalization and especially its negative aspects, it is urgent that we insist on making better use of innovation and technology, especially in education." Gabriel shared, "Before I started studying this program I did not know anything about the computer, but now I know [how to] turn on the computer, create free Prezi, Glogster create and use many educational tools, etc." Henry was disturbed at not being able to apply what he had learned, but was happy to "have had the opportunity to meet and interact with these technologies in the program."

Research Question by Participant Roles

The research question was divided into three subquestions, each of which concentrated on one of the groups in the study. The three groups were firstly the teachers, secondly the stakeholders (the people from the partner institutions, IMVF, ESECS-IPL, ISP, the school principals, the heads of the chemistry and physics departments), and thirdly the prior minister of education.

The interview data, the recordings, the teacher narratives, and the summaries were all uploaded to the NVivo software. Files were created for the teacher data, the stakeholders data (IMVF officials, the ESECS-IPL faculty, ISP faculty, school principals and heads of physics/chemistry departments). The sources were then all coded (Appendix L).

What are the experiences and perceptions of the individuals involved with the integration of technology into a first-wave country? The data were disassembled following the coding system developed for the study (Appendix L).

What are the experiences of the teachers in STP during the implementation of the program? The data from the teachers was based on data retrieved from the interviews and the confidential narratives of the teachers. The teachers' experiences, perceptions and recommendations were listed (Table 9). This data were later triangulated with the data from the stakeholders and that from the prior minister of education.

Experiences and perceptions. The teachers' experiences were divided into the following themes: most useful, most difficult, importance, implementation, dissemination, further education, satisfaction, benefits, challenges, likelihood to continue to use technology, student, and recommendations (Table 9). The matrix coding in the Nvivo software were used to view all the references that concerned the teachers' experiences and perceptions. Text search and word frequency were also used.

Most useful. The information on the most useful aspects of the program was all retrieved from the interviews. Anthony spoke of time reduction: "Technology summarizes our ideas and even what we could give in 20 minutes, we can give in 10 minutes." Bernard used several tools "since they are already fans and enjoyed it so much why not use it" … "We also had an advantage because our teacher insisted on us using a platform." Games and simulations were considered most useful for Anthony, Charles, Edward, Hunter, and Jack with "because the games created interaction and the simulators created a link between theory and practice." Edward liked the games and simulations but also the concept maps "most useful. I think it was concept maps, …. and games and simulations as well." Hunter mainly used simulations and emphasized the student's attitude when the simulations were used: "I started using it, and I saw that the students liked it. The students became more motivated with the use of simulations. It was win-win for me with this training because, like I said that motivated the pupils, and they became interested." Francis focused on the student motivation: "I learned, and improved my former way of working with my students and not only that but the students got motivated, and lessons became more accessible and pleasant." I noticed that some spoke about the tools that they used with their pupils in the research projects like, for example, Daniel with his explanation of the utilization of the software Stellarium which is an astronomy software:

> It is like bringing a faraway world to the students. Note that we made that satellite demonstration to the student, instead of using a telescope, that program Stellarium makes the students that wouldn't be able to see, the students who wouldn't have access to these programs would never see these things, never, so these tools brought the world to them, the world that was beyond their reach, a little nearer.

Francis also considered the program he used in his research project, which was a timeline, most useful: "that particular program developed for the teaching of history. It´s good, not only for the chronological aspects, not only the dates; it was also good to see the timeline of scientists' lives as well."

Most difficult. The information on the most challenging aspects of the program was retrieved from the interviews. The teachers generally did not find the program difficult although two did consider the bad internet connectivity at the time, Bernard "a difficulty, not in the sense of learning, a technical problem, that was a little… internet matter" and Hunter: "The only difficulty I had was because of the Internet" and Jack: "the connections here are complicated." There were teachers that did not know how to use the computer before the program started and found it difficult at first but admitted that it just needed some dedication to overcome, Daniel: "But it was because of difficulties with the use of computers, we didn`t know how to use them", Edward: "For me it was the simulation programs and the games", Francis: "we still had some difficulties in controlling these techniques" and Isabelle :"In the beginning, I wasn't good with the internet or computers, and it was a bit hard, then I adjusted, and it became easier."

Implementation. The information on the implementation was retrieved from the interviews and showed that five teachers changed their way of teaching after having participated in the program. Bernard referred to the implementation in the following way:

> The range wasn`t limited to the subject, such that it is still reflected now, if you ask, it drastically changed our way of being in the classroom and if now we feel more comfortable with these tools well it is thanks to the beginning, the beginning of that subject in our course.

Charles referred to two different experiences: "Nowadays, for example, when I introduce a new theme, right, I also had that experience, right, demonstrating through simulations" and in relation to having been a speaker at the MasterClass 2014 he said:

> In the MasterClass I was one of the speakers, right, and used PowerPoint to do my presentation, right, and that is thanks to the program we had, usually I didn't use PowerPoint in my presentations, but nowadays I see that that technology helps me a lot so I had an excellent presentation in this year`s MasterClass.

Daniel referred to the number of students in the classroom and the lack of resources as the reason for not implementing technology in his classroom although he stated that "it has brought a new dynamic to learning." Edward, on the other hand, has used the technology in a different way:

> It decreased the amount of time necessary to explain the introduction of contents, facilitated the construction of graphs, and we also work with digital laboratories. Through that, I managed to enter the internet with the students to make the lab experiments."

Francis started using simulations: "my way of teaching was influenced"…"don't have a laboratory, so with this program I noted that with some simulations I could take my knowledge to the students" and "the teaching program demands more practice and with the simulations it makes sense to grab on to new technologies." Hunter has used simulations to demonstrate experimentally: "I have been using PhET a lot in the simulations" and as for the fact that he did not have internet at his school, he said "I can only use offline, but it is already on the computer." Hunter also referred to the fact that the program changed the way he taught:

> My way of teaching was influenced because we used, it was very hard to explain something simple to a student, electrical current, uniform linear motion, especially relativity in action, and some calculations. Because most of the time, they didn`t understand what I was talking about, but they started using the program, and they saw a dummy walking. If that was in a curvilinear surface, after x seconds it is going to be in a particular position, and they saw that, so they started understanding very well what linear motion was through PhET.

Isabelle used technology mostly for research purposes and admits the technology has influenced the way of teaching and the preparation of tests: "The important aspect is associated with the utilization of the computer for research." Jack introduced simulations into his educational practice: "I used it in the search of some contents on the Internet. Afterward, I also used simulators. That helped a lot because the students were able to connect the theory to reality" and "Because I don't have a lab, the simulation can substitute a little bit." Jack also spoke of the social learning project he developed with his students for the domestic use of rainwater, where the students did research on the internet: “The students also studied and we were able to find a solution; this program helped the students a lot.”

Satisfaction. The levels of teachers’ satisfaction with the program were retrieved from the confidential narratives. Andrew was very satisfied: “In my opinion, I think the program was very good with excellent results.” Barry was also a satisfied teacher: “I am very pleased with the program because the results were encouraging. My school does not have a laboratory, so to provide my students with the required knowledge I have used new technologies in the classroom.” Ethan was very satisfied with the program: “About the program I feel a huge satisfaction at having participated in it, this program is a vehicle of connection between theory and practice.” Although rather confusing, Frederick was very satisfied: “The degree of satisfaction by which I evaluate my participation in the use of educational technology program, between negative, positive, and very positive, choose the latter.” Gabriel was very satisfied: “I thought the program was interesting and was very satisfied with its implementation.” Christopher was satisfied: “The degree of satisfaction is positive in the sense that it is because of a system, which provides an access to a technological culture in the school context in order to allow everyone a scientific literacy.” Dean had learned a lot, but that did not express the level of satisfaction in words therefore I considered it as not identified:

> This program provided me with the knowledge base and mastery of research tools as well as word processing. With these I am able to prepare and organize data that allows me to plan lessons with new technologies, PowerPoint presentation, use of

> simulation as a phenomenon of Physical Chemistry programs, using games as exercise for student.

Henry was satisfied to participate in the program but felt unsatisfied at the fact that he is not able to apply the knowledge acquired in the educational practice:

> I would like to express my dismay at not being able to apply many of the lessons learned, because of the lack of means that the school suffers and because of the excessive number of students, but at the same time I am happy to have had the opportunity to meet and interact with these technologies in the program.

Important. The important aspects of the programs according to the teachers were retrieved from the interviews. Bernard and Jack considered the fact that they were pursuing a higher degree to be crucial: “firstly there was the opportunity of complementing our education.” Francis felt that he had needed to make an effort to improve his teaching skills: “I had to make an effort and I liked it. As a teacher that made sense and it was time to follow that path.” Finally Jack felt that he was able to evolve his skills as a teacher: “I was able to find means to evolve in terms of teaching” by using the technology for his lessons to bring practice to theory, being “able to connect the theory to reality.” Daniel, Edward, Francis, Gerald, and Isabelle considered the fact that they learned how to use the computer to be important: “I learned how to work with computers in a orderly way;” “I sincerely wasn`t able to work with a computer. I have learned, … computer, internet, we worked with search engines;” and “Turn on, off, nothing beyond that. In technical terms, I didn’t know.” Henry was interested in the programs that supported his teaching of physics and chemistry: “The computer programs applied to physics are extremely important as it allows, on the one hand, a strong interaction of the learners with the tools involved. Secondly, there is an advantage in terms of time to resolve exercises, as well as providing greater the accuracy of the results" while Anthony considered the games and simulations to be important in the program. Daniel also found the fact that they had participated in the technology program made his peers from the other programs feel envious of them attributing in this way value to what they were learning to do "but the truth is that our colleagues of other courses were jealous because of the kind of work we had been doing. So, that means the tools we had been using gave great importance to our course."

Further education. Bernard believed that the program was implemented at the correct moment. In the masters degree which he was pursuing, online, he had a course for learning in technology "because having a degree is the stepping stone toward the masters degree which I am taking" … "in pedagogical supervision in sciences, right, there is a subject which is about knowledge and learning in technology."

Dissemination. Bernard and Jack have helped other teachers in their schools start using technology for research purposes as well as for use with the students: "First I try to see if it is worth it, I am the first to spread it around the other colleagues;" and "in Santana, these last few years I have tried and encouraged teachers in terms of new technologies, through these programs we have learned." Francis has also started to share with his colleagues his knowledge in technology:

> Not only me but my colleagues as well. I have been sharing the knowledge I acquired with them. We don't have a lab so we have the help of virtual

simulations and that has improved our performance and our way of taking the knowledge to the students.

Benefits. The teachers all believed that the integration of technology brought benefits to their educational practices although some of these teachers did not use the technology with their students. Christopher referred to the fact that technology “facilitates education and training.” Jack also commented on the fact that there were many tools to facilitate a “lot of programs we use in teaching.” Within the greatest benefits, they perceived the different tools that they could use to simulate experiments as most of them did not have access to laboratories at their schools. The simulations were employed in an attempt to facilitate the comprehension of the different concepts by the students as happened with Hunter: “everything becomes easier. It became easier for the students to understand;” and Christopher explained that the technology “improves access and efficiency of education and training." Time reduction was another of the benefits that the teachers focused on. Edward: “It decreased the amount of time necessary to explain the introduction of contents.” Another benefit of the program according to five teachers was the fact that the use of technology made up for the lack of laboratories. Barry: “My school does not have a laboratory, so to provide my students with the required knowledge I have used new technologies in the classroom.” Jack: “We don`t have laboratories, and because we have no lab, most of the things we teach the students is through these technology programs.” Charles: “We should take the students to a laboratory, but we don’t have one so we usually use the simulations.” Francis: “We don’t have a laboratory, so with this program I noted that with some simulations I could take my knowledge to the students.” In the case of Edward there was a laboratory that is not equipped, so he used simulations: “I managed to enter the internet with the students to make the lab experiments.” In another case technology was not a substitute, but it complemented laboratory sessions. Bernard: “If one day I made a PowerPoint, the next day I used a simulation or we went to the laboratory, not always using the computer.”

Challenges/Constraints. The challenges were mainly related to the lack of internet and lack of resources in the schools. Hunter: “So, until now, my greatest difficulty was accessing the internet to investigate and my students became interested in downloading programs.” Jack: “We have the Internet problem, which is hard.” Bernard: “A technical difficulty, that was a little… internet matter.” Hunter: “That is the difficulty I felt on the internet.” Daniel: “But due to the conditions of the classrooms our knowledge is not applied.” Henry: “I would like to express my dismay at not being able to apply many of the lessons learned, because of the lack of means that the school suffers and because of the excessive number of students.” Francis felt generally overwhelmed with the new curriculum and the integration of technology as he feared that with so many new things something could go wrong. “It was also the reforming process, we have to adapt new content. It is so much to solve and apply” and “we cannot fulfill every curricular content. Sometimes tools go wrong; it’s not easy.”

Likelihood to continue to use technology. In some cases it was visible that the teachers did not use technology much or even at all. In other instances the teachers used particular technology frequently and not others. For example, Hunter used the PhET simulations often but did not use games in his classroom. There were cases in which the teachers tried to use different technology like Andrew: "There is no doubt that I will continue to use technology in education in the future" and "develop more dynamic, creative and interactive activities. (Students learn to use simulations, perform WebQuests, view videos, and animations, participate in school Moodle platform, etc.)." Barry showed the intention to continue to use technology in education in the future: "I intend to pursue this work, as technology is very important for the practical aspect of education, where students develop their skills with great advances in research and learning." Ethan quantified his thoughts:

> The probability of using educational technology in the future would be the probability of about 80%. This, in my view, would develop in students the spirit of research, present research data, connect the theory to practice through simulators, games, and observation.

Christopher referred to the country's leaders as being responsible for the continuation or not of the use of technology in the schools: "The likelihood of the continuation of the program presenting the technology depends on the country's leaders who need to review, in detail, the importance of teacher training for proper integration of technology for teaching and learning." Dean referred to limitations of means but wrote that teachers and students would use this way of education, meaning that this was entirely dependent on exterior influences. Frederick thought that to continue to integrate technology into the classroom, a good educational policy was needed, expressing the importance of the fortnightly planning that would be necessary to cement these practices. He believed that with these fortnightly sessions the integration of technology in the classroom would be of about 75% versus the 25% which he thought would happen if this support did not exist. Henry referred to the explosion of students that transitioned to the secondary education and that the infrastructures were not prepared, they did not have equipment nor laboratories so the probability of the future use of technology was still remote.

Student behavior/motivation/performance. In terms of student behavior, motivation, and performance, there were various experiences that provided me with an idea of how the students that had technology in their classroom reacted toward this technology. Firstly, Anthony shared his opinion that new things create interest in the students: "Whenever we get something new, it creates appetite, especially for the students themselves." Charles noticed that adding to the interest in technology, his students were able to assimilate more: "technology created an interest in the students and I saw that the assimilation was more, I don`t know, consolidated." In the cases of Edward, Francis, Hunter, and Jack, the students became very motivated. Edward stated that "I made the inclined surface and the students were happy to see the experiment in practice and successfully managed to make calculations and so on." Francis said that "the students got motivated and lessons became more accessible and pleasant" and " students finished the curriculum with great results and that is what I expected of them." Hunter explained that "the students became more motivated. It was win-win for me with this training because, like I said that motivated the students and they became interested." Jack said "the students were excited with the experiments. Thanks to that we have been able to achieve the goal of the program." Isabelle noticed a significant change in terms of behavior and performance: “I saw in the students is mainly on their improved behavior in class” and “The students became more independent.”

Recommendations. Anthony recommended that there be more dedication on the part of the teachers toward the implementation of technology. “We need more dedication of the teachers toward implementing educational technology, thus involving their students in this new form of teaching and learning” and more commitment of the heads of departments and the methodologists because “the delegates must also be involved. They are responsible -- not only the delegates, but the methodologists as well.”

Bernard also recommended that “teachers need to invest a little more, and even ISP has to invest a bit more in that field. You can still notice a lot of vulnerability, right, it’s important” while Charles recommended that there should be more of these projects. “That there are more programs like these for teachers, right, more frequently, periodically so that it is not only our group.” Daniel thought it important to suggest that there be an educational program to distribute these materials to guide the teachers: “It is, therefore, necessary for there to be an education program where they distribute these materials.” Edward, Francis, Hunter, and Isabelle go further to suggest that the program is expanded to all science teachers in STP. “I suggest that the program is specified for teachers all around the world, so that they employ the educational system in the teaching of their students.” Francis: “I would also like it if the program focused on other regions of São Tomé, São Tomé e Príncipe.” Hunter: “It would be good to train more teachers.” And Isabelle: “The recommendation I have is that this program that was just for physics and chemistry teachers expands to other teachers.” Jack had recommended the creation of a

Table 9

Teachers' Experiences and Perceptions in Relation to the Program

Teacher Interviews/Narratives					
Experiences, Perceptions and Recomendations					
Most Useful	#	Most Difficult	#	Important	#
Several specific tools	7	Internet connectivity	3	Better computer skills	5
Games and simulations	5	No difficulty	3	Improve teaching skills	2
Improved teacher skills	2	Difficulty using the computer	2	Getting a higher degree	2
Summarized content	2	Different tools	2	Value attributed by others	1
Student motivation	2	Simulations and games	1	Research	1
Research Projects	1				
Implementation	1				
Opened a new world	1				
Implementation		Dissemination		Further Education	
Changed way of teaching	7	Help other teachers with technology	3	Pursuing Masters Degree	1
Simulations	5				
Research	2				
Presentation at MasterClass 2014	1				
Graphs	1				
Better time management	1				
All the tools	1				
No implementation	1				
tests	1				
Satisfaction		Benefits		Challenges/Constraints	
Very satisfeid	5	Facilitates Teaching	7	Lack of Internet	4
Satisfied	2	Facilitates student understanding	7	Lack of resources	2
Not Identified	1			New Curriculum	1
		Minimizes lack laboratories	5	Insecurity with technology use	1
		Reduces time to explain	2		
Likelihood to continue to use techn.		Student		Recomendations	
Very likely	4	Performance	5	Expand program	4
Dependant on exterior factors	4	Motivation	5	Teachers more dedication	2
		Behavior	2	Distribution of tutorials	2
				Creation of science center	1
				Distance learning	1
				Responsibility on Heads of Dep. and Methodologists.	1

Note. In each section, there are the parameters the teachers mentioned and the number of teachers who mentioned the parameters.

center for teaching physics and chemistry because they did not have a laboratory at his school; this center has already been created at the school "We created centre where we can dedicate ourselves to the study and implementation of physics because in Albertino Bragança school we don`t have laboratories."

Ethan suggested a book with guidelines as well as equipment "Firstly I wish there was a book with guidelines to orientate the teacher, supply of equipment, and that it could be extended to all the secondary level teachers in the country" and Frederick was interested in accessible materials "The creation of portals and accessibility to the technology to create a more dynamic activities."

What are the experiences of the representatives of the partner organizations and the directors of the schools during the implementation of the program? The data from the stakeholders consisted of data retrieved from the interviews with the school principals, the stakeholders from the partner institutions that were the IMVF, the ESECS-IPL, and the ISP. The data extracted from the interviews with the heads of the physics and chemistry departments of the schools also belonged to the stakeholders' group. The chemistry department methodologist was one of the educational stakeholders who participated in the study.

Experiences and perceptions. The stakeholders' experiences and perceptions were divided into the following themes: roles, importance, benefits, challenges, further education, and recommendations (Table 10). The matrix coding in the Nvivo software was used to view the references that concerned the stakeholders' experiences and perceptions. Text search and word frequency were also used.

Roles. The role of Sharon was that of the person responsible for designing the programs for the *Licenciatura* degree in the physics, chemistry, math, and biology teachers. “In designing the program, the physics and chemistry teacher’s training was framed within a more general training program. So there was a training package that was training in mathematics, training in physics and chemistry and biology.” From a global standpoint, Sharon was involved in the allocation of funds for the program:

> It was my identification of this necessity that these three training programs progressed. The funds were intended for the training of supervisors and the continuing education of directors that did not happen because the funds were allocated for the teacher's training programs.

Patrick participated in the creation of the program for the *Licenciatura* degree of the physics and chemistry teachers. Uzma became part of the coordinating team of Project Escola+ after the project had already been developed. “My role was then just to maintain what had already been agreed on, and I also acted as the bridge between all the work that was developed and Project Escola+.”

From a specific point of view Sharon provided training for Research in Education to the physics and chemistry teachers. Rebecca and Theresa were both faculty members for the ESECS-IPL who provided training to the physics and chemistry teachers at the ISP. Rebecca: “The only role I had been was that of training the teachers so they could finish or get equivalence, I think, to the degree.” There was a distance education component to this program, and the courses provided all had a part of virtual synchronous sessions which were provided through the webconferenceing software WebEx. Both

Rebecca and Theresa offered two courses each to the teachers, one before the teacher's introduction to technology and the second at the same time and after the introduction of technology. Uzma: "Also in the particular case of distance classes, made in collaboration with teacher Dolores and some classes at a distance helped prepare the call and maintain it at the time that teacher Dolores was out of the country."

Since the end of the program Patrick has monitored the physics teachers' educational practices in order to try to guarantee that they remain up to date and continue to use technology. "I also challenge the teachers. They need to keep constantly up-to-date, with constant practice so that they do not lose the knowledge they have obtained from these indispensable tools." William and Xana were the two Portuguese cooperating agents who became responsible for the physics and chemistry laboratories at Alda Espírito Santo school and for the maintenance of the resource center Kemese that had been developed at Alda Espírito Santo school. They also had direct contact with these teachers during and after the program. Vincent was the national coordinator of the Project Escola+. "I'm the national coordinator of the project that engaged the IP Leiria for which you worked as a trainer for the further training of the physics / chemistry teachers of São Tomé" and he was the chemistry methodologist. Quinn was responsible for the Department of Technology at ISP and was also a member of the Autoridade Geral de Regulação (AGER), the information technology and telecommunications regulator in STP. Quinn's role in this process has to do with the technology that was accessible to all students of the ISP, but did not have any direct contact with the teachers. "I'm in the technology department, but I do not have any direct contact nor do I teach physics or chemistry." The other educational stakeholders were the school principals Kim, Louis, and Nelson. These three principals had active roles in the integration of technology, but Michael, another principal, did not. The head of the physics department, Oscar, did not know anything about the program; therefore, he did not play any role in the implementation of technology. The other three heads of the physics departments were teachers who had participated in the program. The head of the chemistry department was also a teacher who had been involved in the program. Two of the vice principals at the schools were also teachers who participated in the program.

Important. Patrick shared his perceptions on the importance of the training for the physics teachers: "information technology was very important for teachers and for the teaching of physics, firstly because physics teachers, especially here in São Tomé have had certain difficulties in implementing practice into the teaching of physics." He then explained what the program had done for these teachers: "this program had some advantage for teachers of physics because it provided them with tools that allow in their respective schools the teaching-learning process in a more enjoyable way."

Both Rebecca and Theresa provided two training courses each to the teachers in STP. The first time Rebecca went to STP the teachers handed in all the work hand written. The second time, which was a couple of months later, all the teachers possessed laptops "I remember the second time they all had computers" and they used these for their projects. The second time all the work was computer written " when they gave me the work I noticed that instead of handwritten it was written on the computer." Theresa had a similar experience in that aspect because she had also administered a course to these teachers before they started with technology and then afterward as well:

> Regarding technologies, what I noticed and I was frankly and pleasantly surprised when I went to the Didactics II because I noticed that almost everyone had a personal computer, something that had not happened in Didactics I and they were all very enthusiastic about the new technologies that were PowerPoint presentations, interactive videos, laboratory simulations. I did not realize exactly what they were doing in the classroom because it was not what I was there for, but I realized the enthusiasm, and change, the big change in attitude toward new technologies that had resulted, I think that the discipline you taught.

According to Sharon the number of physics and chemistry graduates had risen significantly with these better-trained teachers. She believed that this was very difficult to measure due to the constraints:

> It is very difficult for us to measure because the constraints are so great that we can talk in general as to say with certainty that the system has improved because teachers are better trained and more but it is very difficult for us to measure this impact because the constraints are so many and they are always there.

There were a few of the students that implemented technology, but Alda Espírito Santo school was too big and teachers would need to work in small groups so that it would be easier for them to continue to implement technology. In the smaller schools, it would most probably be easier for the teachers to introduce technology in a more sustainable way. Sharon said that it was possible to do modern and innovative things in STP. People at first did not believe that these teachers could gain these skills.

> In terms of resources, the resources, here is an aspect that was raised which is the following: the training, how the three courses were held, including physics and chemistry. The features that came to be applied have shown that it is possible to do modern and innovative things in São Tomé. This in my opinion should be stated systematically and should be highly valued.

Sharon went on to say that

> people at first did not believe that it was possible to do this with such elaborate technological resources and with students in terms of digital skills, etc. People did not believe it was possible. These programs came prove that it is possible to do innovative things as long as there is an effort, and, the effort to implement technology in STP is greater than here in the training context in Portugal.

Rebecca, Sharon and Theresa experienced the distance education component of the program where they had synchronous sessions with the teachers and in this section there were some difficulties mainly due to internet connectivity and to the web conference tool that had been used. Theresa: “Ah, the distance learning classes worked very poorly because the connection was very bad.” Some sessions needed to be rescheduled because of this. In others the web conference software was not used and was substituted by Skype as happened with Rebecca: “I met Skype, I used Skype for the first time to work with them in one of the sessions because the program we used did not work." This problem is one that has since been overcome due to the broadband internet that the country has now, which they did not have at that time.

According to Uzma the teacher at Sara Pinto Coelho school had used technology, but she did not have any information on the other teachers because she did not have any contact with them.

> One of the teachers who did the training at Sara Pinto Coelho school used technology, other teachers, I have no feedback because I believe they have some difficulties. It has to do with the lack of equipment they have to implement anything of the kind, but I have no feedback.

Uzma also believed that the program, generally and specifically had been very good and that the distance education aspect of the program had contributed to the digital inclusion of these teachers: "The program was great in every sense. In the specific case of distance learning and technology integration, contributes significantly to the digital inclusion." Vincent had the opinion that the program had a strong component of educational technology and that the teachers enjoyed the program but did not implement the technology. "Teachers learned an enormous amount and I could experience the satisfaction of some of them."

After the teachers started the training program, they already had access to the internet at the *Kemese* that was in Alda Espírito Santo school, and they would go there to do their research. William and Xana, as the cooperating agents who had direct contact with some of the teachers that worked at Alda Espírito Santo school, verified that after having participated in the program the teachers started using computers to search for simulations and other educational materials. “There was curiosity. There were teachers who went to the Kemese and searched the internet for simulations and materials, but it was difficult to implement in the classroom.” Although the methodologist insisted teachers teach in the way they felt fit, teachers and students started to do reseach. Although they did not use the computers directly, they started to change their attitude.” William and Xana thought that the teachers did not take the experiments to their classrooms because they did not have the equipment.

> They used them for themselves to prepare their classes but could not take this to their students, right, it continued to be very difficult although there were teachers who were really thrilled and spent several hours in Kemese on the computer, looking for materials but then actually in terms of the classroom context had many limitations, right, it was very difficult to use because there is no computer technology, no projector nothing. It is very difficult; then it is not used.

When asked if there were no projectors at Alda Espírito Santo school, they responded that these were not available to these teachers. “Only cooperating teachers could have access” and “the cooperating teachers and those São Tomé teachers in professional education had access to the projector and the rooms with projectors.”

William and Xana commented on the fact that it was not only the teachers that were researching on the internet. The students had also started to do their research. “Oh and it also started a funny thing, not only at the level of the teachers. At the level of students, our pupils in the more advanced classes began researching and started going to the internet. While teachers were also going we began to see a big change in the students."

The two teachers that worked with Xana worked outside the Liceu as well. One of these teachers worked at Albertino Bragança school and the other worked at Conceição Lima school. According to William and Xana, these were limited to simulations because they did not have laboratories. "They were also a bit restricted to the simulations due to the fact that they also did not have access or even if they had access to the lab, they did not use them." William and Xana also commented on the fact that these teachers who had participated in the *Licenciatura* program practiced simulations and even showed these to them as well as sharing them with the students. They also spoke about an occasion when William was talking to Hunter and had said to Hunter that he would not do a particular experiment because the students would not understand it and that Hunter had responded that he took his portable computer and turned it around and that the students would sit quietly to see the simulation ""look in my class I turn on the computer and they all sit quietly to do it" because in fact these students have much more thirst for knowledge than our students here."

Kim referred to the physics and chemistry teachers, saying that they did use technology in the classroom with their students. "They use it as a teaching material, in the classroom, to educate the students in their research and video conference - let`s just say it is a very useful tool." Louis said that the teachers at his school used their laptops in the classroom and that the school had projectors which they used. "At that moment they use their laptops more, because we have some computers but not in sufficient numbers and they use their portables" … "And there is also another issue, we have a projector, they also use the projector for the collective so that they can show more people." Nelson said that the school did not have a lab and that the experiments were done using innovative technology.

> The school has no laboratory in physics or chemistry, but students were able to see some work that other colleagues were doing in physics and chemistry, and that's what was very pretty and this was very important, so I give a positive note to this project, this innovative way of teaching.

Principal Nelson also said that the students were interested in learning through the use of technology and that at their school the resources are used for this. "Students are interested; we do everything for them to access and understand the technology. A teacher has to enjoy and also enjoy working with students for students to learn as well. The physics teachers do this too."

Bernard said that with technology he had changed his way of teaching completely and that he tried to use technology as much as possible: "I attempt to take the greatest amount of technology to the classroom, right, not in the …in a more interactive manner."

Benefits. Patrick shared his thoughts on the benefits of the program: "This program had some advantage for physics teachers because it had provided them with tools that allowed in their respective schools the teaching-learning process in a more enjoyable way." Patrick believed that distance learning could be done in areas where there was a shortage of faculty at the ISP. "Okay, this distance learning can contribute to the improvement of teaching because it will to some extent reduce the scarcity in some areas of training. We are working but are not self-sufficient in all fields, all areas" … "Those where it is harder, right, that distance learning will suppress these same difficulties."

Sharon said that the first benefit to these teachers' lives was the fact that having acquired their degree they were repositioned in their jobs. "They were automatically repositioned in their career, changed their salary, got a diploma, all these in the São Tomé context are very important." Uzma, William, and Xana said that the teachers "have the possibility of having a degree." According to Vincent, the teachers lacked training and received it through the program. "Teachers lacked adequate skills to teach the second cycle of the secondary level. The additional training was, therefore, an asset."

According to Kim, the physics and chemistry teachers were leading change at their school in terms of the use of computers:

> The teachers of physics and chemistry have been the major leaders in the use of computers and the internet, right, like I said. They are also responsible for the Moodle platform, where they put work materials and interact with colleagues and students. ... and will also feed the site, we have Facebook and so on, so it is indeed a great instrument at this time.

Nelson said that the students at his school had improved their grades and that their participation in the classroom was much better.

> They improved their grades, and there has been great participation in the class. Participation is a way of saying the students have significantly improved their

> dispositions toward the subject. And before, students thought that physics and chemistry were always the worst school subjects.

According to Principal Nelson, the physics teachers at the school were helping their colleagues from different subject areas use technology. “The knowledge was not only for them as they also began to transmit it to all the other teachers.” and

> I noticed that the other day the teacher Jack was explaining such sites and tools which they can work with, but they started researching this work and were astonished at the quantity of information and materials they found to support their lessons.

Nelson said that with technology “the teacher can summarize in five minutes a program that would have taken three months to teach.”

Uzma felt that the distance education part of the program had been very important because otherwise these teachers would not have had the possibility to do this further training. “The distance part was important because otherwise they would not have had access to these classes. They were not able to be there all that time, and through technology, they had access to things that they otherwise would not have had. That turned out to be a fundamental solution.”

Challenges. Uzma and Vincent referred to the lack of resources. Uzma: “the lack of physical equipment for the ownership of the program” and Vincent: “But, in our schools, both teachers and students continue to lack access to computers and the internet. I fear that for this reason, your work will not have the expected result.”

According to Sharon, there was a lack of consolidation. “There is not actually a consolidation because there are no physics or chemistry teachers there and other people who are close did not follow the training.” There were also many constraints, even the simple fact of getting an extensions cord for the computer is a challenge. Alda Espírito Santo school did not facilitate the integration of any innovative practices: “The immensity of Alda Espírito Santo school of São Tomé makes innovative practices very difficult. Then there is all that pressure, people lecture on three different schedules.”

Michael shared that they did not have computers at school. “Unfortunately we do not have computers.” Charles also spoke about the lack of resources. “We could have, I mean, we don’t have means. And the classrooms don’t facilitate their use. If we had, it might be easier, right? We haven’t been using technology. The class is theoretical.” There is also the case of the people that say that they do not have the resources because they are unable to supervise them. Sharon: “they do not have the resources and … they could not supervise and did not want to change the system.”

Sharon stated that the methodologists refused to have training with the heads of the departments. “They already had their diplomas, they declined training, they would not sit in the chairs next to the delegates who we prepared training for.” They did not facilitate the development of the project Escola+. She also shared, “The fact is that methodologists played a role that was not favorable to the project.” Methodologists earn much more than do other teachers, but many of them were not available to support and orient the teachers “their role, they should oversee the subjects nationwide.” Patrick referred to the fact that the methodologists should provide pedagogical support for the teachers. He stated, “The pedagogical support should be provided more by the methodologists.” According to Sharon, some of them are not even in public education anymore yet maintain their positions. “They receive higher salaries than do the teachers. In reality, most of them do not even work as a teachers, and earn as a supervisors.”

Oscar believed that the teachers should explain what was in the handbook for each chapter and then the students should do the exercises accompanied by the teachers. “The students do their exercises; afterward they give the students homework, and the teachers accompany the students with their exercises. It is basically that. We almost don`t use technology because we don`t have those materials.” When asked about the possibility of simulations he said that computers are needed in the laboratory, but that the computer labs are only there for the teachers that teach Information Technology. Otherwise the labs are always closed and are not able to be used by them.

The challenges also had to do with internet connectivity and with problems faced by the ESECS-IPL lecturers who needed to do their research while in STP, especially during distance education sessions when they tried to have the synchronous sessions with the teachers. Theresa had to adjust the content of her program after arriving in STP. “This adjustment was to get materials that were not available. This challenge component was rebuilding the program and providing support materials.”

According to Sharon there were many constraints, some came from the coordinating team in Escola+ where there were members who were not open to innovations and did not facilitate any innovative process to move forward “She is not, is not a facilitator or someone with the will to move things forward” … “neither of them is innovative or have any system in place for cooperative work." Some constraints came from the ISP. "ISP itself is not an innovative institution, rather the opposite."

William and Xana left STP last year. A lot had been done in a very short period of time in terms of experimental science and implementation of new curricula, but they were afraid that there would not be consolidation and that the people would fall back into their old habits. "Now if they lose this contact with the new educational procedures, the slow way of working will take set in and that will be complicated". It is a survival instinct because it is difficult to live in STP as teachers work in many different places in order to make end meet.

Further education. Quinn said that she had pursued a distance education program and that many people in São Tomé were pursuing their graduate degrees online. At ISP there was a center for online training where people could go to do their distance education.

> I have personally had distance training;, it has to do with my work. In STP now there are many people doing distance training. Even for their master's, there were people doing their training at ISP where there is a center where one can also do distance learning. The program was implemented by an Indian University, and it occasionally worked really well. We have one training center in ISP for distance training.

Quinn informed me that at the technology department they had short training sessions that people could attend to see what was new in terms of technology. "In the department there are small training sessions to update us with the technologies that have come out recently for us to see and at least hear about it, and this is already very good." Two of the other stakeholders are pursuing their master's degrees, and one is pursuing his Ph.D.

Recommendations. Patrick recommended that all leaders should consider media essential for education. "Now it is necessary that our leaders, who are responsible for the acquisition of these tools, see media as essential to the process of teaching and learning, or else it is not possible." He challenged all the teachers that participated in the program to use the resources at their schools. Patrick said that after this phase was completed, then the generalization of the program to other subject groups could start. "I was referring to the teachers in the first place. The teachers who participated in this training should deploy resources in their schools and then we can start generalizing it to other areas." Sharon suggested that due to the rigidness of the institutions it was necessary that the teachers organized themselves into small groups in order to survive all the constraints to the integration of technology. Sharon also spoke of the consolidation: "I don't know. However, the consolidation and someone on site, on site and in groups so that they can advance and prepare small nuclei that advance." Louis hoped that these teachers made use of information and communication technology: "I think this has improved the process, the performance of the students themselves, and also improved the way they convey the knowledge. I hope that all people can come to use it." He believed the program should continue because technology facilitated learning and there should be ways for this technology to be applied to their school where they did not have computers nor did they have much space for a computer lab. "I think the program should continue, however [we must] find ways to apply these technologies. Without resources, it is impossible, because the technology facilitates [learning]. If it makes things easier, it should continue." Nelson believed that the program should be continued:

> This innovation has to be maintained, right? For students who have to continue to use it. They have come to like physics and chemistry and science in general. Today based on physics and chemistry they could do mathematics. Children were seeking sites and found a teacher talking to a class of ninth graders. They saw the lesson with their teacher and asked questions about some things and this was very positive.

Oscar recommended diminishing the number of students per classroom: "I mean [there are] at least 30 students per class. We could divide into two groups of 15 and we would have a nice amount of students for the laboratory" and "the materials too. We need the materials. For every theme, we need the materials for the application of practical lessons." When asked if this were possible, he answered that more classrooms would need to be built and that this was not possible. "There are no conditions, no means for that, I think. We are going to continue having overcrowded classrooms."

Quinn suggested creating an inventory of all the resources that the schools have and need, and then contacting the authorities in the area. "Secondly, ask the entities that work directly on the subject to provide a list of the greatest necessities of the teachers and also the students." She also spoke about the internet accessibility for all, which would also facilitate distance education. "First is the internet because not everyone has this facility; the internet is expensive. It is still expensive even here in the country and one cannot speak of distance learning when you have the raw material that the internet is a good internet, even though we already have the fiber but still we are working for things to be the way we want."

Theresa suggested the teachers have more training because she had identified very serious gaps in their knowledge which needed to be worked on. "They needed more training. This required program leading to *Licenciatura* should not have ended so quickly … the gaps that I identified were indeed many and deep."

Other projects. The project that supported research and technology was the resources center project, *Kemese*, at Alda Espírito Santo school where teachers and students alike could go to do their research. According to Xana, "they only started having access to the resource center which was created at the *Kemese*." The resource center had several computers with internet connection. Next to it is a big hall where sometimes the teachers had conferences. There they could use the projector with several classes of students at the same time. According to William:

> There was a projector where they made some significant educational conferences … Yes, they already used PowerPoint, only it was hard, they could already do these things but then they couldn't take them to the classroom, right, given the limitations of these rooms.

The other project was the laboratory project, implemented as IMVF's program Escola+ was implemented in STP. The laboratory at Alda Espírito Santo school had been rehabilitated presumably by the International Monetary Fund in their program in STP for Poverty Reduction (IMF, 2005). According to William:

> They made changes there. The laboratories were rehabilitated by the United States of America. They placed the materials there. A company remodelled the labs and placed there lots of materials, reagents, lots of reagents. Lots of reagents that came in boats. They were redirected to Alda Espírito Santo school and they locked them up and they stayed there in the laboratory for almost a year.

The subject of experimental teaching arose and the laboratories started being used with the new curriculum implementation under the supervision of the two cooperation agents, who developed the protocols for the experiments in the new curriculum. Xana said, "From the moment we started the curricular revision we started taking experimental teaching that was something that didn't exist." This project made the teachers realize that experiments could be done to exemplify the theory and in a way helped the integration of technology because with the simulations the teachers realized that they could do these experiments using the computers without needing reagents. For the teachers who lectured in schools that did not have laboratories this was a breakthrough. For the teachers who worked at Alda Espírito Santo school, the technology could complement the chemistry and physics laboratory experimentation.

Table 10

Experience, Perceptions, and Recommendations of Some of the Stakeholder Participants

Stakeholder Interviews/School Principal Interviews			
Stakeholder's Roles	#	Important	#
Development of the training program at ISP	2	Teachers used technology in the classroom	5
Technology Department at the ISP	1	Teacher satisfaction	333
Lecturer at ISP	1	Distance education component was very positive	2
ESECS-IPL Lecturers at ISP	2	People did not believe it possible	
Escola + project management	2	Teachers acquired laptops between 1^{st} and 2^{nd} course with	2
IMVF - Chemistry and Physics teachers	2	ESECS-IPL lecturers	2
School Principals	4	Teachers used technology	2
Head of Physics Departments	3	Teachers researched on the Internet	2
Head of Chemistry Department	1	Students researched on the Internet	2
		Used laptop to show simulations to students	2
		Did not implement	2
		Practiced simulations	2
		Modern Innovative things can be done and continued in	21
		STP	1
		Limited to simulations	
		Success cases	1
		Teachers changed their way of teaching	
		After program teachers presented work written on the	
		computer instead of handwritten	
		Satisfaction with whole program	
Benefits	#	Challenges	#
Change in attitude towards technology	5	Lack of resources to implement technology	5
Got their *licenciatura* degrees	4	Many constraints	44
Facilitated student understanding	4	Insecurity with technology use	3
Distance learning contributed to educational improvement	3	No access to projectors or computers to use in classroom	33
Facilitated Teaching	3	Difficulty in the synchronous DE lectures with teachers	2
Teachers were repositioned after training program	3	No consolidation	2
Reduced time to explain	2	Synchronous sessions had difficulties	2
Teachers acting as change agents	2	Web conference tool would not always work well	2
Prepared *Kemese* as a Resource and Internet Center	2	Taught the lessons exactly as methodologist said	2
Developed scientific competencies	1	No computers	11
Developed educational competencies	1	No access to computer labs	
Provided tools for lessons	1	Classes are theoretical	
Minimized lack of laboratories	1	Alda Espírito Santo school is a very big heavy structure	
Program contributed for digital inclusion	1		
Broadband Internet	1		
Summarize	1		

Stakeholder Interviews/School Principal Interviews			
Further Education	#	Recommendations	#
Pursuing short courses	1	Creation of science center	1
Program graduates (teacher)	1	Distance learning	5
Pursuing Master's Degree online	2	Put responsibility on Department heads and Methodologists	3
Pursuing PhD online	1	Distribution of tutorials	2
		Expand program to other groups	1
		Teachers need more training	1
		Consolidation	4
		Leaders must know that media is essencial	1
		Organization into small groups	1
		Internet for everyone	1

Note. The numbers reveal the number of people who specifically focused on each topic.

What are the experiences of the former minister of education during the implementation of the program? The final data source was that of the prior minister of education.

Role. Yves had knowledge of the program and spoke of the role of technology integration in the educational system as opposed to his role in the implementation of the particular program. He said that the role of technology was important in school and organizational management, as well as the integration into education, to facilitate teaching.

> The role of information technology in general is important in education both in the school management, organizational management, in this case the Ministry of Education itself as well as in the integration of technology as a pedagogical element to facilitate teaching and learning, as well as a tool for teachers to have more access to knowledge and also to use the tools in their teaching activities. Within that training program, I no longer remember very well what the content

was but what I remember is that it enabled teachers to use some tools, I think they also had access to a web portal.

Experiences and perceptions. Yves recognized the importance of technology and considered it to be an essential element. When the Educational Forum was held, this was incorporated and appeared in the strategy that was developed for education "from 2012 to 2022."

> We also released, a public tender for the Technological Plan …..what was done did have an impact because under the scope of the Fiber Optic project, with the entry of new telecommunications operator, we foresee that a portion of the license is invested in information technology for schools and I think a team is working on the acquisition of about 15 to 20,000 tablets for students.

Although Yves considered the tablets necessary he added that for them to be used to their full potential, there should be investment in the training of the teachers so that they could help the students use the tablets educationally as well as recreationally. "It may be important for children to have access to the internet, but still it serves the pedagogical context." The issues relating to financing and the allocation of projects should be rethought "because resources can be resources but if there is not a policy where people realize the importance of these elements in education, the resources, even if they are there, are ineffective."

Yves also concentrated on teacher training. While in office, he tried the Teachers Training School (EFOP) to use distance education as an incentive to train the teachers in Kauê, Lembá and Príncipe.

Benefits and challenges. Projects that are developed and that work well cease to exist when the context and interests change. EFOP's expansion plan to train teachers in remote areas did not move forward, the training provided by ESECS-IPL at the ISP is not active, and the classroom for web conferences which was equipped by IMVF does not exist any more. Currently, the master's degrees are all provided locally.

Yves referred to the fact that when he was in office the Ministry of Education had a website with all the information about what was happening and that this has been lost. In 2012, a project to create computer labs in secondary schools was developed so that students could start information technology training. The equipment arrived last year and was sent to schools where they have not been used to their full potential.

> The equipment was set up but they did not prepare people. This project also had that dimension that was to train people so that they could train teachers how to use various tools that exist today within education so that they can improve, and even find specialized sites on their discipline, mathematics, physics, so there's social networking groups and that, so that can help students and teachers improve their performance.

In terms of distance learning Yves felt that, especially in a country like STP where there is a lack of resources, distance learning would be a good solution. In terms of books, STP has difficulties and virtual libraries would also provide access to information which otherwise the people would not have.

> Particularly in a country like ours where there are few resources, distance learning would be a tool. Then we have difficulties to create physical libraries, so in high

> school with a digital library, today there are thousands of books available to students starting to use virtual libraries in schools and there are databases available, even, there is a Brazilian association willing to offer their e-book databases to education, learning objects, much, but unfortunately we did not want to take the chance.

Yves referred to many people who decided to pursue their master's degree through distance education and he himself started pursuing a PhD in innovation policy. "But individual people are writing themselves into online programs to pursue *Licenciatura* and master's degrees." Yves has tried to promote change after leaving office through exemplifying good practices.

> The way that I do to exemplify so they can see the good practices, etc. Here as I am in the private sector, at Globus we apply it, we also created a multimedia company, to make people see what is possible. If a small group of people, we are only three people here, and we do it, so imagine if the state wants to put together a team and decide to move forward it is possible to do. It is possible.

Recommendations. Yves believed that STP can adopt technology with all its potential in a very short period of time because the foundation has already been created and the only thing that remains to be done is a leadership that believes that the integration of technology in education is important.

> We create a committee for information and communication technology ICT, starting with education and technology education where there were also people from other institutions like the INIC so that we could start working, also counting

> with the support of the possible company which could develop the technology plan. This change was not achieved. Even with EFOP we have serious problems with teachers training of those teachers who live in Kauê and in Principe, so creating a distance education room connected to EFOP, as we have good internet today, we can, we can, they can be done in a short short term. It's not hard.

According to Yves there are countries interested in creating partnerships in these areas, but when they see what has been done, they become discouraged "Brazil itself has funded some projects in this area but I think they have not moved forward. Taiwan also, etc. So this is complicated."

Projects. The technological plan intended new competencies for the teachers in STP. It involved the preparing of the teachers and leaders that would be able to mobilize the educational community, introduce digital literacy as a learning tool, the use and preparation of multimedia artifacts, and through this the fundamental competencies in science and math. As technological support, they intended one computer per teacher, one training center per district, and a teacher portal where the teacher could have access to multimedia and interactive content to use in the classroom. In 2012 a multi-disciplinary team was created, within the Ministry of Education, to create materials that would support education "tools that could assist the students to understand certain concepts of particular subjects, biology, chemistry.". With the change of government, this team did not move forward with the project.

While in office Yves tried to incentivize EFOP to use distance education to train the teachers in Kauê, Lembá, and Príncipe. The Institute for Innovation and Knowledge

(INIC) which also had the mission of promoting access to information technology is also "not meeting the initial objective." The data from the different sources (Appendix T) were compared to verify the patterns that developed from them in order to respond to the research question and validate the data collected.

Data comparison

Experiences and perceptions. The research questions helped me try to understand the experiences and perceptions of the teachers, the stakeholders, and the prior minister of education (Figure 3). The teachers, some of the stakeholders, and the minister of education spoke about resources; some teachers and the stakeholders talked about the lack of resources;, the minister of education emphasized the fact that the schools had received computers to create IT classrooms and that these were not been used in the best interest of education. Most teachers, some stakeholders, and the minister of education spoke about the importance of the use of simulations; most teachers said they used them as well as games; some stakeholders confirmed that the teachers used these simulations, while others said that there were no resources so the teachers were not able to use them. The minister of education emphasized the importance of these simulations in science education. All three groups agreed on the importance of distance learning and in each group there were people who were pursuing their further education programs. The minister of education and the many stakeholders understood the importance of pedagogical training and the teachers said it improved their teaching skills. Most teachers and some of the stakeholders said that the integration of technology motivated students and that this technology opened a new world for the pupils. Some teachers and stakeholders said that the teachers had done research using the internet. The teachers were generally very satisfied with the program.

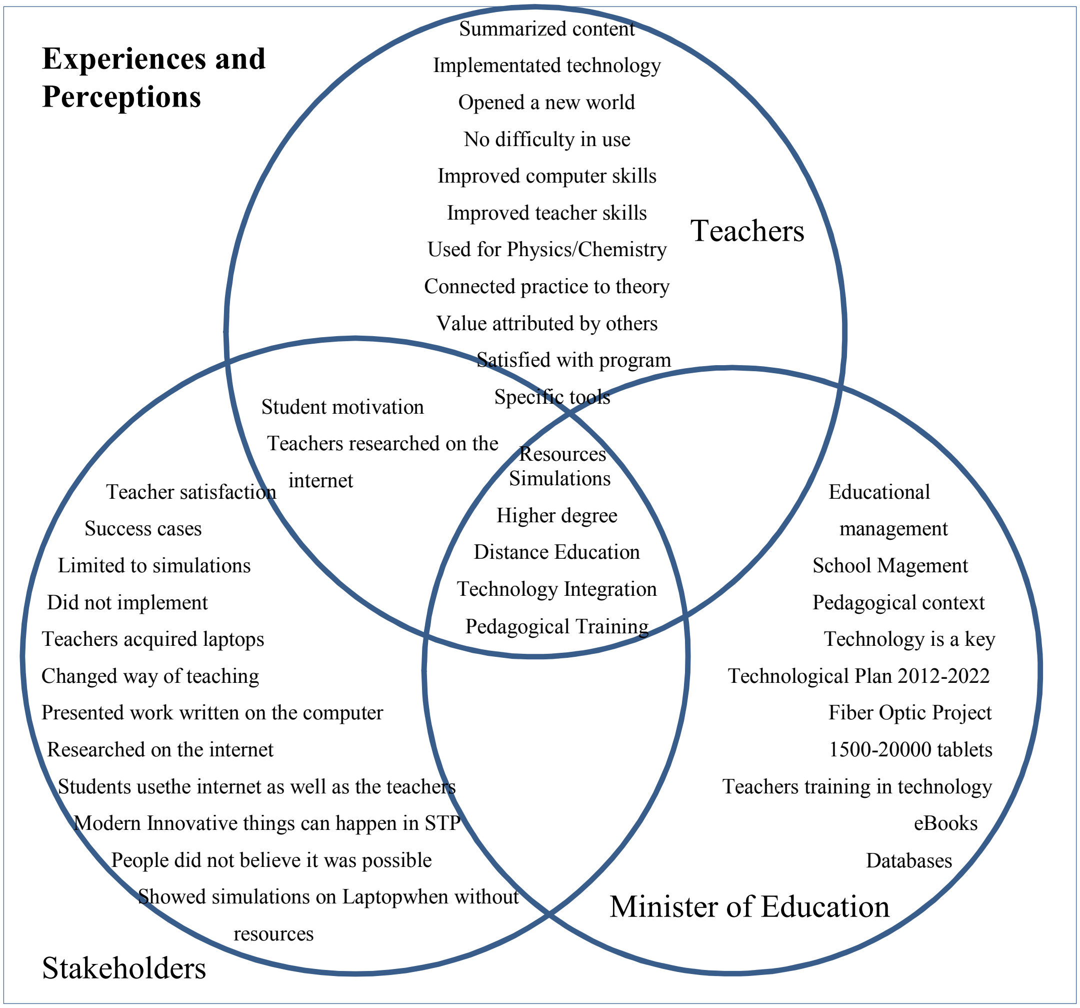

Figure 3. Triangulation of the perceptions and experiences of the teachers, the stakeholders, and the minister of education.

Benefits. In terms of the benefits of the program, people from all three groups believed that distance education was an asset and the stakeholders as well as the minister of education believed that this brought about educational improvement. The minister of education and most teachers emphasized the benefits of the virtual laboratories/ simulations and also on the advantages of teacher training for those teachers who did not have such easy access to further education. The teachers and some educational stakeholders believed that technology facilitated teaching and student learning. There were seven teachers that said that technology facilitated education and seven said that it facilitated student understanding. They thought it reduced the time taken to explain the content and made summarizing easier. Technology also minimized the drawbacks of the lack of physical laboratories.

The teachers spoke of the change in their way of teaching while the stakeholders concentrated on the teachers' change in attitude, their development of scientific and educational competencies, as well as the repositioning in their careers. One stakeholder spoke of digital inclusion while some spoke of the internet and the resource center that the teachers used a lot. They talked about the program that provided the teachers with the tools they needed. The minister of education concentrated on the access to information, the virtual libraries, and databases that were accessible through the international partnerships. He also spoke about the benefits of distance education and how many people in STP were already pursuing their degrees online.

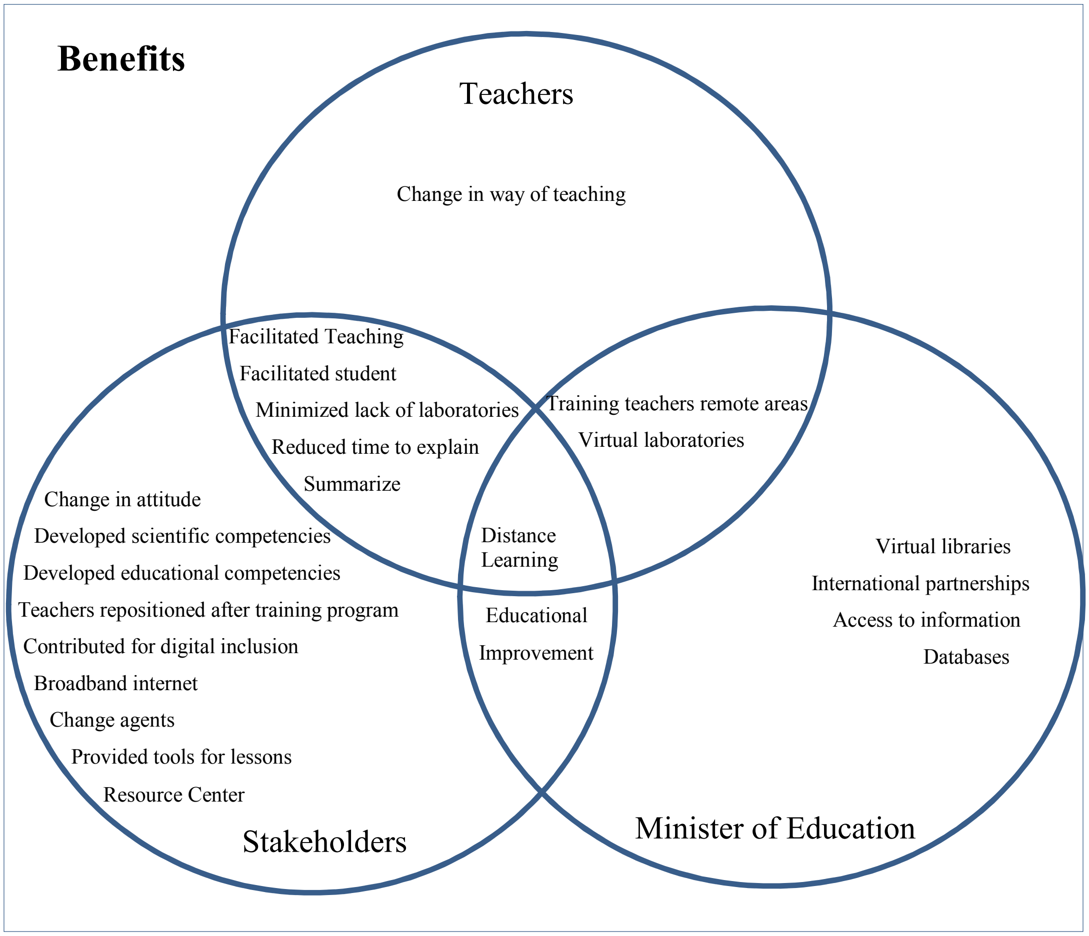

Figure 4. Benefits of the program according to the teachers, the educational stakeholders, and the minister of education.

Challenges. The challenges were many, but not all were referred to by the participants. Firstly some teachers and stakeholders spoke about the difficulty of access to resources and the internet, other than the internet that was provided by the schools and the ISP. A few people talked about the lack of security with the use of technology. One teacher found the new curriculum challenging and said that it did not leave a place to use technology. The other stakeholder's' challenges or concerns were that there was no consolidation and that the program had been reduced to the point where there was no support from the Portuguese cooperation for these teachers. If these teachers did not work together in small groups, they would eventually be forced to drop the use of technology in their educational practices. Some stakeholders spoke about the lack of computers and this went against what the minister of education had said, that there were computers in the schools, although they were not being used correctly from the educational point of view. The ESECS-IPL instructors, who used the web conference tool, had many difficulties in accessing the classroom with this tool and on many occasions had to use skype or reschedule the sessions. Some stakeholders said that the lessons were of a theoretical nature and that the teachers gave lessons according to the methodologists and the heads of the physics and chemistry department's instructions.

The methodologists and heads of the chemistry and physics departments were not always interested or even motivated to overcome the problems that could arise in the implementation of technology due to the lack of resources. There was interest that the teachers should follow the procedures that had been determined and should not stray off course with other proceedings. The fact that these people did not have training in the use of this technology in the science classroom did not make things easier.

The minister of education had created a multidisciplinary team which possessed some knowledge of informatics EduTIC to support education that did not continue. INIC, under the current governance, did also not meet the initial objective which was to promote access to information technology. While in office the minister of education had spoken about the issue of Teacher's Training School to the members of EFOP, to train teachers in Kauê, Lembá, and Principe, but the project did not continue. The technology plan that had been developed had also not been implemented.

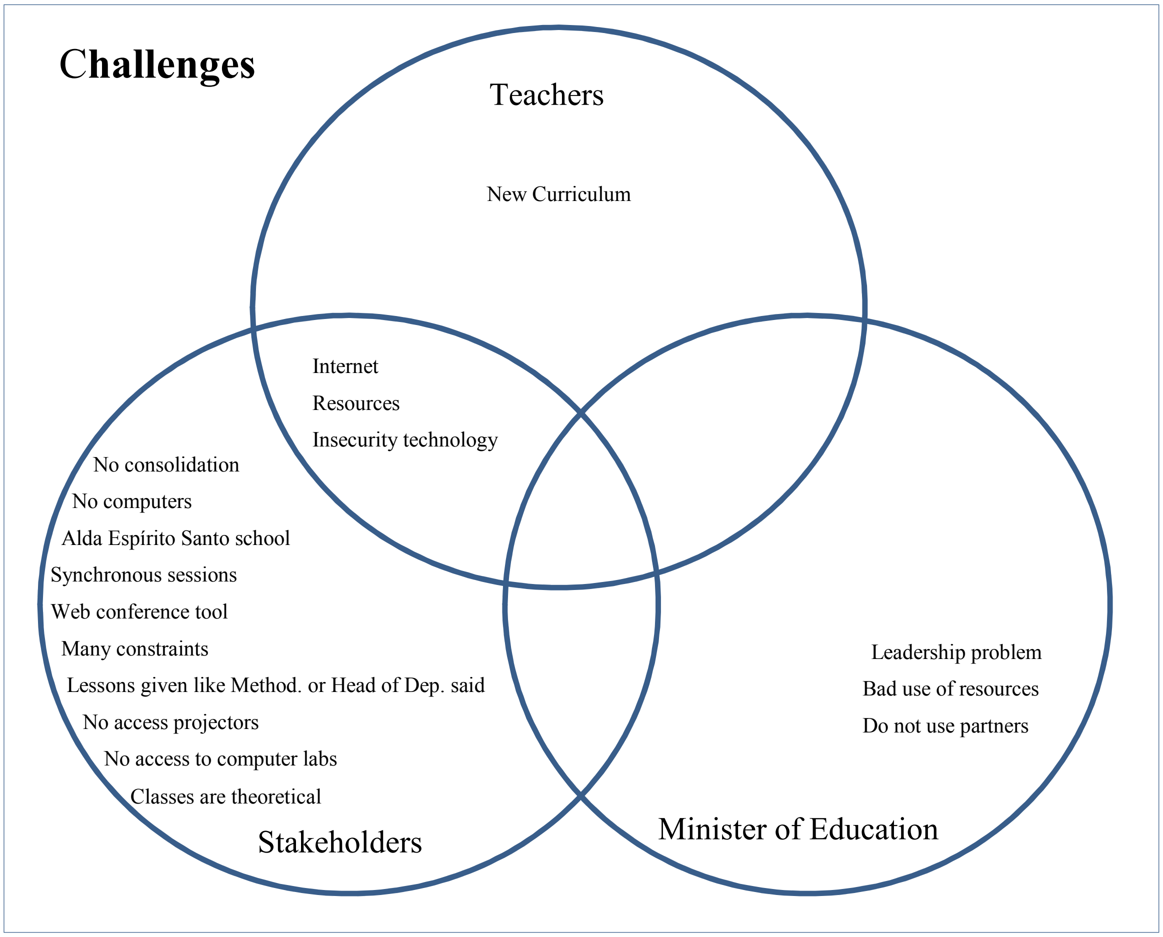

Figure 5. Challenges felt by teachers, stakeholders, and minister of education.

Recommendations. The recommendations provided by the teachers and the stakeholders were similar in many points. The participants suggested that the methodologists and the heads of the science departments should be made aware of the importance of the program. They should support the teachers and support the use of the technology that could promote the best practices in science education. Teachers and educational stakeholders alike believed that the program should continue and be expanded to other groups of teachers, and not only the science teachers. There was also the suggestion of a science center at the school in Santana, and distance education was another of the aspects that the teachers and stakeholders emphasized as being important. The mnister of education and some educational stakeholders believed that the teachers needed training. The teachers spoke of the importance of teacher investment in the use of technology in their practices. There was a need for consolidation and some of the stakeholders talked about this.

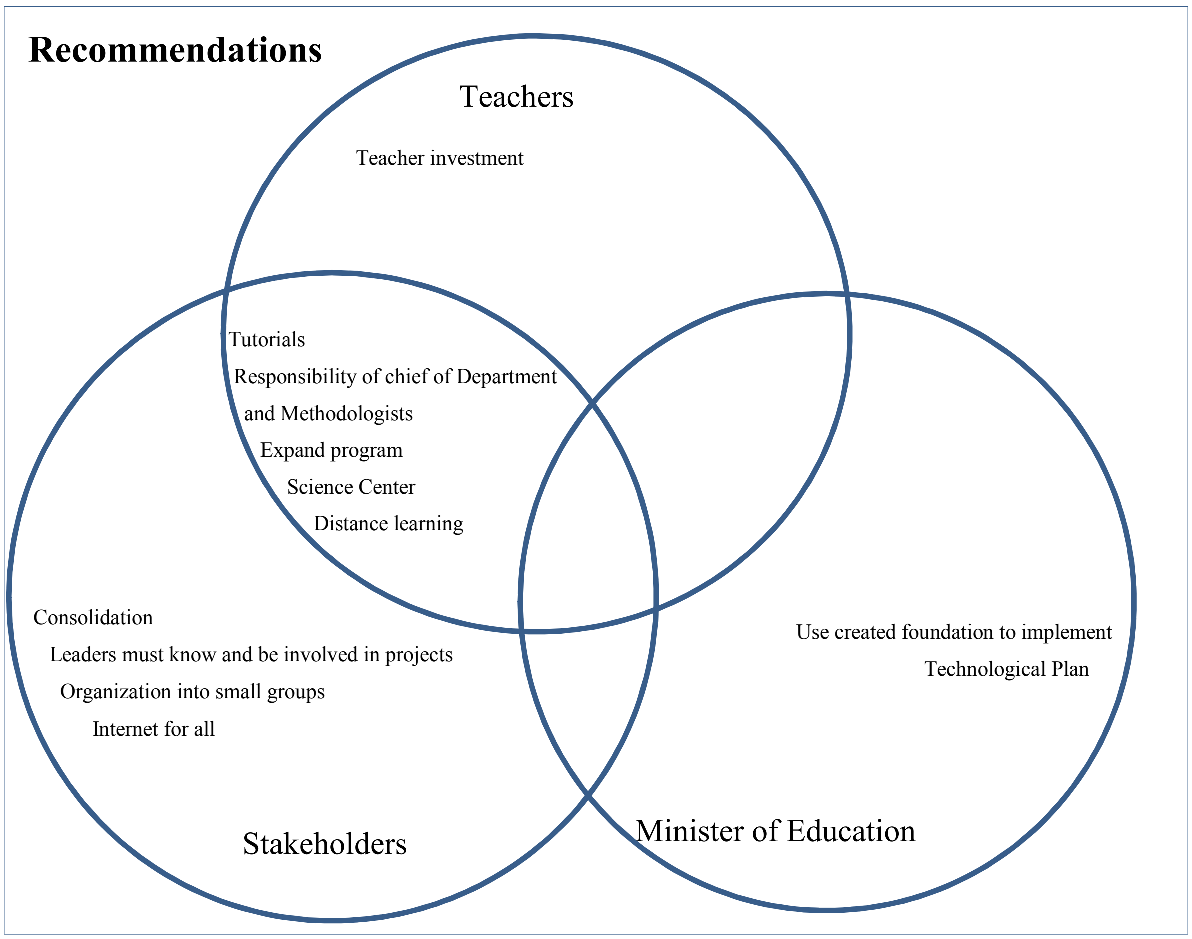

Figure 6. The teachers', educational stakeholders', and minister of education's recommendations.

Stakeholders found it important that the leaders knew about and were involved in the projects that the teachers were involved in so that they could support these projects better. Patrick supported this by stating, "Now it is necessary that our leaders who are responsible for the acquisition of these schools see media as essential to the process of teaching and learning, or else it is not possible." Patrick also stressed the need for investment in the schools. "This requires some investment in schools. Have computers available, internet access." In order to promote sustainability of the integration of technology, it is important that the teachers or lecturers are organized in small groups, so that they are not crushed by the system. Additionally, Sharon emphasized the need for consolidation. "Consolidation, with small steps, but the consolidation so that things become sustainable". With sustainability,

> People end up being crushed by constraint and hence the need for a network of groups, so for example you have here something that maybe works is that Bernard from ISP works with a small group of five, six, maybe it works.

Yves said that the leadership should implement the technological plan using the foundation that was created during his time in office. "There just needs to be a leadership that believes this, that prepares staff for this, and we have already created the foundation for this to happen."

Summary

In this chapter the topics of data collection, data analysis, and results were discussed. The research questions were restated, followed by a short explanation of educational setting of STP, which led to the project where the physics and chemistry teachers learned to use technology. The total number of participants in the study was restated and the reasoning for choosing the particular participants. The interview process proceeded through voice recorded Skype calls in Portuguese, which were transcribed and translated into English, summarized and then translated back to Portuguese and sent to the participants. The teacher participants sent confidential narratives which were translated into English.

The data were divided into categories and themes. All the participants were coded, and so were the teacher narratives, not existing any relationship between the numbering of codes used for the teacher interviews. All the participants had pseudonyms, and so did the narratives, so that reading could be facilitated (Table 7).

The internal validity was ensured through the reflective summaries that were sent back to the participants, and the teachers' interviews were complemented by the confidential narratives. To ensure external validity, thick description of the data were provided. Members checks were made to ensure dependability and to ensure adequate agreement with the data. To ensure confirmability, the quotations of sections of the interviews were included in the data collection and analysis, to show that they were the result of the experiences and perceptions of the participants. The results were organized and assembled according to the research questions into the different sections, as teachers, stakeholders, or minister of education.

The research questions aimed at understanding the experiences and perceptions of the teachers, the stakeholders, and the prior minister of education. The teachers' perceptions showed that most considered games and simulations to be the most useful.

The difficulties mainly had to do with internet connectivity and difficulty using a computer. The program was critical to better their computer skills and their teaching skills. Four teachers changed their way of teaching and five teachers used simulations. Three of these teachers started disseminating their knowledge to their colleagues, and one began pursuing his master's degree online. Most of the teachers were very satisfied with the program; they considered that it facilitated teaching and promoted student understanding. The challenges and constraints were mainly related to the new curriculum and insecurity with the use of technology.

Five of the stakeholders believed that the teachers used technology in the classroom. Three stakeholders saw the teacher satisfaction with the program and three considered that it showed that modern innovative things could be done and continue to be done in STP. The ESECS-IPL instructors saw that the teachers had bought laptops and were using them. The recommendations have to do with the expansion of the program to others groups of teachers, and distance learning.

According to Yves the role of technology in education was to facilitate teaching. He was interested in promoting distance education to teachers in remote areas of STP, but this did not happen. Yves considered distance learning a real solution because STP had a lack of books and laboratories, and he believed that STP could adopt educational technology in a very short period because the foundations already existed.

All the data were assembled in one table (Appendix T) for easier comparison from the different data sources for interpretation and conclusions in the following chapter. The comparison was done using Venn diagrams for the three different groups of sources to see which were the common features. The answers to the research questions, linking these to the conceptual framework, the conclusions, are discussed in chapter 5.

Chapter 5: Discussion, Conclusions, and Recommendations

The purpose of this qualitative case study was to understand how technology integration in schools, for teachers, could be addressed in the first-wave country. A training program for high school science teachers was designed and implemented in STP where participants learned to infuse technology into their classrooms. The study counted on the perceptions and experiences of these teachers, the principals of the schools where these teachers worked at the time of the implementation of the program, the heads of the chemistry and physics departments at the schools, members of the partnership institutions, and the former minister of education. The participants were asked to share the barriers and supports related to the program and to make recommendations for further implementation and future programs.

Most teachers considered games and simulations to be the most useful technological tools. They considered the program to be important to better their computer and teaching skills. Two teachers started disseminating their knowledge to their colleagues, and one began pursuing his master's degree online. Most teachers were very satisfied with the program. The benefits of the program were considered to facilitate teaching and student understanding. The challenges and constraints presented were mainly related to the new curriculum and insecurity with the use of technology.

Five stakeholders believed that the teachers used technology in the classroom, three saw teacher satisfaction with the program, and three declared that the implementation of this program had been possible and that modern, innovative things could be done and continued in STP even though many people did not believe that this was possible. Some stakeholders reported that teachers and students had used the computers at the *Kemese* to do their research, and there were also reports that the teachers at Alda Espírito Santo school did not implement technology in the classroom because of the lack of resources. The benefits of the program revealed the change of the teachers' attitude toward technology, as verified by five stakeholders. The main challenges were lack of resources in implementing technology and many contextual constraints. One stakeholder in STP started pursuing his PhD online, while two started pursuing their master's degrees online. The recommendations pertain to the expansion of the program to other groups of teachers, distance learning, and the creation of a science center.

According to the minister of education, technology is important in school and organizational management and should be integrated into education to facilitate teaching. The allocation of projects should be rethought, and people should realize the importance of technology in education. Under the fiber optic project, students were going to receive tablets, and there needed to be investment in teacher training so that teachers would learn to use the tablets educationally as well as recreationally. Yves referred to the projects that had worked well and that ceased to exist when he left office. He was interested in promoting distance education for teachers in remote areas of STP; he considered distance learning to be a good solution for STP because of the lack of resources in the country. STP could adopt the use of technology in a very short period of time because the foundations already existed. Many people were pursuing their bachelor's and master's degrees online; Yves was pursuing his PhD in "Innovation Policy."

A program for the creation of computer labs in secondary schools had been developed, but when the computers arrived, they were not used to their full potential. With virtual libraries and virtual labs, the students and teachers would be able to research and simulate experiments as they pleased. There were countries interested in creating partnerships in these areas. The technological plan that was developed by Yves was intended to develop new competencies for the teachers in STP. As technological support, the plan entailed one computer per teacher, one training center per district, and a teacher portal where the teachers could access multimedia and interactive content to use in the classroom.

Interpretation of the Findings

The contextual framework was based on a combination of the theories of change, theories of learning, and context theories. The experiences and perceptions of the teachers in relation to technology integration were interpreted in view of this contextual framework.

In Terms of Change

Toffler's wave theory. Teachers in STP were able to adopt and start to implement technology in their classrooms, given the resources and conditions to do so. Among the teachers who had started to use technology, most used technology with their students. Games and simulations were the technological tools most used with the students by the teachers. Progressive education enables students to become active participants in a democratic society, whereas authoritarian education undermines a democratic and equal society (Andersson & Hatakka, 2010; Dewey, 1916). The integration of technology by these teachers was confirmed by some school principals and in some cases by educational stakeholders who had contact with these teachers. It is possible for a first-wave civilization such as STP to take on some features of the third-wave civilization through the integration of technology by some teachers (Toffler, 1980, p. 337).

In the third wave, civilization learning occurs differently as students play an active part in their education, and this leads to discovery, probing, and exploration (Rogers, 2003; Toffler, 1980). The procedure also applies to a first-wave civilization that adopts a third wave civilization's features. In the teacher preparation programs, educational technology courses were provided so that fundamental technological concepts could be introduced because standalone technology courses were no longer considered sufficient to prepare teachers for the use technology for educational purposes in their classrooms (Duran et al., 2009).

Educational technology in the science classroom has enhanced the quality of education (Lamanauskas, 2009; Stizman, 2010). Simulations and game-based learning have been integrated into new educational paradigms (Toffler, 1970). Some of the teachers who participated in the training program used technology with their students; therefore, most of these students learned through games and simulations instead of through real live experimentation because most of the schools did not have laboratories, and in the cases where they did use laboratories, the simulations "reproducing hands-on laboratory experiments through advanced modeling and simulation techniques" (Bhattacharya, 2008, p. 95) and games served to complement these; "simulated and non-simulated experiences will also be combined" (Toffler, 1970, p. 231). The use of technology by these teachers was confirmed by stakeholders, especially those who had direct contact with the teachers.

The introduction of educational technology in schools enabled restructuring necessary to meet higher educational goals, and would have a stronger impact if complemented with educational reform (Bhattacharya, 2008; Jumani & Rehman, 2011), which was exactly what happened in some cases in STP. There was an educational reform that was developed and implemented at the same time as the further education programs promoted for the math, biology, geology, physics, and chemistry teachers. Three stakeholders indicated that the implementation of this program had been possible, and that modern, innovative things could be done and continued in STP even though many people did not believe that this was possible.

Some teachers did not use technology in their classrooms directly with their students but did research before lessons to acquire new knowledge of what they taught the students; others only used technology to prepare tests and documents to provide students. In some cases, students also started doing their research on the Internet; this was a significant change of behavioral patterns whereby they took on some third-wave traits.

Students may more reflective and know what they want for themselves in the future (Toffler, 1970). Some students started to use the Kemese to do their research after the teachers started to do the same. With knowledge of the use of technology, the students will be able to use the tablets that will be provided to them in a much more beneficial way, instead of only promoting digital inclusion in terms of social media. Yves believed that the schools in STP could start using technology at the same level as third wave civilizations:

> This can be done in a short period of time, in a short time span. There just needs to be a leadership that believes this, and that prepares staff for this, and we have already created the foundation for this to happen.

Rogers's diffusion of innovations. The time that is necessary for an innovation to be implemented depends on the people to whom the innovation is transmitted and the advantages that it brings them (Rogers, 2003). The teachers that participated in the program agreed that the technology had opened a new world to them, that they had improved their teaching skills and that it helped summarize content. Most of them used technology in their daily practices; some of these used technology with the students. The technology used was mainly simulations. Some teachers had also promoted research to be done by the pupils. The benefits of the program showed that seven teachers believed that technology facilitated teaching and another seven believed that it facilitated student understanding. Only one of the teachers used almost all the tools with their pupils. This teacher did not only apply technology in his classes at the Sara Pinto Coelho school and ISP, but he also taught the teachers at his school to use technology where they had training sessions. Other than that he helped the head of the physics department at the ISP to use technology and also motivated him to see the importance of technology in the science classroom. This is an example of a teacher who has acted as an agent of change, both in his practice as a teacher with his students and in his practice as a promoter of the use of technology by his colleagues, providing training sessions which were promoted at his school.

From the interviews with the principals and the heads of the physics and chemistry departments it was visible that at the schools where the principals were open to innovation even though they may not have known how to use the technology themselves, the teachers in their schools ended up being the ones that mostly used technology. The teachers saw the program as being important to better their computer skills. If the opinion leaders found the innovation beneficial to them, they would support its diffusion, narrowing the time to implementation and adoption (Rogers, 2003).

The importance of the use of technology in education was one of Yves's priority objectives for education in STP. During his time in office, he created conditions for technological innovations to be implemented. The technological plan for the educational system in STP which had been prepared while he was in office, the ministry of education site, the distance education programs for the teachers in the remote areas, and the use of an informational database with access for all teachers and students had all been abandoned. In this aspect it is evident that the person in front of the institution was the opinion leader which would make a difference in the STP educational system. Since Yves left office things regressed, the technology plan did not advance, the EFOP did not develop the distance education support for the teachers in remote areas and the teachers did not receive training before the computers that were offered to the schools arrived, so most schools do not have teachers to support the students with the use of technology. "Degree of implementation varies from province to province depending largely on the leadership, skills base, and human resource capability available in the Provincial Departments of Education" (Isaacs, 2007, p. 24).

Factors that influence the rate at which an innovation can be adopted in a society are dependent on the amount of publicity behind the innovation. In STP, Yves included the technology and technological plan in the Educational Forum, which envisioned education between 2012 and 2022. He left office shortly after this, not having had time to implement or advance the inclusion of technology in education and the educational management as intended. During his time in office Yves had a site to inform the population about what was being done by the Ministry and the programs that were being developed; after leaving office this site ceased to exist. Due to elections in November the government changed once again and Yves was reinstated to office which provides an opportunity for technological development in the STP educational system.

Fullan's change theory. The seven premises of change that need to be kept in mind are motivation, capacity building, creation of opportunities, changing the context, reflective action, tri-level engagement, and persistence and flexibility (Fullan, 2006). From the interviews with the teachers it was visible that all the teachers had found the program satisfactory or very satisfactory; the majority did use the educational technology they had learned to use during the program. In the program the teachers were involved in capacity-building training which prepared them to become better teachers, and also supplied them with an arsenal of technological tools and know-how which they could use in their physics and chemistry lessons. Four of the teachers said they had changed their way of teaching, five teachers used simulations, and two spoke about research. The teachers in the program interacted with one another and also researched in order to promote knowledge flow and purposeful thinking. The minister of education spoke of the teachers training center EFOP, where he had tried to develop online teacher's training for those teachers in remote areas of STP.

The teachers needed to engage with the school, the community, and the district as did Jack with the social learning project he developed with his students. Five teachers were persistent with the use of technology with their students, and some of them used their own laptops to show simulations to students as was the case with Hunter, confirmed by Wilson and Xana. Yves had also referred to the simulations as being important for the students to understand how the things happened in nature. The simulations were interactive, physically accurate representations of physics principles that built bridges between everyday life and the underlying physical principles (Finkelstein et al., 2006). Edward and Francis used their personal laptops but were provided with the projector by the school principal, information provided by Louis. Some teachers did not use technology with their students but used it to prepare their lessons and tests for the pupils, mainly due to lack of resources to implement technology at the schools where they taught.

Within the faculty members from ISP, the chief of the physics department had become familiar with the technology used in the program due to the teacher who had participated in the program and had been invited to become a lecturer at the ISP. He was motivated to support the implementation of this technology without having participated in the training. The teacher had shown him how to use some of the technology, and he realized its importance in the education of physics whether at the secondary level or at the higher education level.

At the Escola+ the people realized that the teachers had enjoyed the program and also its importance in the context of digital inclusion, but they were not sensitive to the importance that it could have in the science classroom in STP. There were so many fronts on which they needed to work that this one that involved more computers for the schools was far beyond their immediate objective. In the case of the two Portuguese physics and chemistry teachers who were there through IMVF, they helped the teachers implement the new curriculum and to got the laboratory at Alda Espírito Santo school working so that the teachers could use it. Nevertheless, they did speak of particular cases where the teachers who had participated in the program used their own laptops to show experiments or simulations to the students, and the cases where the teachers and students were using the resources center to do research online. They also left STP before the second phase of the program, involving consolidation, was implemented and it seems from the interview with the chief of the chemistry department at Alda Espírito Santo school that the laboratory experimental part of the curriculum may be at risk of being abandoned because, as he said, the classes were too big and students could not do the experiments or even fit in the laboratory all at once. He also insisted that the teachers at Alda Espírito Santo school did not use technology in their classrooms.

On the contrary, the principals of Sara Pinto Coelho school, Albertino Bragança school, and Conceição Lima school said that education had changed in the science departments at their schools and that the student success rates had risen since the implementation of technology. Sara Pinto Coelho school also has a physical laboratory but even so technology has been implemented at the school. They realized its importance in education, not only in the science classroom but in all areas and therefore training sessions have been promoted there. At Albertino Bragança school, the principal was also motivated with the implementation of technology and at that school they developed a research classroom where students and teachers could go to do their research. At that school, technology has also promoted higher levels of student success according to the teacher and the school director. In the case of Albertino Bragança school, the teachers have also started to use technology, mainly simulations, and this has promoted higher student success rates according to the two teachers there and the school principal as well. Here the people were among those promoting the school reform instead of waiting for it to happen (Fullan, 2006, p. 14).

In Terms of Learning

Bandura's social learning theory. The process of change is based on the idea that people are able to adopt behaviors that they observe, and most likely the practices that people value most (Bandura, 1977). The teachers started using the internet to do research and the students in turn became motivated to do the same. Education that was related to authentic social issues is essential for the advancement of the society and it helps students become prepared for the real world (Roy, Kihoza, Suhonen, Vesisenaho, & Tukiaianen, 2014). In the social learning approach people find that the information change which occurs outside the person promotes behavioral change (Rogers, 2003). In STP, Jack used a social learning project during his training program to resolve water shortage problems in the area close to his school. He and his students researched to find solutions to this problem, and they developed a system for capturing rainwater for domestic use. In 2012, they constructed a system for a home that did not have piped water. He has continued this program with his students since then. This behavior has changed the students, making them aware of solutions to the problems that their community had, and these problems could be solved with information that was available to all through the use of technology where they got some ideas for the construction of the water deposit and the plumbing that they needed to do.

> In developing countries, appropriate educational technology solutions using technology along with pedagogy should be preferred; not only for their cost effectiveness but also for the quality learning which they promote. By combining contemporary pedagogical practices like PBL along with ICTs, CASC promotes a deeper learning experience among learners as well as self-reliance within the communities (Roy et al., 2014, p. 86).

Vygotsky's cognitive development theory. Social interaction is essential to the development of student's mental abilities developed through discovery and influenced by social and cultural environments (Vygotsky, 1978). Students started doing their own research according to some principals, teachers, and stakeholders. Students became more motivated when they became more responsible for their own learning and their performance at school was improved. Three of the school principals agreed that students had better performance and so did five teachers. The students on the other hand needed to be well informed on what they were going to learn and why they were going to learn it as well as its usefulness to them. Students have become self-learners as they use more and more information technology in their learning (Tavakol, 2009).

Siemens's connectivism theory. The majority of learning occurred in an informal manner and people learn by observing others in their behaviors and adopting these behaviors according to their own capacities (Siemens, 2005). The training program was prepared so that the trainees would use an online portal prepared for the programs, and here the teachers had access to all the materials which were intended to facilitate learning in physics and chemistry. "New teaching technologies represent an opportunity to gain access to a global network of knowledge. Potentially it could fully change the location inequalities derived from having studied in different countries" (Yáñez, Badia-Miró, Carreras-Main, 2014, p. 282). The tools that were used during the program were exemplified, and had tutorials which the teachers could view on their own time. The teachers had a hands-on experience trying out the software and sharing their products, experiences, and perceptions with their peers. As a final part of the program the teachers applied what they had learned with their students. According to Yves technology was the key to educational development and to knowledge acquisition. "Everyone should be aware of the importance of technology in developing student's learning and should strive to overcome the barriers which prevent the use of technology in classroom settings" (Khan et al., 2012, p. 73). By including technology and promoting connection learning, knowledge flow became too rapid for any other learning theory to interpret (Siemens, 2005).

In Terms of Context

Tessmer and Richey's context in learning and instructional design. For learning to take place not only the learning theories needed to be taken into account, but the context factors also needed to be considered (Tessmer & Richey, 1997). Context can facilitate or inhibit learning. In STP there were many contextual factors which influenced the learning and teaching experiences of the teachers and their students. Firstly the teachers that had a favorable working context had more facility in integrating technology into their teaching practices than those who did not. The school principals who collaborated and provided the teachers with the necessary resources facilitated the implementation of technology at their schools, and this promoted its use and success in student outcomes (MacKinnon & Mackinnon, 2010; Odera, 2011). It, in fact, was verified in the case of STP. Students that had access to computers to do research were able to discover information that they ended up sharing with their teachers (William, Xana, Kim and Nelson). The limited technology that schools have in developing countries and the support of the management impact the frequency of the student access to the technology: "school support is essential but sometimes difficult to acquire" (Rodrigo, Sugay, Agapito & Reyes, 2014, p. 80).

On the other hand when the teachers did not have resources and did not have superiors who provided the resources for them to use the technology, they had much more difficulty in implementing it and were even bound to abandon its use altogether, as demonstrated by stakeholders, school principals, and teachers. Limited access to computers, unstable internet connectivity, limited knowledge of computer use by students and teachers alike, and ineffective technical support were all contributing factors that led the African Virtual University back to radio and video technologies for the developing countries (Muhirwa, 2009).

Context factors which consider the locations where the teachers and students live, their level of preparedness, economical background, culture, and educational setting also influence learning (Khan et al., 2012; Howie, 2010; Lave & Wenger, 1991; Stricht, 1997; Tessmer & Richey, 1997). The economic situations of the teachers and students are very low, making it difficult for them to have internet access at home; some of the teachers who use the internet for research do it at school or at the ISP where they have internet. At school, some teachers use the internet to download the simulations which they use in the classroom with their laptops. Not only the access to resources, the support of the school principals, and the economic background but the educational setting also influences the use of technology. In the case of some teachers the heads of department did not have access to any information about the program and naturally he advised the teachers to follow the curriculum that had been implemented by the Project Escola+, without the use of technology. Here it seems there was a lack of communication where the head of the department was not informed and did not receive any training in order to be able to implement and guide the teachers in the implementation of technology. One teacher felt the need for weekly guidance with the new curriculum and with the implementation of technology because he still does not feel comfortable with it and says that this is due to the tremendous size of the classrooms and the new curriculum which is very extensive.

Literacy and a literate population are essential elements of economic development, personal achievement, and social well-being anywhere in the world (Dorner & Gorman, 2011). Tessmer and Richey proposed an instructional design model that promotes learning that includes the orienting context, the instructional context, and the transfer context. Three of the teachers that had participated in the program, after having learned to use technology in the science classroom, started disseminating their knowledge to their colleagues.

In STP, distance education has also become an attractive alternative for people to pursue their further education. Of the teachers who participated in the program one had started pursuing his master's degree online. Patrick and Yves began pursuing their PhDs online. Uzma had also started pursuing her master's degree online while in STP. These programs were pursued mainly in Portuguese, Brazilian and Spanish universities because of the challenges that other languages posed to the trainees. In developing countries e-learning has spread; higher education institutions and other organizations have adopted e-learning strategies in their training (Mensah & Chuck, 2014).

Lave and Wenger's situated learning. Situated learning depends on the observation, repetition, and reproduction of what is being done in the community (Lave & Wenger, 1991), having at its base Bandura's social learning theory. If the teachers had actually had the opportunity to watch me use the technology with students in a real lesson, it would have been interesting, but this did not happen. I demonstrated the technology and told them in which situations it would be helpful and they also remembered parts of the program where they could use the technology to facilitate learning. Yves served as an example of good practice in terms of technology integration in the STP educational context

> We apply it, we also created a multimedia company, to make people see what is possible. If a small group of people, we are only three people here, can do it imagine if the state wants to put together a team and decide to move forward it is possible to do. It is possible.

Stricht's functional context theory. Functional context theory suggests the creation of courses that facilitate the whole process of learning, from the beginning up to the application of what was learned (Stricht, 1997). In the case of the program in STP the teachers had access to a functional learning context, with the exemplification of how to use technology provided by me and tutorials that had been prepared for them. They then worked with the software to prepare the materials they would use in the classrooms with their students. In this aspect, the training did result very well as the teachers were excited and satisfied with what they had learned throughout the program and with what they would be able to do with their students. "The increased use of digital technologies to provide learning opportunities across Africa, is seen as an efficient workforce development initiative" (Mensah & Chuck, 2014, p. 25). The increased use of technology does not support only in terms of student learning but also in the economic aspect. "In developing countries, appropriate educational technology solutions using technology along with pedagogy should be preferred; not only for their cost-effectiveness but also for the quality learning which they promote (Roy et al., 2014, p. 86)."

The program showed that it was possible to develop innovative procedures in STP even though many people thought it was not possible. Here the context factors were emphasized where the fact that the continued use of technology would be more sustainable in schools where teachers worked together and organized themselves in small nuclei preparing joint strategies of implementation. Teachers that worked alone would eventually turn back to old practices.

Limitations of the Study

The study was limited to 10 physics and chemistry teachers, the educational stakeholders from three partner institutions, three school principals, four chiefs of physics, and one of the chemistry department, and the prior minister of education of STP. These results cannot be generalized (Hodkinson & Hodkinson, 2001). The teachers were also my students during the program that could have influenced their participation in the study although these limitations were minimized with the confidential narratives. In the confidentiality agreements, the participants were also informed of the voluntary nature of the study, and that their refusal to participate would in no way affect them negatively. The participants could at any moment refuse to answer any question or even withdraw their participation in the study. The participants were also assured of the confidential nature of the interviews. The purpose and benefits of the program were explained, and the interviews were conducted in order to obtain the information that was necessary for the study.

Recommendations

People in STP started to participate in online training to acquire their bachelor's, master's and PhD's. In this way they were able to continue working in STP while pursuing their degrees. In terms of follow-up studies I would suggest the analysis of the extent to which distance education/elearning programs in remote areas of first wave countries could promote development within these communities.

Due to elections in November, the party where Yves was minister of education won the elections. Therefore Yves was reinstated to office at the end of November. The governing body should implement the technological plan that was outlined by Yves and, through the EFOP, distance education training programs for teachers in remote areas of STP so that the level of preparedness of the teachers in STP could rise. The topic for study here could be the analysis of the opinion leader's influence on the diffusion of the innovation.

Project Escola+ developed by the IMVF has been prolonged for another four-year cycle to guarantee consolidation of the new curriculum that they introduced in the schools in STP. In this cycle the Escola+ staff should also concentrate on the consolidation of the knowledge acquired, especially the consolidation of the knowledge acquired by the teachers in the *Licenciatura* in physics and chemistry programs. It would be interesting to see that the teachers who received the training all had access to technology to use in their classrooms with their students. The heads of the science departments, the methodologists, and the Escola+ members that were not familiar with this technology should have access to some training in the area so that they could evaluate the importance of technology in supporting science education. It would also be important for IMVF to continue to implement the *Licenciatura* programs for teachers that were developed by the ESECS-IPL staff, also covering teachers of areas that were not considered in the first round of training. I would recommend that after the end of this next four-year cycle, a quantitative study to determine the impact of the implementation of educational technology in the science classroom on the student outcomes should be developed. “Effective aid in education can become an investment in the firm foundation and long-term development of a country. However, aid is often expensive and comes at a high cost” (Roy et al., 2014, p. 85).

The integration of technology to obtain knowledge of how to help solve problems within communities was demonstrated through the work of Jack with his students and was of the utmost importance to the social awareness and development of these students. The pedagogical framework named Children as Agents of Social Change (CASC) “can be useful to individuals, schools or non-governmental organizations to better prepare youngsters to meet the challenges of life beyond the boundaries of the school walls and hence make education a truly meaningful experience” (Roy et al., 2014, p. 71). Practices like these should be encouraged.

Implications

The implications for social change are promising. The integration of technology in education opens doors to knowledge and empowers both educators and students. Teachers in STP will be able to better their academic qualifications and participate in educational development programs, even outside the country as happened with one of the teachers who participated in the program. The broadband internet, though expensive for teachers, has opened doors to distance education programs which many have already started to pursue in STP. Although good internet connectivity is still a constraint because it is too expensive for home life, many pursue advanced education with the use of the internet available at their workplaces.

The teachers were no longer the sole source of information in STP; students had access to all the information openly available on the internet (Siemens, 2003). If STP developed the partnerships suggested by Yves they would also have open access to online libraries and virtual laboratories provided by partner countries. Students had access to simulations, games, and a lot of other interactive software that supported the teachers in making the subjects more motivating and accessible to students. “The flexibility of the technology that elearning is built on, facilitates quick instructional design and revisions to suit quickly changing needs. For learners in developing countries, this provides easier access than textbooks, which can be expensive, inadequate or unavailable” (Mensah, Chuck, 2014, p. 44).

The educational reform provided by IMVF modernized the STP educational system, and the training program provided by the ESECS-IPL in partnership with the ISP provided some teachers with better educational competencies. The implication is that the continuation of these procedures in STP would result in a better educational system in STP, which in turn would result in a better trained workforce in the future and consequently in a faster development rate of the country. With the minister of education back in office, the procedures he had started before leaving office would most probably continue. “The opportunities of ICT depend not only on the existence of infrastructure and access, but to a large degree on the existence of ICT related human capacity.” (Yáñez et al., 2014, 282). With the virtual libraries and the databanks that the minister spoke about, the access to information would increase immensely. With the distance training provided by EFOP to teachers in remote areas, education would have the opportunity to develop, consequently taking on third wave country features as were predicted by Toffler.

Conclusion

Teachers in STP were able to adopt and start to implement technology in their classrooms, given the resources and conditions to do so. It was therefore possible to observe that a first wave civilization like STP could take on some features of a third wave civilization (Toffler1980), through the integration of technology by some science teachers in their classrooms and in their professional practices. With the integration of technology into their educational practices these teachers and students became more empowered through the acquisition of knowledge that they would otherwise not have had access to. Implementation of educational technology in schools enabled the restructuring that was necessary to meet higher educational goals, and it could have a stronger impact if it were complemented with educational reform (Jumani & Rehman, 2011; Bhattacharya, 2008).

In terms of learning the students became more active learners and started doing their own research where they showed what they had done to their teachers. This made these students active participants in their own learning, with the internet as their resource as opposed to the textbooks that they had which contained limited information. The students were therefore able to broaden their horizons with the research they started doing. Even though this study was limited only to a few, it showed that the integration of technology is possible to be done in a first wave country. “In developing countries, appropriate educational technology solutions using technology along with pedagogy should be preferred; not only for their cost-effectiveness but also for the quality learning which they promote” (Roy et al., p.86).

When the educational stakeholders took a series of contextual factors into account, like the provision of the resources and support, many teachers would start to integrate technology in their classrooms with their students. In order to integrate this technology correctly in the science classrooms teachers needed adequate scientific and pedagogical training. The support of the main educational stakeholders are and continue to be essential for the sustainability of the implementation of technology in the science classroom. Many educational technology projects in developing countries fail due to management practices, bureaucracies, costs, sustainability concerns, and a mechanistic mindset (Brunello, 2010).

The results of this qualitative study showed that modern technology can be implemented in the science classrooms in STP successfully. It therefore represents a leap toward the integration of technology in the science classrooms in schools in STP. The sustainability of these procedures is not clear and procedures for consolidation of acquired knowledge and practices should be kept in place in order to guarantee the sustainability of the execution of the new curriculum and of the modernization of educational procedures with the integration of technology.

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Appendix A: Example of a Consent Form

CONSENT FORM FOR TEACHERS

(English Version)

You are invited to take part in a research study that will investigate the implementation of educational technology in the physics and chemistry classroom in Sao Tome and Principe. You were invited to participate in the study because you were one of the teachers who participated in the course at the ISP "Information Technology in the teaching of physics and chemistry ," Please read this form and ask any questions you have before agreeing to be part of the study.

This study is being conducted by Maria Dolores Rodrigues Jardim, who is a doctoral student at Walden University (United Stated of America), a teacher and a teacher's trainer in Portugal. The researcher was in São Tomé and Principe between 2010 and 2012 where she participated in teacher's training programs provided by the IPL and others provided directly by the IMVF. The researcher's role in this study is separate from that role

Background Information:

The aim of this study is to understand how participation in training programs for teachers in the use of educational technology can improve procedures and educational strategies of these teachers. The study also aims to determine whether student's access to educational resources, strategies and software increase motivation, participation, understanding and knowledge. The study includes the context in which the factor may play an important role in the implementation of educational technology in Sao Tome and Principe.

Procedures:

Materials related to your participation, including reports and designs used in the study have identifiers removed.

If you agree to be in this study, you will be asked to:

1. Participate in a one-on-one recorded interview. The interview will last approximately 60 minutes and may be through Skype.
2. You will also be asked to complete a confidential narrative where you may share thoughts about the program you were not able to share during the interview. You will be supplied

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with an envelope addressed to me, with a stamp on which you will be able to send through the mail.

3. Once completed the initial interpretation of your interview you will be asked to verify whether your intentions were accurately represented. This will be done through e-mail, and you will be asked to respond within one week. Please allow at least 30 minutes for this review.

Voluntary Nature of the Study:

Your participation in this study is voluntary. This means that the researcher will respect your decision if you do not want to be part of the study. You may decide not to join the study. If you decide to participate in the study now, you can change your mind later. If you are uncomfortable during the study, you can leave at any time. You may refuse to answer questions that you do not feel comfortable answering. Declining or discontinuing will not negatively impact your relationship with the researcher.

Risks and Benefits of Being in the Study:

Risks are minimal. This study may support the future integration of educational technology in the classroom that may provide access, for teachers and students, to the educational resources that they would otherwise not have access to.

Compensation:

There will be no compensation for participation in this study; however participants will receive a recharge card worth 100,000 dobras (4 euros) to cope with internet expenses because the interview may be via Skype.

Confidentiality

Any information you provide will be kept confidential. The researcher will not use the information for any purposes outside of this study. In addition, the researcher will not include your name or any other document that can identify you.

Contacts and Questions:

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The researcher's name is Maria Dolores Rodrigues Jardim. The faculty advisor is Dr. Jennifer Smolka. You may ask any questions you have at this time. If you have questions later you can contact the researcher by phone or by email at 000351969177966 maria.jardim @ waldenu.edu or consultant jennifer.smolka @ waldenu.edu. If you are interested in talking with someone at the Research Centre at Walden University about your rights and responsibilities, you may contact the research representative at 001-612-312-1210 or irb@waldenu.edu

Consent:

By answering the email with the words "I consent" you will agree to participate in the study. You may print or keep a copy of the consent form.

This has been approved by the Institutional Review Board of
WALDEN UNIVERSITY
as acceptable documentation of the informed consent process and is valid for one year after the stamped date.

Approval # is 06-10-14-0147858.
The current IRB approval expires on June 9, 2015.

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Appendix B: Interview Questions for Teachers

TEACHER INTERVIEWS

English

1. Tell me about your experiences during and after the participation in the education technology training for chemistry and physics teachers?
    a. Why did you participate in the program?
    b. What elements of the program did you find most helpful?
    c. What aspects of the program did you find most challenging?
    d. How did the program influence your teaching?
    e. How did the program influence your use of specific technology tools in the classroom?
2. What changes in student behavior and performance did you notice?
3. What aspects of the program do you identify as important to your on-going use of technology?
4. What are your recommendations concerning the program and its continuation or expansion?
5. What else would you like to share?

Appendix C: Interview Questions for Directors of Schools

SCHOOL DIRECTORS INTERVIEWS

English

1. What is your understanding of the technology training program provided to science teachers? (probe goals, processes)

2. What do you perceive as the challenges and benefits of the program?

    a. What kinds of resources were needed?

    b. What kinds of resources were provided?

    c. What kinds of changes did you see in teachers' use of technology?

    d. What kinds of changes did you see in student engagement and performance?

3. What recommendations or concerns do you have about the continuation or expansion of the program?

4. What else would you like to share at this moment?

Appendix D: Interview Questions for Educational Stakeholders

INTERVIEW QUESTIONS FOR EDUCATIONAL STAKEHOLDERS

Partner organization representatives:

English

1. Tell me about your role in the implementation of the training program for science teachers. (probe = collaboration, goals, operations) (probe = contact with teachers and any demonstrations or products)

2. What do you perceive as the challenges and the benefits of the program implementation?

   (probe = resources available and resources needed) (probe = teacher behaviors and expectations) (probe = importance of distance education offerings)

3. What recommendations or concerns do you have about the continuation or expansion of the program?

4. What else would you like to share?

Appendix E: Interview Questions for Minister of Education

INTERVIEW WITH MINISTER OF EDUCATION/DIRECTOR OF INNOVATION AT THE MINISTRY OF EDUCATION

English

1. What was your role in the implementation of the training program for teachers to integrate technology in the classroom?

(probe knowledge of program operations, processes, and outcomes)

(probe resources)

(probe expectations for the integration of technology in schools)

(probe = student learning, human capital, global access)

2. What recommendations or concerns do you have about the continuation or expansion of the program?
3. What else would you like to share at this moment?

Appendix F: Transcripts of Teachers' Interviews (Sample of a Transcript)

Teacher Anthony

Interviewer- Maria Dolores Jardim

Anthony- Teacher #1

Interview Setting: Interview conducted in home office through a Skype call with interviewee who was in STP at the time of the interview. The interview was conducted on Tuesday the 23rd of June at 15:00 hours.

Interviewer- Thank you for taking the time for this interview. Your participation in this project will help us learn more about the integration of technology in the classroom and understand your perceptions on the implementation of educational technology in the science classroom. We will be interviewing you and the other teachers who participated in the program, the directors the schools, people from the IMVF, ESECS-IPL, ISP and ministers of education (past) as well as the director of innovation. We will therefore have information from the different viewpoints which will contribute to the project.

I know you have read about the project and why we are conducting it, but I would like to review a few items with you. As you know your participation is totally voluntary, so if I ask you a question which you do not want to answer or if you need to stop the interview at any time please let me know. As you know I will be taping this interview and I will be taking some notes. When the interview is over I will send you a transcript of the interview so that you may review it and make any corrections that need to be made. This study will be published and in publication we will not use any names and if we use direct quotes we will use pseudonyms.

Anthony- Yes.

Interviewer- Tell me about your experiences during and after participation in the educational technology for chemistry and physics teachers 'program? That has to do with technology.

Anthony- Well ... in relation to this, I as a teacher, I mean, I see that this is a methodology that is important because the teaching methodology is not a stationary system, is a changeable system ... right? And therefore there is the need for a teacher in their strategies use some support of information technology ... right? Using computers, mainly to teach their students. And so it is important, the use of education technology, that is.

Interviewer- Yes, what, do you feel was most useful in this program? Anthony?

Anthony- Ah, this simplifies our ideas, so these tools, for me, are useful. Reducing the time that we take to explain any given matter, simplify and summarize our idea and even what we could give in 20 minutes we can give in 10 minutes and have time to respond to questions or something.

Interviewer- Yes. What changes did you notice in the behavior and performance of students when you used technology with them?

Anthony- Well, you know, students often, they seem a bit uninterested in the class but the teacher, sometimes asks himself: but after all, these children come to school, parents send them to school and they are unwilling to attend classes. But it may also be that the change is the methodology, we have to change, adapt to the environment and, therefore, what I have to say is good disposition, there is a good disposition in many of the students and this creates even a greater willingness to understand content, to understand content. I see. Is that even a will, closer to the content because their attention is focused on the content, to understand the content. And then we can turn to the technique and here I speak of these techniques that emerged and we are addressing is why the technology is, their greater approach to content and have greater ease, greater willingness to assimilate what we want to achieve.

Interviewer- Yes. What aspects of the program do you perceive as important to the frequent use of technology?

Anthony- What are the changes that were ?

Interviewer- What aspects of…

Anthony- What aspects of the program?...Ah.

Interviewer-Yes.

Anthony- All this. Aspects like I said. I want to mention very important aspects, I have two. Games and simulations. Games and simulations. We can simulate, we can also use games, use games, I'm not ... not everyone has a computer, not everyone can..

Interviewer- Yes.

Anthony- The teacher can guide them and they then turn to colleagues, only to their group. The teacher, the teacher creates a program using games focused on the content, on the various contents for students. Well of course it would be evident that they would be on their own computers.

Interviewer-Yes.

Anthony- Because we would take them to the computer center, there where they would do the work.

Interviewer- Yes..

Anthony- Well, that has not been tried. But I believe that games and simulations.

Interviewer- Yes..

Anthony- It is important because it is as if we are

Interviewer-Yes??? (Anthony)???

Interviewer-Oh. Ok, I can hear you.

Anthony- Yes..

Interviewer- OK. Another question. What are the recommendations about the program and its continuation?

Anthony- I have to say this: there must be more dedication, more dedication of the teachers towards implementing educational technology, thus involving their students in this new form of teaching and learning. So there must be more dedication. Normally, it is true that we all recognize the importance of this, now, we have to assume this. We learn but this assumption, we have to be more dedicated. We have, as I said above, we must also engage and involve our students.

Interviewer- Yes.

Anthony- And only in that way will we be able to get them and ourselves accustomed to do more things for our students. This is, this is my recommendation, be more dedication, that teachers become more involved, because I see that it takes even more dedication from teachers. Yes, do you understand?

Interviewer-I do, I do, thank you.

Anthony- Thus, I am saying that there needs to be more dedication of the teachers, all of us. Our colleagues, those who were your students, we were prepared to make sure that we can apply this educational technology to facilitate our learning system. Whenever we get something new, it creates appetite, especially for the students themselves, students with an education system in which there is educational technology, connected to the computer, linked to information systems, although today we all think it is anyway, and with this technological movement and for this to be accomplished we also need to work, we have to work. Hence the reason I say more dedication.

Interviewer- Yes.

Anthony- Greater dedication. We use computers for other things and we also to apply this technology. I recommend this.

Interviewer- Yes. Is there something else that you would like to share about the program, regarding the integration technology problems you may encounter, etc.?

Anthony- Well, so, I do not ... What I'm saying is this: we ... us, let's see, two disciplines that is physics and the other is chemistry, which is our training, physics and chemistry. I, however, I teach physics now. Others teach chemistry. What do we need to do? That greater involvement, not only by the teachers but they also need to feel the pressure that comes from above so they do not think they can do what they please at their will. African city is a man without patience, let someone else do it, and so ...

Interviewer-Are you there??? (Anthony)??? Are you there??? (Anthony)???

Anthony- Yes I am. I'm here.

Interviewer- Exactly. Yes. There is a problem with the line.

Anthony- There is a problem with the line, yes sir. It is a line problem. I do not know if you can hear me?

Interviewer- I can hear you. Continue.

Anthony- I was saying. I was saying that it is necessary that the subject delegates themselves feel mobilized in the sence ... also directing, right? ... Directing this practice, so that we do not have the situation of each one having learned, but that they can do as they please and no one can say otherwise, right?

Interviewer- Yes.

Anthony- Recommending that apply this technology and educational practice. Do you understand?

Interviewer- I understand, I do.

Anthony- That's what I'm saying, that the head of the subject area, right? The people responsible for the subjects, both physics and chemistry, are also involved in the process. Do you understand? This is my recommendation. I may not know, and I assume what I am saying, the delegates must also be involved. They are responsible not only the delegates, but the methodologist as well.

Interviewer- Yes..

Anthony- They are responsible for these subjects because, if it was not so everyone could do as they please and then, well, things continue but cannot evolve.

Interviewer- Yes..

Anthony- They will not have this multiplier factor.

Interviewer- Yes..

Anthony- They will multiply but is very slowly.

Interviewer- Ready. This is a great contribution. And anything else you have to share about, your thoughts?

Anthony- Well, nothing else because, you know, we, in São Tomé and Príncipe, it is not like other countries where students in the second ... already have computers in secondary education. Parents buy computers for their students, furthermore, for their children, students ...

Interviewer- Yes..

Anthony- Because they think I need, it already begins to make sense that the computer is not only Facebook, is not only for, well, for word processing but also to implement new educational technology. That is why, we are not in a situation of technology but, we are starting to see many students with computers and ...

Interviewer- Yes..

Anthony- Well, it is also necessary that there is some mobilizing work, mobilizing work, by all, for all, not only at our level. We know, we will apply, apply, and so ... I have nothing more to say, only that.

Interviewer- OK. Thank you very much, I really appreciate your cooperation and your participation in the interview with me.

Teacher Interview Bernard

Interview Setting: Interview conducted in home office through a Skype call with interviewee who was in STP at the time of the interview. The interview was conducted on Tuesday the 20th of July at 22:00 hours.

Interviewer- Thank you for taking the time for this interview. Your participation in this project will help us learn more about the integration of technology in the classroom and understand your perceptions on the implementation of educational technology in the science classroom. We will be interviewing you and the other teachers who participated in the program, the directors the schools, people from the IMVF, ESECS-IPL, ISP and ministers of education (past) as well as the director of innovation. We will therefore have information from the different viewpoints which will contribute to the project.

I know you have read about the project and why we are conducting it, but I would like to review a few items with you. As you know your participation is totally voluntary, so if I ask you a question which you do not want to answer or if you need to stop the interview at any time please let me know. As you know I will be taping this interview and I will be taking some notes. When the interview is over I will send you a transcript of the interview so that you may review it and make any corrections that need to be made. This study will be published and in publication we will not use any names and if we use direct quotes we will use pseudonyms.

Bernard- Yes..

Interviewer- Tell me about your experience during and after your participation in the program of education technology for chemistry and physics teachers, for example, why did you participate in the program, what was useful to you in this program etc.

Bernard- Well, firstly there was the opportunity of complementing our education, which is always good.

Interviewer- Yes yes.

Bernard- We only had bachelors degrees in chemistry and physics and the complementary training came at a good time because having a degree is the stepping stone towards the masters degree which I am taking.

Interviewer- Ah great

Bernard- That is while I had my bachelors degree I would have great difficulties entering the masters, now with the education complementing training, I the master's degree easily, that was the…

Interviewer- main?

Bernard- That is, the main objective of continuing with the training, but in the training we had a subject called Information technology in the teaching of chemistry and physics, and therefore essentially what we learned. On the one hand we became familiarized with the subject given in physics and chemistry with simulators, the teacher had, I mean, was able to present various tools like interactive periodic tables , many models for physics and chemistry lessons, graphic calculators, remember. We played with Electro-City, Stellarium, I can`t leave out Stellarium. Actually it`s one of the software's I use the most during lessons, Stellarium. It is, without forgetting to mention PhET, an arsenal of simulations at our disposal. But the course wasn`t limited to simulators, we also had access to methods of learning with Word, Excel, right.

Interviewer- yes yes

Bernard- Therefore, some, it is therefore necessary for us as teachers to know how to work with a spreadsheet, right, and the course enabled that introduction and development, and

Interviewer- but in that part you already knew a lot, in your case it wasn`t as necessary as it was in the case of other colleagues, some didn`t know how to use computers, right?

Bernard- Also, the people who prepare the course or syllabus aren`t thinking about what people know or don`t know, so it was necessary and it is always good to refresh, the ideas, right. We also had experiments with other search engines besides Google, we are used to Google, but there are many others, there is also OpenMath which enables you to make calculations online, it presents the results, besides Skype, and also Hotmail, which were software's we used, more information software's, right,

Interviewer- Yes, exactly what for you, was more useful in the program?

Bernard- Besides what I just mentioned, right, we are trying to find ways to captivate our students, right, we know they are in education in a new context, where mobile phones, computers are present in their daily lives and we have to take advantage of these tools to take education, I mean, since they are already fans and enjoy it so much why not use it, right, the computers and make them learn to use the computers, so that was very good, very good.

Interviewer- Yes..

Bernard- We also had an advantage because our teacher insisted on us using a platform, which was created for the programs that took place at the ISP.

Interviewer- Exactly, of course.

Bernard- And therefore this was an opportunity for the students to be a little familiarized with what a “blackboard” is, right.

Interviewer- Exactly.

Bernard- It wasn`t a very… blackboard, but it was a first approximation, right

Interviewer- Exactly, meanwhile that platform still exists if you want you can still use it

Bernard- Yes, we have to see to it so that ISP, because sometimes things… it`s why teacher Jardim called attention so many times, often when the subject or course ends there is no continuity afterwards, right, and things became a little stagnant.

Interviewer- Exactly, what was harder for you in the program? Which were the most difficult aspects?

Bernard- Like this, at first I can`t see great difficulties, really not, because of the dynamics the subject had, and a little because of my previous experience, right, I didn`t find great difficulties in any of the programs. Proof of that is the high score I obtained in the end.

Interviewer – But there were some difficulties there, we would sometimes have Internet problems.

Bernard- Ah yes, a difficulty, not in the sense of learning, a technical difficulty, that was a little…the Internet matter, we had to use the platform and had difficulties with Internet speed, but nothing… the subject itself didn`t create great problems, now there were exterior factors, right, therefore in that case the Internet, it wasn`t because of the teacher or the ISP.

Interviewer – Yes.

Bernard- This when it doesn`t… especially the use of the platform.

Interviewer- You`ve already answered the other questions, what were the changes you noticed in the behaviour and performance of the students?

Bernard- Yes, the great advantage of the complement course was the bigger comfort with technology and ability to prepare presentations, right, and to notice that the students won and still win, it`s always that surprise, they never know what the teacher is going to bring for the next lesson, it is not always the same thing, if one day I made a PowerPoint the next day I used a simulation or we went to the laboratory, not always using the computer.

Interviewer – Yes..

Bernard- But, I noticed that we often just worry, the student just worries about the grade. To me, that is not very important, I like it when in class, I end the lesson and, I reflect back on the lesson I say yes, I liked it, the students achieved the objective…

Interviewer – Yes.

Bernard- Of course, according to the evaluation we prepared, we prepare the lesson prepare one… and based on that evaluation we are satisfied o not, right, with…

Interviewer – Don`t they become more motivated, when you use different methods?

Bernard- Exactly, they... there is more interaction, and it is noticeable in the results and the willingness to do the tasks. For example, when we made a webquest or something similar it is noticeable, and we prepare it carefully. Right, when they work in groups, then it is really noticeable the motivation they feel.

Interviewer- Great. What aspects of the program do you identify as being the most important for the frequent use of technology?

Bernard- Aspects, let me see the … repeat the question again?

Interviewer- What aspects of the program you identify as being the more important for the frequent use of technology?

Bernard- Well, the program or the course?

Interviewer- Yes.. In the technology program? The technology that was used beyond the subject, was used in the technology program and then used in the research projects.

Bernard- The range wasn`t limited to the subject, such that it is still reflected now, if you ask, it drastically changed our way of being in the classroom and if now we feel more comfortable with these tools well it is thanks to the beginning , the beginning of that subject in our course.

Interviewer- What are your recommendations about the program and its continuance or expansion?

Bernard- Well, I recommend that the entire course, I think it is a very current directive, right, the entire course of physics and chemistry can`t leave behind, right, the technologies and knowledge in the learning of technology must be, right.

interviewer- Yes..

Bernard- Connected and before we would maybe pursue our degrees and not talk a lot about computers. Not now, now we do, in whatever course, education complement, even the masters degree I am taking, which is in pedagogical supervision in sciences, right, there is a subject which is about knowledge and learning in technology, precisely because it is noticeable, right, that we have to take advantage of technology in the context of teaching, and learning.

Interviewer- Yes., precisely, and you`ve learned about more technologies now in this course? Are you learning much more?

Bernard- - Much more, we are even building sites, we are consulting wikis.com and one that in which is very easy to build a site, a webquest, I mean, we open and we quickly have a webquest and tools at hand, we place the buttons, place the photographs and we decide how we want those photographs if we want them in photo galleries, how many pages the site is going to have.

Interviewer- More or less like the webs you have there in SARA PINTO COELHO SCHOOL.

Bernard- Exactly. Therefore, now we even build sites.

Interviewer- Exactly.

Bernard- That is what is very good.

Interviewer- It`s great, because those sites are quick, easy, you don`t need to be experienced with computers, they`re easy, their use in the classroom is easy for the students.

Bernard- There it is.

Interviewer- And for the use of science without wasting much time because of the electro… the part of creating a site.

Bernard- - There it is, the person focuses on their target, is not muddled with, with the site. The suggestion, the numerous templates that appear guide the person to their aim, if you want to speak about environment, the time wasted is speaking about the environment, right. If you speak about cars ou planes. The person concentrates on the contente.

Interviewer- Exactly, you can make some customizations but the content is already organized.

Bernard- Very good, exactly.

Interviewer- Is there anything else you want to share, about this, about technology, about how the teachers use technology?

Bernard- In reality, teachers need to invest a little more and even ISP has to invest a little more on that field. You can still notice a lot of vulnerability, right, it`s important. The last question is pertinent, concerning the continuance of this because we are talking about the good things in technology but in the public teaching system we still detect various problems, right, it is necessary for us to always meet with other teachers, show, when the teacher shows a tool, I also try it, first I try right, I try it to check.

Interviewer- Matter, might not matter.

Bernard- The advertisement of something you don´t know. First I try to see if it is worth it, I am the first to spread it around the other colleagues.

Interviewer- You are very good, very good, you divulge and end up making the quality of teaching improve around you.

Bernard- Exactly, and I like it because the other teachers have computers but for what? To write documents, right? To write a letter, to make a test or a table but they don't explore it to the maximum, right. Prezi is also one of the... On many occasions it is actually better than ppts. Right, PowerPoint is important, because the person clicks, and it is almost like a…it is really interactive, very much, it is not that…anymore, that, slide slide slide, no the person has a context, and brings it closer to it, but also using various templates, right. On prezi, we have various templates in accordance with what we want,

Interviewer- So do you use prezi?

Bernard- Exactly,

Interviewer- Exactly, ok.

Bernard- Well, even during, many times when the principal has the opening of the school year and the first meeting where she needs to show new activities, I often use prezi so that it becomes more enjoyable, then we specify entering each topic in a more enjoyable way.

Interviewer- Great, it is much better, much better and there is a certain diversification and the school increases its quality because you use everything in different and lively ways, therefore it is not monotonous. I think it is very good. I have no more questions for you and I thank you for your participation.

Interview with Charles

Interviewer- Tell me a little about your experience during and after your participation in the program of education technology for chemistry and physics teachers, so you can talk about your experience, why did you participate in the program? What was more useful, etc.

Charles- So, in concrete terms, I mean, I am going to answer according to the way the questions are organized, right. Regarding the first question, you ask why I participated in the program I would say, seeing that we are in a globalized world nowadays, education, right, must be constantly updated, right , so that we, I don`t know, can use these technologies, right, more, tuned, right. But, as our teacher said, right, perhaps, right, because we are in the world we are now we have to stay updated in these new technologies, I don`t know, man, man creates it, man uses it daily.

Interviewer - Yes..

Charles- Now, concerning the second question, right , what was more useful to me in the program, I would say, especially concerning investigation project I and II, right, those programs, mainly investigation project I, right, where they had a concept map, right, games, simulations, right. Making work presentations from PowerPoint, right, is kind of like that and that for me was really useful and I actually said that it is one of the tools that existed but we hadn't used on our day-to-day lives.

Interviewer – Yes., and now can you, did you start using it more frequently? Of course you can`t in São Tomé, you still don't have the means, but can you use anything else now?

Charles- Yes, my participation, for example, my participation now and trip to Switzerland last year, normally in MasterClass I was one of the speakers, right, and used PowerPoint to do my presentation, right, and that is thanks to the program we had, usually I didn't use PowerPoint in my presentations, but nowadays I see that that technology helps me a lot so I had a good presentation in this year`s MasterClass.

Interviewer - That`s great,

Charles- Well, I don't know if I should proceed…

Interviewer – You can, you can proceed, what were the aspects of the program you found to be the most difficult.

Charles- I would even say, I would even say that there isn`t an aspect that is really difficult, but I can say that the most cumbersome one was the one concerning investigation project II, all that work we did, we had to do that, it took some work but, other than that, for me the programs weren`t that hard except for the amount of work required, that project I had to about metal corrosion.

Interviewer – Exactly.

Charles- That project required some work, but other than that, I didn`t think it was that hard.

Interviewer – Yes. great. How did the program influence your manner of teaching. Did it influence in any way your manner of teaching?

Charles- Yes., Yes., it influenced in a way, I must say that, of course it has. Nowadays, for example, when I introduce a new theme, right, I also had that experience, right, demonstrating through simulations, right that created an interest in the students and I noticed that the assimilation was more, I don`t know, consolidated, right, and that`s not all. From the simulation I also used research work, getting the students to do group work. I was also able to notice that the knowledge becomes more consolidated once they work in groups, doing research and we just guide them, their knowledge gets more consolidated that way.

Interviewer – Yes.. Great. How did the program influence your use of technological tools in the classroom?

Charles- That it leads me to, I mean, not only, right. It makes us prepare our classes better. The preparation of a lesson has to be, if I am going to use one of these technologies that they do, I would advise that, before going to the classroom we have to have a good preparation so that we can give a great lesson in the classroom, right.

Interviewer – Yes.

Charles- They too have to use, the teacher also has to be creative. If I use these tools, right, it is necessary to have a good control and a good creative ability so that, I don`t know, teach better using these tools.

Interviewer – Yes, that is true. What were the changes you noticed regarding the behaviour and performance of the students?

Charles- The changes?

Interviewer – Afterwards, when you use this

Charles- The changes, yes, of course, the motivation to learn increased in a way yes. When I, when introducing a new topic, right, do a simulation related to the topic, I notice that that creates an interest in the students and consolidates what they learn.

Interviewer – Regarding experiments, for example, do you use laboratory experiments or do the simulations substitute those experiments?

Charles- We use more simulations of the laboratory. We should take the students to a laboratory, but we don`t have one so we usually use the simulations.

Interviewer – So, simulations then, those simulations end up replacing and making up for the lack of laboratory facilities? What aspects of the program do you identify s being the most important for the assiduous use of technology? What aspects of the education program?

Charles- I mean, referring specifically to games and simulations, they are the two more interesting aspects, right, games and simulations.

Interviewer – What are your recommendations for the program and its continuance and expansion? What do you think it must be like?

Charles- That there are more programs like these for teachers, right, more frequently, periodically so that it is not only our group, right and so that when you tell other groups and teachers, and also when teachers use those technologies when possible, right.

Interviewer - Yes.. Exactly. Is there anything else you want to share about the program or your experiences with technologies with the students, anything else you want to share that might be important for the study?

Charles- I think there isn`t, nothing relevant. I think that it`s all, right. About that no, I have nothing to say. For me everything else is alright just as it is.

Interviewer – Everything is fine. I just wanted to know if there was anything in particular that happened with some students with the use of technology or something like that. So there was nothing special?

Charles- No, no no, I mean, usually the student gets a little strange when they see a simulation, but it is just wonder , nothing special, right. What I was able to notice is that it sparks more interest, they get curious.

Interviewer- More curious. Ok. Thank you very much.

Appendix G: Transcripts of School Directors' Interviews (Sample)

Interview Nelson

Interviewer- What do you know about the program that includes the integration of technology provided to physics and chemistry teachers?

Nelson- The teachers who done the research worked with her students and they loved it. The other teachers also wanted to know and then the teachers started working with other colleagues who were not doing research. After a small exchange a lot happened with these teachers.

Interviewer- Ah, so the students liked and really liked what the physics and chemistry teachers were doing?

Nelson- Yes, exactly.

Interviewer- Use of the technology and began to do research etc. Okay. Which changes have you seen in the development and performance of students? They began to like it, they began to have better grades?

Nelson- They improved their grades, and there has great participation in the class, participation is a way of saying, greatly improved the way of being of students and good disposition towards the subject. And before, students, physics and chemistry were always the worst school subjects.

Interviewer- Ah yes.

Nelson- And became the most beloved subject by students.

Interviewer- Ah good.

Nelson- The results improved a lot. The results improved greatly.

Interviewer- Oh great, that's great. What are the recommendations or concerns you have regarding the continuation or expansion of such programs for the teachers?

Nelson- Yeah, I mean, it is a very good program that has revolutionized the teaching of physics and chemistry and general science in some secondary schools, and taking into account that many of the schools and our school, we have no laboratory in this served as a very good example for the school, right, and I advise the program to continue and that more computers are needed. Now we have a school in Colónia Açoriana and in Água e Zé which do not have computers.

Interviewer- Ah, ok.

Nelson- Fortunately we have computers in our school.

Interviewer- Yes yes, I know.

Nelson- That is, we need another datashow would, if we could one data projector to do the work we would be very love that, but in general and I have to admit that due to teachers of physics and chemistry technology cannot be forgotten. They have been implementing these tools. Always continue to pursue that, way of teaching in high school, right. This innovation has to be continued, right? For students who have to continue to use this like it, they have come to like the physics and chemistry and science in general. Today based on physics and chemistry they could fetch mathematics and children were seeking sites and found a teacher talking to a class of ninth grade, they saw the lesson with their teacher and were questioned about some things and this was very positive.

Interviewer- Oh great, so now they are taking this to other subjects?

Nelson- Other subjects, not only chemistry and physics, this led to other subjects. For the Portuguese language, mathematics, sciences, this was a very big evolution here at our school.

Interviewer- Great, this is very good. But you are also responsible because you also like technology?!

Nelson- It's true, I love, I love technology.

Interviewer- Yes, yes. One needs to like technology to motivate teachers, right?

Nelson- Exactly, to support, and when students are interested, we do everything for them to access and understand the technology. A teacher has to enjoy and also enjoy working with students for students to learn as well. The physics teachers do this too. The knowledge was not only for them as they also began to transmit it to all the other teachers.

Interviewer- Ah, it was good. That was what I also wanted to ask. You also promoted training for other teachers?

Nelson- Yes, yes, yes..

Interviewer- These physics teachers also provided training for other teachers?

Nelson- Thus, we have some teachers who received training at the ISP, the second year in natural sciences and I notice that the other day the teacher T#10 was explaining such sites and tools which they can work with, but this work they started researching and were astonished with the quantity of information and materials they found to support their lessons, just thinking of the headaches they had when studying Biology at the ISP having to understand what the teachers wrote on the board which was their only source oof data, with this information they were delighted.

Interviewer- Ah good.

Nelson- It is very good indeed.

Interviewer- Ah, that's great. Is there anything else you'd like to say about the program and what do you think of it and in the future for students, basically anything that you think is important and useful for, for research, for the study.

Nelson- It is basic but I've said it all. The basic I said everything, right. I liked it, I loved that work precisely because we do not have a lab at school. The school has no laboratory in physics or chemistry lab but students were able to see some work that other colleagues were doing in physics and chemistry, and that's what was very pretty and this was very important, so I give a positive note to this project this innovative way of teaching, and to complete. Continue.

Interviewer- Is ah well, thank you. Do you think this is very important, and have you seen anything in terms of programs? So the programs requirements are met when teachers use technology or think that the program takes longer to perform or less time?

Nelson- I think it takes less time.

Interviewer- Ah, yes.

Nelson- Because the teacher can summarize in five minutes a program that would take to give three months.

Interviewer- Yes, yes..

Nelson- That's a great evolution. In five minutes the teachers could summarize the program that will take three months to develop.

Interviewer- Yes. Okay, great. I thank you very much for your cooperation. It was very important. I really appreciate Nelson. Thank you.

Appendix H: Transcripts of Educational Stakeholders' Interviews (Sample)

Interview Patrick

Interviewer- I would like to know about your role of the implementation of the training program for physics and chemistry teachers and therefore the collaboration, the goals and operations.

Patrick- Regarding the physics program for physics teachers, here we are talking about information technology was very important for teachers and for the teaching of physics, firstly because physics teachers, especially here in São Tomé have had some, certain difficulties in implementing practice into the teaching of physics, right? We must therefore go back to the theory, that is, in their respective schools because they do not have the resources to effectively implement what they have learned here. However this program has brought some added value for teachers taking into account they can use other tools that may be, that are useful for the teaching-learning process. For example, some simulations, right? And they are very enjoyable for this process of teaching learning physics as such.

Interviewer- Yes yes

Patrick- ….

Interviewer- I'm hearing some interference not know if …

Patrick- I

Interviewer- Yes? Dr #

Patrick- Yes yes yes, I can hear you.

Interviewer- I did not hear the last part.

Patrick- Ah, ok. I was referring to this program had some advantage for teachers of physics because it has provided them with tools that allow in their respective schools the teaching learning process in a more enjoyable way.

Interviewer- Yes

Patrick- using some simulations which can often reproduce what in fact we actually have difficulty performing.

Interviewer- Ah yes yes. For you what are the challenges and benefits of implementing the program?

Patrick- The benefits are visible because teachers were more prepared for teaching. Now challenges do arise. The challenges we have to face is the teaching of physics in another perspective. This perspective requires the acquisition of some means of simulations for teaching because we have to use new technologies, right? This requires some investment in schools. Have computers available, Internet access, projectors, video, ... these are materials that are indispensable for this process of teaching learning. Now it is necessary that our leaders who are responsible for the acquisition of these schools see media as essential to the process of teaching and learning, or else it is not possible.

Interviewer- You think you are making an effort?

Patrick- And for the teachers, I also challenge the teachers. They need to continually maintain themselves updated. With constant practice not to lose that bond they already have with these tools that are indispensable.

Interviewer- Yes yes. What is your view on the opportunity, on the importance of distance learning? Do you think this can help? What do you think of the program promoted between the ISP and the IPL?

Patrick- Ok, this distance learning can contribute to the improvement of teaching because it will to some extent reduce the shortage in some areas of training. We are working but are not self-sufficient in all areas, all areas.

Interviewer- Yes yes.

Patrick- Those where it is harder, right, that distance learning will suppress these same difficulties.

Interviewer- Yes yes. Thank you. Which concerns or recommendations do you have regarding the continuation or expansion of the program? The program at this moment is not in action is it?

Patrick- At this moment no, this moment not because first in some subjects there is not a sufficient number of applications to justify the opening of the program.

Interviewer- Yes

Patrick- For example in physics and chemistry after the last group that graduated there are not enough students to justify opening training training. Serves as a means to streamline resources.

Interviewer- Ah yes

Patrick- Resources are scarce, we need to optimize these. Now when the number of

Interviewer- Hi, I cannot hear. I cannot hear you right now.

Patrick- Therefore, to justify this training, yes.

Interviewer- Then the confirmation is justified. Yes yes.

Patrick- I will refer that there does not exist at this time the program for physics and chemistry for example.

Entrevista- Yes

Patrick- The number, there are not the sufficient number of students to justify the opening of the program as a way to rationalize resources.

Interviewer- Yes yes

Patrick- Currently there is only training in History and Geography.

Interviewer- Ah yes, these are the areas that are needed at this time? So open only in areas where it is justified to think are necessary?

Patrick- Mainly due to the number of students enrolled.

Interviewer- Exactly, okay that is good. Is there anything else in this area about technology that would like to share, about the implementation of technology? Do you think it should be just as we started, with physics and chemistry students? We should, should it be used in general by teachers of all subject areas? Is there anything you would like to share on this?

Patrick- I think the following, we first had to have an intervention with the physics and chemistry teachers that participated in this training program to properly implement these features, this learning in their respective schools because from my perspective not all are properly using these resources. This is the first phase, then it would pass to the second stage would be to generalize this for teachers of other areas, it seems to me very important.

Interviewer- Do you suggest any method to see that the physics and chemistry teachers use the knowledge gained in their classrooms? Is there any way to do this?

Patrick- Some teachers have used these resources, others unfortunately do not. First, the conditions under which ..

Interviewer- Sorry, I can't hear you. I do not understand this last part. Dr # this last part could not understand.

Patrick- I said that teachers ..

Interviewer- Yes ... I do not hear. Dr #

Patrick- Ok, I also have some problems.

Interviewer- Do you want me to end the call and call again only for the last question?

Patrick- It can be.

Interviewer- Thank you.

Interviewer- Dr#

Patrick- Yes

Interviewer- Oh, I'm hearing better. Before I could not hear anything.

Patrick- Yes I am also hearing better.

Interviewer- Thank you, the last question is related to what you suggest be done.

Patrick- I was referring to the teachers in the first place those teachers who participated in this training should deploy resources in their schools and then we start generalizing it to other areas. Well I think you asked a question

Interviewer- Yes, which is what would be your suggestions to make these teachers, teachers who are not implementing technology in the classroom and therefore are not using the new methodology they have learned to use? Do you have any suggestion on how to motivate these teachers to begin using their knowledge for the good of the students?

Patrick- I've done a bit, right? I have been a little by schools trying to stipulate that they use these same means and resources for their classes.

Interviewer- Yes, are you there? Dr#

Interviewer- yes Dr#

Patrick- I am here

Interviewer- Ah

Patrick- Have difficulty with communication.

Interviewer- Yes yes, this time it is a bit difficult, I just wanted to finish now, so I heard that Dr # is already trying to make all teachers begin to implement technology in the classroom, so at least all who participated in the training program.

Patrick- Exactly, exactly, now we have to also pass this information to some people such as delegates and methodologist of the subject area, this is the person who should be, is one of the first people who should pass this information and also be in a position to monitor their teachers.

Interviewer- Yes, so are the delegates and methodologists of the subject? I did not hear well the first part, is it delegates you said?

Patrick- Delegates and methodologists.

Interviewer- Ah, methodologists, ah yes, okay, that's great.

Patrick- The pedagogical support should be provided more by the methodologists than the delegates.

Interviewer- Ah, okay. Moreover, is there anything else in this area that would like to share?

Patrick- At this moment I cannot think of anything, right.

Interviewer- Thank you. Thank you for your participation, it is valuable and I'll prepare the summary.

Patrick- It’s okay.

Interviewer- Okay, thank you.

Patrick- Whenever you need anything I am always available.

Interviewer- Thank you, thank you. Thank you for having granted me the interview.

Appendix I: Interview Transcripts of Minister of Education (Past)

Interview with Minister of Education

Interviewer- What role did you have in the implementation of the training program for teachers to integrate technology in the classroom? This has to do with the programs that was developed in the ISP.

Yves- Here you refer to that project developed by Escola + with Leiria?

Interviewer- Yes.

Yves- Well, the teacher's role, providing knowledge, it was in 2011 I believe, was in 2011.

Interviewer- Yes. It was precisely at the time of your mandate.

Yves- Yes.. Well the role of information technology in general is important in education both in the school management, organizational management, in this case the Ministry of Education itself as well as in the integration of technology as a pedagogical element to facilitate teaching and learning as well as, a tool for teachers to have more access to knowledge and also to use the tools in their teaching activities. Within that training program, I no longer remember very well what the content was but what I remember is that it is enabled teachers to use some tools, I think they also had access to a web portal.

Interviewer- Yes.

Yves- So they can do some exercises, share documents. At the time I understood that everyone was satisfied with the training. Today I do not know what is the follow up, not even that project with Leiria which that was executed at the ISP, I passed by later and saw that room with the equipment for video calls no longer exists. That equipment that was assembled there unfortunately no longer exists there. But, in the educational framework we always attributed an important role to information technology. We recognize information technology as a key element and in that sense, even when we organized the Educational Forum this element was incorporated into the forum and therefore appears in the strategy that we developed for education from 2012 to 2022. Therefore, later we also released, a public tender for the Technological Plan, and it did not happen, then there was a change of Government. But basically, what was done did have an impact because under the scope of the Fiber Optic project, with the entry of new telecommunications operator, we foresee that a portion of the license is invested within information technology for schools and I think a team is working on the acquisition of about 15 to 20 000 tablets for students.

Interviewer- Yes.

Yves- Given that this may be important but only the tablet itself will not be very important. It may be important for children to have access to the Internet, but still deserves the pedagogical context, it cannot be considered as an important element because it is necessary to establish a team within the Ministry of Education, we even and EduTIC but unfortunately after my departure it was not continued. It was a team of information technology which began to reflect in various fields, so it was a multi-disciplinary team which possessed information technology, educational data, pedagogy etc. The team started off we thought of content which would facilitate teaching and learning, therefore not only the issue of computerization of manuals as such but also some tools that could assist the students to understand certain concepts of a certain subjects, biology, chemistry which currently does not have laboratories, there are not sufficient laboratories in the country for all the schools, but with the technology, the student can have access to some experiments, thus virtually experimenting to know what happens, what is the composition? Not knowing the issue of biology zoology etc. geography. So information technology can support in that area. So overall, we always emphasize the important role of information technology in education. Issues related to resources, unfortunately, taking into account the dynamics of the country. There is no clear position on information technology, better science and technology as such. We created the Institute for Innovation and Knowledge (Instituto de Inovação e Conhecimento - INIC), with this role, unfortunately today this institute is not meeting the initial objective which was to promote access to information technology. Therefore they need to rethink the issue relating to the financing and allocation of some projects because resources can be resources but if there is not a policy where people realize the importance of these elements in education, the resources, even if they are there they are ineffective.

Interviewer-Yes.

Yves- And even with resources, if they are not well distributed, as is this case now, I've been here with the commission, which fortunately contacted me to ask for my opinion and I said that the distribution of tablets would not solve the problem, we needed to put it a more systematic way and consider that this could have been more effective in the scope of digital inclusion but, in the educational perspective one could go further and conceive a more systemic project. Therefore, the resources the country has. However there are ways that the state itself can incentive create a policy to promote some practices that sometimes they do not, these do not require many resources. Even in tax incentives, they can help companies importing computers and thus have reasonable cost which could allow teachers and students to acquire computers. Today there is free software that is not expensive, this is available and can be used to provide pedagogical training for teachers as well as distance training. We also had in education, when we were in government we also spoke about the issue of Teacher's training School (Escola de Formação dos Professores –EFOP) to use information technology to train teachers in Kauê, Lembá and Príncipe, but we were not able to continue this project. Let's say, there is still a lot to be done but I think it is urgent for us to conceive a technology plan for education then achieve

Interviewer- Yes?

Interviewer- Yes?

Yves- Yes, the call fell.

Interviewer- Ah, it fell, it fell. This is normal, there is no problem. Well, but in your time in office, were you already developing the technological plan?

Yves- Yes. because we had already criated the terms of reference, we had launched the tender.

Interviewer- Yes.

Yves- For a company that could compete, companies that would be able to bid, but unfortunately we could not finish. We did not have the opportunity to conclude.

Interviewer- So things will have to change to be able to continue with the expansion?

Yves- Yes.

Interviewer- In relation to distance education, is there any expansion in Sao Tome? Aren't there are no more people interested?

Yves- Well distance learning, at the Ministry of Education within EFOP's expansion scope, teacher training, does not exist. That training with Leiria meant for teachers also no longer exists, but, I mean, at the ISP training there is teacher training for masters degree, but it is not online. It is another modality, not via the Internet. But, in education as such, today we have no real experience in this sense, it does not exist, does not exist, does not exist.

Interviewer- And then anything else you would like to share about this, about alternatives? What could ..

Yves- Not so, I mean, everything depends on the establishment of an objective method and we noticed that people today do not have this concern. Today, in the past the Ministry had a site, today it longer has a website, so to say, it seems absurd, doesn't it? There was already a website so that people could know what was going to happen, especially today with the fiber-optic Internet, and a new telecommunications company that will start operating, many young people have access to their computers, they are always on the Internet and this is an opportunity the Ministry should use to create, strategies, communicate with students, even with the schools themselves. Thus, under some computer project with some schools.

Interviewer- Yes? I cannot hear you.

Interviewer- Good afternoon, we are again.

Yves- ok

Interviewer- Ready, I did not hear the part about the schools, then the call fell. Yes?

Yves- Hello

Interviewer- Yes? I cannot hear you.

Yves- Hello

Interviewer- Yes? I can already hear. I did not hear what you said about the school, you spoke of schools.

Yves- It began last year. In 2012 we developed a project that was to create computer labs in secondary schools, to start having information technology lessons too, only that these, the equipment arrived last year. These devices are at the schools, unfortunately as the people who have knowledge of the project, it ends up not being an orientated action with a concrete goal and what happens, it is more for students, to access Facebook, therefore, it is not a tool for learning in the context to get the student to understand the role of information technology today, how to do research, help the teachers themselves when choosing resources for their lessons etc. So the equipment was set up but did not prepare people also had this project in our dimension that is also train people so that they could train others to use such equipment and teachers learn how to use various tools that exist today within the education so that they can improve even specialized sites on their discipline, mathematics, physics, so there's social networking groups and that, so that can help students and teachers improve their performance. But computers are there, it is more for Facebook and so on. and not for more positive work that was called for, is not it? That's the problem.

Entrevista- But you agree that a country like São Tomé can pass from the state where it is to a state where you can use technology as we do in Portugal, the United States or any other country, is it possible?

Yves- I do believe that, and this can be done in a short period of time, in a short time span. There just needs to be a leadership that believes this, that prepares staff for this, and we have already created the foundation for this to happen. We create a, committee, for information and communication technology ICT, starting with education and technology education where there were also people from other institutions like the INIC so that we could start working, also counting on the support of the possible company which could develop the technology plan, start thinking on this, but unfortunately we did not, could not. This change was not achieved. Even with EFOP we have serious problems with teacher's training of those teachers who live in Kauê and in Príncipe, so creating a distance education room connected to EFOP, as we have good Internet today, we can, we can, they can be done in a short short term. It's not hard.

Interviewer- Yes.

Yves- And there are also other interested partners, only that when these partners see what is being done and that things do not move forwards, they are also discouraged. Brazil itself has funded some projects in this area but I think they have not moved forward. Taiwan also etc. so this is tricky.

Interviewer- Yeah, but don't you think for example because of your position, can't you make things go forward like while you were in office? Everything was already in progress.

Yves- Okay so in my current position is difficult to do anything. The way that I do to exemplify so they can see the good practices, eg, here as I am in the private sector, at Globus we apply it, we also created a multimedia company, to make people see what is possible. If a small group of people, we are only three people here, and we do it, so imagine if the state wants to put together a team and decide to move forward it is possible to do. It is possible.

Interviewer- Yes.

Yves- Unfortunately this lack of political will especially for things to happen. Right? Especially in a country like ours where there are few resources, distance learning would be a tool. Then we have difficulties to create physical libraries, so in high school with digital library, today there are thousands of books available to students starting to use virtual libraries in schools and there are databases available, even, there is a Brazilian association willing to offer their ebook databases to education, learning objects, much, but unfortunately we did not want to take the chance. Let's see what happens in the future, who knows. Things happen by themselves, changes happen (laughs).

Interviewer- Usually change, have you read the book by Everette Rogers, "Diffusion of Innovations"?

Yves- No, I have not. I do not know this book. I need it, it is important for my work as well.

Entervistador- I will try

Yves- I am also pursuing my PhD.

Entrevista- Oh that is great.

Yves- and my PhD is in the context of innovation policy.

Interviewer- Oh, great. He says that a leader of opinion, someone in a position of power and a change agent, so in this case São Tomé you were the two people in one. The Everette Rogers is very good.

Yves- An opinion leader in that respect therefore we create influence through participation in some debates or organized some lectures, so these are the opportunities we have to influence the public opinion. This strategy is slow but we believe it is possible. We are creating an association for people connected to information technologies, it may be that this association also can also have a strong impact in changing opinions at national level.

Interviewer- Yes. Teachers I also know, some of those teachers who participate din the training program, there are two or three who want to do their masters degrees.

Yves- The master's level, a lot of people have done it through distance education. Here in São Tomé, with Brazilian Universities, Spanish Universities, also in Portugal there is also a university that has joined this project. The individual at the national level, there are many people who have made distance education, but the state level, the state to assume such a process has not yet, not yet, not yet exist. But individual people are writing themselves into online programs to pursue licentiate and master's degree. My brother Octavius is also completing his master's degree online.

Interviewer- Yes yes, is he also doing it in Brazil? Also?

Yves- Yes.

Interviewer- Ah, ok. Thank you for your contribution, it was very important.

Yves- Ok

Interviewer- I thank you very much, I will make a transcript of the interview and then a short summary and submission to you for your feedback.

Yves- ok, ok.

Interviewer- After the dissertation is done I will send you a copy.

Yves- Ok, thank you.

Interviewer- Thank you.

Yves- Thank you too. Any more information, we are available to assist, if you need more information we are available.

Interviewer- Thank you.

Appendix J: Teacher Narratives

TEACHER NARRATIVES

English

Please provide a narrative response to each of the following three questions in type-written format. Please make certain that your response does not contain any identifying information. Once you have completed the narrative please place your response in the attached envelope addressed to me. Your responses will remain private. Thanking you in advance for finishing these narrative responses and for taking part in the interview.

1. As you reflect back on the program, how satisfied are you with your participation and its results?
2. As you think about your use of education technology in the future, how likely is it that you will continue to use technology as included in the program? What reasons do you have for your response?
3. Please add any other comments about the program that you did not share during the interview.

Appendix K: Teachers' Narratives

Teacher Narrative #1TN

3. ***As you reflect on the program, how satisfied are you with your participation and its results?***

   In my opinion, I think the program was very good with excellent results.

   The program made me reflect on the following questions: How would the ideal school that would prepare train new generations be? What activities would be used? Which technological resources would be needed?

   The program made me realize that the work we are currently doing at school is not enough to prepare the future generations for what the will experience and face. This allowed me to understand that the classroom where the teacher talks all the time and the student listens, the student "receives" content and "returns" which he returns during the tests, in which almost no one uses the computer, tablets, etc, is no longer possible.

   Therefore, the program helped me to become familiar with technology and assume a new attitude toward the students, providing place for different methodologies.

4. ***As you think about your use of education technology in the future, how likely is it that you will continue to use technology as included in the program? What reasons do you have for your response?***

There is no doubt that I will continue to use technology in education in the future. There are several reasons. For example, thanks to the use of technology I have achieved:

- Streamline the day to day activities and collaborate with the learning process.
- Develop more dynamic, creative and interactive activities. (Students learn to use simulations, perform WebQuests, view videos and animations, participate in school Moodle platform, etc).
- Save paper and reduce the weight and volume of material.
- Facilitate reading, planning and correction.
- I therefore hope that similar programs have continuity, helping teachers and students to make effective use of technology. We, the teachers, must increasingly use modern and interactive to develop the students' creativity means, makes them more participatory and active.

5. ***Please, add any other comments about the program that you did not share during the interview.***

Nothing to mention.

Teacher Narrative #2TN

3. ***As you reflect on the program, how satisfied are you with your participation and its results?***

   I am very pleased with the program because the results were encouraging. My school does not have a laboratory, so to provide my students with the required knowledge I have used new technologies in the classroom. We face a new century with new format for receiving and transferring knowledge, as well as an endless quest for knowledge. No doubt that I need electricity to resolve several of my student's concerns, relatively to the practical use of small simulations and the application of scientific or technical knowledge, knowledge which helps them overcome difficulty which they may have encountered.

4. ***As you think about your use of education technology in the future, how likely is it that you will continue to use technology as included in the program? What reasons do you have for your response?***

   In the future to I intend to continue this work, as technology is very important for the practical aspect of education, where students develop their skills with great advances in research and learning, but it is also fundamental to their experience in society.

   These may cease to exist if labs there are real laboratories that help students better understand the practical classes, but that is nearly impossible. Nowadays, the use of technological is changing work patterns to help achieve individual goals.

To firstly I would like to emphasize my gratitude for the opportunity, and secondly I would like to acknowledge that teachers work better. Schools are equipped with technology, only there are cases where the teachers do not use these devices, for example he may prefer to teach in a traditional way.

5. ***Please, add any other comments about the program that you did not share during the interview.***

Teacher Narrative #3TN

3. ***As you reflect on the program, how satisfied are you with your participation and its results?***

   The degree of satisfaction is positive in the sense that it is because of a system, which provides an access to a technological culture in the school context in order to allow everyone a scientific literacy, although I realize that its use in room class requires the mastery of new skills by the teachers.

4. ***As you think about your use of education technology in the future, how likely is it that you will continue to use technology as included in the program? What reasons do you have for your response?***

   The likelihood of the continuation of the program presenting the technology, depends on the country's leaders who need to review, in detail, the importance of teachers training for proper integration of technology for teaching and learning. The reasons for this response are as follows:

   a. Improves access and efficiency of education and training, it is important for development;

   b. Facilitates education and training, there is a wide gap between the potential use of the program and what was done. There is hardly another area where the gap between the imaginable benefits and the reality is as great as in education and training;

   c. Provides learning experiences where students can experiment and apply knowledge as well as construct knowledge individually. Interacting with the world around him, builds, tests, and refines representations of strategies effectively integrated into the program in an educational context;

d. Teaches students to work together in solving problems or in other collaborative activities

e. Provides an active role for students in interactive activities and motivating problems;

f. Emphasis on motivation with motivating activities and stimulate student's interest, curiosity and appreciation for the topic under study;

5. ***Please, add any other comments about the program that you did not share during the interview.***

It is noteworthy that this program in teaching is considered essential for the development of a country by training better prepared citizens for a world in constant change. Individuals with in-depth education are needed in several areas, demonstrating flexibility and ability to communicate. The promotion of education and training has become of paramount importance for all citizens throughout their lives. This program promises to play a significant role in enhancing teachers and students.

Teacher Narrative #4TN

3. ***As you reflect on the program, how satisfied are you with your participation and its results?***

   Concerning the program my level of satisfaction is as follows:

   In fact this program provided me with the knowledge base and mastery of research tools as well as word processing. With these I am able to prepare and organize data that allows me to plan lessons with new technologies, PowerPoint presentation, use of simulation as a phenomenon of Physical Chemistry programs, using games as exercise for students.

4. ***As you think about your use of education technology in the future, how likely is it that you will continue to use technology as included in the program? What reasons do you have for your response?***

   Not all parents have the means to purchase computer for their children, I believe that all teachers and their students (will use the system) and will be an integral part of the system where new technologies are used in education system if it is within the framework of the programs with the guidance from subject delegates, methodologists and senior educational managers.

5. ***Please, add any other comments about the program that you did not share during the interview.***

   Nothing to add here.

Teacher Narrative #5TN

3. ***As you reflect on the program, how satisfied are you with your participation and its results?***

   About the program I feel a huge satisfaction at having participated in it, this program is a vehicle of connection between theory and practice. It is the basis for the development of new avenues in the search for new information in the teaching learning process. Thus the implementation is remarkable satisfactory growth in commitment and assimilation of students.

4. ***As you think about your use of education technology in the future, how likely is it that you will continue to use technology as included in the program? What reasons do you have for your response?***

   The probability of using educational technology in the future would be the probability of about 80%. This, in my view, would develop in students the spirit to research, present research data, connect the theory to practice through simulators, games, and observation.

5. ***Please, add any other comments about the program that you did not share during the interview.***

   Firstly I wish there was a book with guidelines to orientate the teacher, supply of equipment, and that it could be extended to all the secondary level teachers in the country

Teacher Narrative #6TN

3. ***As you reflect on the program, how satisfied are you with your participation and its results?***

   The degree of satisfaction by which I evaluate my participation in the use of educational technology program, between negative, positive and very positive, choose the latter. As for the immediate results, it has only been two academic years, one in training and another that followed, the results of visible behaviors in terms of general educational objectives classify as slightly positive.

4. ***As you think about your use of education technology in the future, how likely is it that you will continue to use technology as included in the program? What reasons do you have for your response?***

   A reflection on the probable use of educational technology in the future presented in the program in the scope of a good educational policy. The creation of portals and accessibility to the technology to create a more dynamic activities, and having in the pedagogical aspect faculty which dominate these techniques and to promote recycling sessions (training). I mean the meetings planning and methodological preparation, which is usually fortnightly, could be alternated with presentations of topics and technical work practices for classroom use for more dynamic practices (forgive the repetition).

   In an occurrence of twenty events it could occur in at least fifteen for full correlation factors, without which there would only be the probability of happening at least five events occurring within the twenty events.

5. ***Please, add any other comments about the program that you did not share during the interview.***

   I'm very optimistic about the future of the program in the best interest of São Tomé and Príncipe and its education.

   The thought of the education technology comes in good time, when the challenges of globalization and especially its negative aspects, it is urgent that we insist on making better use of innovation and technology, especially in education.

Teacher Narrative #7TN

3. ***As you reflect on the program, how satisfied are you with your participation and its results?***

   I thought the program was interesting and was very satisfied with it's implementation, this because it was my first contact with the new educational technology for teaching in chemistry and physics lessons. The results were honestly satisfactory.

4. ***As you think about your use of education technology in the future, how likely is it that you will continue to use technology as included in the program? What reasons do you have for your response?***

   I agree.

   It promotes better learning;

   Using PowerPoint-one can capture and maintain the students' attention better;

   You can transmit knowledge, culture, society;

   Allows the student to interact with the course content;

   The student ceases to be an assistant (passive to assume the role of the builder of his own knowledge);

   It facilitates construction of position graphs, velocity and acceleration versus time.

5. ***Please, add any other comments about the program that you did not share during the interview.***

Before I started studying this program I did not know anything about the computer, but now I know turn on the computer, create free Prezi, Glogster create and use many educational tools, etc.

Teacher Narrative #8TN

3. ***As you reflect on the program, how satisfied are you with your participation and its results?***

   The computer programs applied to physics are extremely important as it allows, on the one hand, a strong interaction of the learners with the tools involved, secondly, there is an advantage in terms of time to resolve exercises, as well as providing greater the accuracy of the results.

   It is unfortunate that São Tomé and Príncipe takes so long to accompany the technological evolution, to say that the probability of use of educational technology in the future is still a mirage due to profound shortage experienced in the country.

4. ***As you think about your use of education technology in the future, how likely is it that you will continue to use technology as included in the program? What reasons do you have for your response?***

   With the curricular reform the educational system has lived with in the last four years, we are witnessing an educational explosion in the quantity of students transitioned, but for this, this was not accompanied by the infrastructure, the equipment of these infrastructures, equipment, laboratories etc. Fortunately we have some teachers who have pedagogical-didactic training. For these reasons the use of technology in the program is still a mirage.

5. ***Please, add any other comments about the program that you did not share during the interview.***

I would like to express my dismay at not being able to apply many of the lessons learned, because of the lack of means that the school suffers and because of the excessive number of students, but at the same time I am happy to have had the opportunity to meet and interact with these technologies in the program.

Appendix L: Coding System

Participants		1
Teacher School Principals Stakeholders: IMVF ESECS-IPL ISP Minister of Education Teacher Narratives	T# SP# S#IMVF S#IPL S#ISP ME TN#	1.1 1.2 1.3.1 1.3.2 1.3.3 1.4 1.5
Program		2
Roles: Minster of Education School Principal Stakeholders **Experiences:** Dissemination Distance Education Further Education Implementation Important Most Difficult Most Useful Satisfaction **Perceptions:** Benefits Challenges/Constraints Change Context Knowledge Likelihood to continue using technology Student Behavior Student Motivation Student performance Success/Impact Teacher Investment Technology use **Recommendations:** Consolidation Continuation or Expansion Distance Education Future of Educational Technology Sustainability **Other Projects:** Curricular Development Laboratory Project Resource Center Technological Plan World Bank	**ROLE** ROLE-ME ROLE-SP ROLE-S **EX** EX-DISSEM EX-DISTED EX-FURTHERED EX-IMPLEMENT EX-IMPORT EX-MDIF EX-MUSE PERCEP-SATIS **PERCEP** PERCEP-BENEF PERCEP-CHALLENGE PERCEP-CHANGE PERCEP-CONTEXT PERCEP-KNOW PERCEP-CONT-USE-TECH PERCEP-STUD-BEHAV PERCEP-SUC-IMP PERCEP-STUD-MOT PERCEP-STUD-PERFORM PERCEP-TEACH-INV PERCEP-TECH **RECOMEN** RECOMEN-CONSOL RECOMEN-CON-EX RECOMEN-DISTED RECOMEN-FUT-EDTECH RECOMEN-SUSTAIN **OP** OP-CUR-DEV OP-LAB OP-RES-CEN OP-TECH-PLAN OP-WBANK	**2.1** 2.1.1 2.1.2 2.1.3 **2.2** 2.2.1 2.2.2 2.2.3 2.2.4 2.2.5 2.2.6 2.2.7 2.2.8 **2.3** 2.3.1 2.3.2 2.3.3 2.3.4 2.3.5 2.3.6 2.3.7 2.3.8 2.3.9 2.3.10 2.3.11 2.3.12 **2.4** 2.4.1 2.4.2 2.4.3 2.4.4 2.4.5 **2.5** 2.5.1 2.5.2 2.5.3 2.5.4 2.5.5

Appendix M: Confidentiality Agreement for Translator and Peer Reviewers

CONFIDENTIALITY AGREEMENT

Name of Signer:……………………………………………………………………………………………………

………

During the course of my activity as peer reviewer for this research: "**Case Study of Implementing Technology in Science Classrooms in a First Wave Country"** I will have access to information, which is confidential and should not be disclosed. I acknowledge that the information must remain confidential, and that improper disclosure of confidential information can be damaging to the participants.

By signing this Confidentiality Agreement I acknowledge and agree that:

1. I will not disclose or discuss any confidential information with others, including friends or family.
2. I will not in any way divulge copy, release, sell, loan, alter or destroy any confidential information.
3. I will not discuss confidential information where others can overhear the conversation. I understand that it is not acceptable to discuss confidential information even if the participant's name is not used.
4. I will not make any unauthorized transmissions, inquiries, modification or purging of confidential information.
5. I agree that my obligations under this agreement will continue after termination of the job that I will perform.
6. I understand that violation of this agreement will have legal implications.
7. I will only access or use systems or devices I'm officially authorized to access and I will not demonstrate the operation or function of systems or devices to unauthorized individuals.

Signing this document, I acknowledge that I have read the agreement and I agree to comply with all the terms and conditions stated above.

Signature:……………………………………………….………Date:………………..

Appendix O: Teachers' Reflective Summaries

Anthony: Teaching is not static and teachers need to rely on educational technology through the use of computers to teach their students. Technology is useful as it simplifies and summarizes the teacher's thoughts. With these tools teachers are able to present in 10 minutes content they would otherwise need 20 minutes to teach, leaving them with extra time for questions. The two very important aspects of technology are the games and simulations. Teachers need to become more dedicated towards the implementation of educational technology, thus involving their students in this new form of teaching and learning. "We were trained to make sure that we can apply this educational technology to facilitate learning. Whenever we get something new, it creates appetite, especially for the students." There is the need for greater involvement, not only by the teachers but by the people responsible for the subjects, both physics and chemistry, and these people are the head of the chemistry and physics departments at the schools, and the methodologists "If these people are not involved there will be no multiplier factor."

Bernard: The program provided the teachers who participated in it the opportunity to complement their education. They originally held their bachelor's degrees in Chemistry and Physics and the complementary training was the stepping stone towards the master's degree which is currently being pursued. In the program in the use of technology in the science classroom the teachers became familiar with several tools among which was Stellarium, a free opensource planetarium, "stellarium is among the software's I use the most during lessons. PhET, also provides an arsenal of simulations at our disposal." There were more technology tools among which was Prezi, cloud based presentation software, which was often used to prepare presentations for the school Principal to show at the opening of the school year, "I often use prezi so that it can be more enjoyable, entering each topic in a more enjoyable way." During the training program at ISP the instructor insisted on the use of the Learning Mangement System (LMS) which had been created for the training programs at the ISP, consequently everyone became more comfortable using it.

The students enjoy technology therefore teachers are currently trying to find ways to captivate them in the new educational context, where technology is all around. The greatest advantage of the program was the comfort with technology, and students high interest levels because they never know what the next lesson will be like, "if one day I use a PowerPoint presentation the next day I'd use a simulation or we would go to the laboratory, not always use the computer." The importance of it all is that "at the end of the day when I reflect back on the lesson I say yes, I liked it, the students achieved the objective" using the new educational methods they become more interactive and that is observable in the results and the willingness to do the tasks.

"The program drastically changed our way of being in the classroom and if now we feel more comfortable with these tools." Bernard is pursuing master's degree in pedagogical supervision in sciences online, and there is a course on "technology in knowledge and learning" which shows the importance of taking advantage of technology in the context of teaching and learning. It is necessary to invest more in technology integration, even ISP, because the use of technology for education is still very vulnerable. Teacher Bernard enthusiastically shared the knowledge he has acquired with his peers "When somebody teaches me to use a new tool I am the first to spread it around to the other colleagues" and "I like it because the other teachers need to explore."

Charles: The most useful part of the program was the part concerning research projects I and II, mainly research project I, where there were concept maps, games and simulations. In the program there was no aspect that was really difficult, but the research project II which focused on metal corrosion involved a lot of work. PowerPoint presentations was very useful. At the MasterClass this year, because of the trip to Switzerland, due to invitation to visit CERN

> I was one of the speakers, and I used PowerPoint to prepare my presentation, and that is thanks to the program we had. Usually I didn't use PowerPoint presentations, but nowadays I see that technology helps me a lot so I had a good presentation in this year's MasterClass.

Simulations have been used to introduce new topics "I notice that it creates an interest in the students and consolidates what they learn." As no laboratory exists at the school, simulations have been used instead.

Daniel: At the ISP there had been a introductory course for basic computer use, but not to a extent where teachers could use tools like those used in this program where the tools used "open doors to information and provide tools" for them to use with their students. "I used Stellarium, which I had never even heard of and was very happy to be able to use it." "We gained a lot with all that work, with the tools, the new technologies we didn`t know." The normal classroom conditions and lack of equipment made it difficult to use, even though it brought a new dynamic to learning "it is like bringing a faraway world to the students." Students viewed the night sky

> Stellarium makes the students that wouldn`t be able to see, the students who wouldn`t have access to these programs would never see these things, never, so these tools brought the world to them, the world that was beyond their reach, a little nearer.

The lesson with the use of Stellarium was provided to a group of 7th grade students who were not this teacher's students and three years later they still ask him, in the school corridors, when he is going to be their teacher. He had made a lasting impression on them "It is something that sticks with the students, our way of working" … "they have seen the difference, they have seen that it is easier for them to assimilate the contents, using these tools." It is important for teachers to know how to use the technology, students and teachers alike want these programs but they are difficult to implement due to classroom conditions and the lack of equipment. Students only learn theoretically, Daniel provided the example of an exam which he had watched

> Today tenth graders had a TIC test that I was overseeing and, by the end of the school year, the students, most of them had never had contact with a computer and were still having to search for the letters to type in a word.

Daniel concluded the interview with a comment on the feelings of teachers from the other programs at the ISP which did not have technology integration in their subject area included into their training.

> Well, let me say first that I don't know how the other programs were at the time I was studying, but the truth is that our colleagues of the other programs were jealous because of the kind of work we had been doing. So, that means the tools we had been using gave great importance to our course.

Daniel suggested the program continued so that more teachers would be able to learn and use it.

Edward: After the training at ISP on information technology Edward has started to use technology because he did not know how to use a computer. Since the program he started to use technology for his research and to prepare his graphs, use concept maps, games and simulations. Edward had enjoyed the Research Projects I and II where he had worked with the inclined plan. Edward built a plane with wood and a measuring tape up the plane so he could measure the distance, and a protractor to measure the angle, the only thing missing was the stopwatch and the sensors. He used information from the Internet to help him build this plane which he used with his students. The students also used a simulation where they had the opportunity to measure the angles and the time accurately. What Edward found most challenging in the program were the simulations and the games because of his lack of experience using the computer "I sincerely wasn't able to work with a computer." He started to use simulations and these have decreased the time necessary to explain the introduction of contents. The students have become more interactive with better performance "better results." Edward suggested the program be extended for teachers "all around the world", so that they could employ the educational technology with their students. According to Edward this is in the interest of every school in São Tomé "so that they interact with each other and this makes the teachers more open."

Francis: For Francis it constituted a big effort to participate in the program which would benefit him and his students, he would have the opportunity to improve his activities as a teacher. He said that he had "improved my former way of working with my students and not only that but the students got motivated and lessons became more accessible and pleasant." His way of teaching was influenced and because there was no laboratory at his school he used simulations to make the students understand. He has shared his work with his colleagues and has improved the performance of the teachers at the school in general "we don't have a lab so we have the help of virtual simulations and that has improved our performance and our way of taking the knowledge to the students." After being questioned on the changes noticed in the students he shared "I would joyfully share that my students started participating more" … "with these simulations with clear examples the students finished the curriculum with great results and that is what I expected of them." In terms of continuation and expansion Francis said that the program was very good and that it "helps the students a lot because, with all that effort, now I think that we need to think of the students" and that at the middle school level that he is teaching they need a lot of practice and the simulations are at hand and can be used therefore he would like to see the program being used with teachers from other areas in STP. He had corrected exams from other schools and saw that there were many glitches that could be corrected with a change of strategy.

Gerald: Started the program with very rudimentary knowledge of the text processing software which he bettered during the program. He did not develop any of the programs learned other than what he had learned with the text processor which was being used "I use mainly text tools." During the research programs I and II he developed a project which involved him creating a timeline for the development of the atomic theory and he also included the scientists in the timeline.

> Well, yes that specific program was made for the teaching of history of the atom. It´s good, not only for the chronological aspects, not only the dates, it was also good to see the timeline of scientists lives as well.

Gerald did not use this technology in the classroom since the time he needed to implement the project with the use of technology in the classroom in my presence. The reasons for his lack of use of technology were the Internet quality and the extensive new curriculum which did not leave him with time to use technology with his students. Gerald was afraid that the program could go wrong while he was working with the students and because the new curriculum was very extensive he opted not to introduce or apply technology in the classroom. “It was also the curriculum reform, we have to adopt new content. It is so much to solve and apply.” When asked if the program influenced in any way his teaching he responded that mainly the new curriculum did and added that “at the moment we still don’t have many results” … “The time for the planning didn’t facilitate the usage.” Gerald defended that the chemistry and physics curriculum should have more hours per week in order for all the content to be provided, from two to three weekly sessions. Gerald also felt the need for weekly or biweekly coordination between physics and chemistry teachers “to plan and organize the work, assemble the experiments, and then when we went to the classroom we could be more familiarized with the content to present to the students.”

Hunter: Participated in the program to learn how to use the technology in physics and chemistry education. After having discovered the possibilities for the use of technology, specially simulations, he started using it “I started using it and I saw that the students liked it” and realized that these tools motivated the students “Each time we use this type of tools in the classroom, especially PhET, right, with the simulations. They begin to say, that they understand the subject better.” T#8 felt the challenges of the Internet connectivity even though he said that the Internet in the country was good, it was very expensive in Angola. In the research projects I and II Hunter worked with differentiated instruction which he only done for 2 years because it involved a lot of preparation of documents and procedures for 60 student classrooms but he has used technology, mainly PhET. “I have been using PhET a lot in the simulations.” He did not use games. Hunter built a Leslie cube for his lessons which he left at Alda Espírito Santo school when he moved to Angola this year

> We have an experiment we do in the tenth grade with the cube, before that we used a bottle covered in black and another with tin foil to measure the temperature, it increased much faster and now with the cube we do experiments with the surfaces black, blue and white, to see in which the temperature increases more rapidly.

T#8 felt that the program influenced his way of teaching very much, and the concepts were easily conveyed using PhET simulations

> It was very hard to explain something simple to a student, electrical current, uniform linear motion, especially relativity in motion, and some calculations. Because most of the time, they didn’t understand what I was talking about, but they started using the program and they saw a doll walking. If that was in a curvilinear surface, after x seconds it is going to be in a certain position and they saw that, so they started understanding very well what linear motion was through PhET.

T #8 said his students had become more interested in physics and were even interested in downloading the PhET experiments for themselves. In Angola he felt greater difficulty to practice new programs, other than these simulations, because Internet access was very expensive as opposed to STP were he had easier access “In

São Tomé the Internet access is much easier, everything is almost free.” He downloaded the simulations so he could use them in his classroom offline. When asked about the expansion of the program he said that more teachers needed to be trained. In Angola he also showed the simulations to some of his colleagues which were surprised with them.

Isabelle: According to T #9 the technology program was an important part of the curriculum. The technology was useful for physics, chemistry, and science in general. Before the program there had been no contact with computers so the course was challenging at first “it was a bit hard, then I adjusted, and it became easier.” Isabelle has started to search online for materials for the physics lessons

> I started using the tools. I teach physics, to make a quick test like that, just online, we have a test and an adequate tool for science tests and American tests, it teaches how to make the test, and take my materials to the classroom too.

Isabelle also used PhET and Modellus, the students changed their behaviour in the classroom and their performance has also improved “The students became more independent. It’s like this, they do teamwork.” Isabelle has invested in research using the Internet “The important aspect is associated with the use of the computer for research.” He recommends the program does not concentrate only on physics and chemistry teachers and expands to other teachers. “I think everyone needs to have some technological knowledge” and “others didn’t have the opportunity to be in the training program like we had.”

Jack: Acknowledges that the he learned a lot in the program and that due to it he evolved in terms of teaching. Due to the lack of resources such as books the Internet is a great source of information which Jack used for his lessons. The games were very useful to stimulate the students while simulations provided them with practice for theoretical concepts “That is because the games created interaction and the simulators created a link between theory and practice.” When asked about what had been the hardest for him in the program he said that it had been the resources but that the program did not pose any difficulty. During the training program Jack developed in the research projects I and II, a social learning project with his students where they built a rainwater storage system for domestic use and he continued this project with his students. The students researched for ways to capture and use rainwater in their homes “The students also researched and we were able to find a solution, this program helped the students a lot.” Jack started to use simulations in his classrooms with good outcomes “That helped a lot because the students were able to connect the theory to reality, when watching simulations they got excited, and with that excitement the results were satisfactory, which means the program had an impact on the students.”

The educational system in STP was always changing and the teaching methodology had changed a lot which he felt was an asset. The program which involved the integration of technology innovated the teaching of physics and chemistry and that he would like the program to continue “I would also like to say that this program innovated the teaching of physics and chemistry so I would like it if the program continued in high school level in São Tomé e Príncipe."

Appendix P: School Principals' Reflective Summaries

Kim: The teachers use technology for a lot of their work at school "they use it as a teaching material, in the classroom, to educate the students in their research and video conference, let's just say it is a very useful tool." Even though the Internet was mostly used by the physics and chemistry teachers, many other teachers are already using the Internet and so are the students, so it is unthinkable to not have Internet "today is unthinkable having a school without Internet because there are already many teachers who are making use of it and also the students." Kim informed that the physics and chemistry teachers at the school are the ones who have motivated the use of computers, the Internet and the Moodle platform. They also maintain the school site and have created a Facebook page for the school

> You know that, in our school, the physics and chemistry teachers have been the major leaders in the use of computers and the Internet, right, like I said, they are also responsible for the Moodle platform, where they put work materials and interact with colleagues and students and also update the site, we have Facebook and so on, so it is indeed a great instrument at this time.

These teachers have motivated the other teachers to start using technology in the classroom breaking through the barriers of resistance that there were.

> Until some time ago there was some resistance, there were many, many teachers who did not master the technology, right, these new technologies, but today, through these two teachers who trained other colleagues, they

almost feel the urge to make the best possible use of these tools in the classroom.

Teachers have started to exchange information among themselves and even with parents. Kim cannot imagine the school without technology and said that due to the fact that in STP there were not many books and other support material for learning the students have don most of their research online "can safely say 80% of what they do ... when they study they use the Internet a lot" therefore the computers and Internet are essential.

The physics and chemistry teachers have prepared activities using technology for teachers at the school. Kim informed that they strive to be able to have a wifi connection in order to be able to have the teachers and students connect their laptops and tablets which would facilitate the use of simulations in the classrooms. Kim said that the younger parents, the younger teachers and the students have adapted to technology very easily but the older teachers offer a lot of resistance and these need to understand the importance of the use of technology in education

> For it is these we have to fear, the failure would be at that level. Not so much the level of the students, not so much the level of new teachers or parents who are young. The problem is, in fact, with the teachers my age, or of an approximate age, right, so many do not have skills in computers to make use of this, and then we have to force it a bit.

Louis: knew about the programs at the ISP where the teachers learnt to use technology but was not informed on how it functioned. When asked if he knew if the teachers used the technology in the classroom he answered affirmatively and also confirmed that these were excited about it and that it facilitated research.

> The teachers use their own portable computers for the implementation of technology in the classrooms, with the school projector " they use their laptops more, because we have some computers but not in sufficient numbers and they use their portable and there is also another issue, we have a projector. They also use the projector so that they can show more people.

Education has improved and at the research level where they can find resources that they had no other way of finding "at the research level, another tool, with some more data with some more content that the ministry itself does not provide." The students also improved their performance. Louis nevertheless showed some concern in the fact that the students and teachers alike could use technology for other purposes other than for work "I'm afraid is that, they use this technology for purposes other than for teaching as such." He hoped technology would not deviate the teachers from teaching what they needed to **"**And that they do not deviate from what is selected to be taught, that they deviate to perform what was not planned" even with these concerns Louis concluded that it has helped the students and that he would like to have tablets and more computers but that they did not have the means to acquire them.

Michael: was not aware of what was learned in the program although he knew it was one of the *licenciatura* programs provided at ISP. Michael knew that technology had contributed to physics as well as education in general although he said the program contributed to the teacher's academic progression. The school is a very small school which has not space for computers to be installed and does not have any space that could be transformed into a computer lab. The only computer at the school is the computer in the Principal's office therefore it is impossible to apply technology in the classroom even because the rooms are small and they are full overloaded with students. Although all these constraints were mentioned Michael said that the program should continue "I think the program should continue, however they need to find ways that these technologies are applied. Without resources it is impossible, because the technology facilitates. If it makes things easier it should continue." There are other schools where computers have already been installed like the Maria Manuela Margarido (Trindade) school. He is waiting to receive computers whether within the project to equip computer labs or through the donation of computers to the school.

Nelson: According to Nelson the teachers who participated in the program for *licenciatura* in chemistry and physics worked with their students using technology and the students loved this. These teachers have also dedicated some time to help teachers in other areas to use technology with their students "The knowledge was not only for them as they also began to transmit it to all the other teachers." The students have improved their grades, and the participation has improved a lot. Students have come to enjoy physics and chemistry which were the subjects that the liked the least. "The results improved a lot. The results improved greatly."

Teaching of physics and chemistry in the school has suffered a revolution specially because many schools do not have laboratories for students to experiment "many of the schools and our school, we have no laboratory and this served as a very good example for the school." Nelson also said that due to the science teachers technology will not be lost at his school.

> Today based on physics and chemistry they could fetch mathematics and children were seeking sites and I found a teacher talking to a class of ninth grade, they saw the lesson with their teacher and questioned her about some things and this was very positive.

The fact that the school does not have laboratories does not limit the school because the students have had the opportunity to see experiments and do research on the Internet and Nelson classified the project as being positive "I give a positive note to this project this innovative way of teaching" and on top of it all the programs have been completed in a shorter time period.

Oscar*:* was not informed about the program although he knew of its existence because someone had mentioned it, and in terms of integration of technology in the physics and chemistry classroom Oscar did not know anything about it. When probed on whether the teachers at the school were working with simulations he said that because of the lack of materials they had more theoretical lessons and used the handbook that was prepared “because of the lack of materials we do more theoretical classes, right?! We have the manual, the handbook” and everything that needed to be taught was on the sheets, which they work with the students. Technology was not used because they did not possess it “We almost don’t use technology because we don’t have those materials.” When asked about simulations and if he knew some of the technology he replied that they could use interactive classes by putting students in small groups to work on different themes and then see what they had done “we could use interactive classes, right? In which we do, put the kids in groups, small groups, and put them working by theme and afterwards see what they did as a group” and use PowerPoint. He insisted that it wasn’t possible to use this because the classes were too large and even in terms of practical lessons in the laboratory it was very difficult

> Normally when we talk about a theme, we could make some practical lessons, about that subject: Now it is not possible to have practical lessons because there are too many students, some we do. We divide the students in parts, two groups. Two big groups and then it is not easy to make these practical lessons. There are too many students.

As recommendations to solve the problem Oscar suggested diminishing the number of students per classroom “I mean at least 30 students per classroom, we could divide in groups of 15 and we would have a nice amount of students for the laboratory.” There was alos the case of lack of material for the chemistry laboratory “For every theme we need the materials for the realization of practical lessons.”

When asked if it was possible to diminish the number of students per class he answered that it was not possible "It is not possible because there are no more classrooms, no extra classrooms, they would have to build more classrooms." When probed on the solution of distance education Oscar said that it would be possible but they would need computers and that the existent computer labs were closed most of the time, but even so it would not be possible to use these labs.

Charles: Admitted that the conditions at his school did not permit him to train other teachers to use technology in the classroom and that he himself does not use it on a daily basis, he uses it mainly to prepare his lessons and to do his own research at home.

Jack: As the current head of the physics department at his school he has encouraged teachers to use new technology "I have tried and encouraged teachers in terms of new technologies, through these programs we have learned." He also spoke to the school principal and in their school a physics research center was created:

> We created a centre where we can dedicate ourselves to the study and implementation of physics because in Albertino Bragança schoolwe don't have laboratories, and because we have no laboratories, most of the things we teach the students is through these technology programs.

According to Jack because they do not have laboratories at their school they need to use technology, and that without it they would not able to apply the theory that they teach "We simply take the theory to the students but the students don't know the practical applications. Because I don’t have a laboratory, the simulation can substitute a little bit.”

Francis: Is also the head of the chemistry department at his school

I have been gathering results, not only me but my colleagues as well. I have been sharing the knowledge I acquired with them, we don’t have a lab so we have the help of virtual simulations and that has improved our performance and our way of taking the knowledge to the students.

Appendix Q: Stakeholders' Reflective Summaries

Uzma: collaborated with the member of the board of ISP who was the connection between the *licenciatura* program at the ISP and the Project Escola+. Uzma also assisted the distance education part of the program by preparing the videoconference call to ESECS-IPL when I was out of the country. Uzma did not have feedback on whether the teachers where using or not the technology in their classrooms or in the preparation of their lessons. According to Uzma the program was good and technology integration, including distance education, were important for the teacher's digital inclusion "The program was great in every sense. In the specific cases of distance education and technology integration, contributed greatly to the digital inclusion that is one problem and one of the new challenges." The distance education part was very important because without this component of the program it would not have been possible for the teachers to pursue their *licenciatura* degrees "They were not able to be there all that time, and through technology, they had access to things that otherwise they would not have had." Uzma commented that the teachers could have found all the technology interesting but that they most probably did not use it because of the lack of resources

> They may even have admitted and found interesting and great for their students but then in practice failed to implement them. They do not have the physical conditions and the students do not have access to these strategies outside the classroom.

Uzma believes that the teacher's training program was important and that the distance education was a solution "the training course for teachers is vital and distance education will be, I believe, a solution for these trainees, even in other countries." Uzma considered the price of the Internet to be an impediment for the use of technology by the teachers, " Very few teachers have Internet at home. They use the Internet at school or go to other sites to use Internet. They do not have an unlimited Internet access as we have." The Project Escola+ could provide the programs that have already been developed by ESECS-IPL via distance education "Specifically for Project Escola+, the university developed an ongoing training plan and no doubt many of these training programs can be provided at a distance."

Vincent: coordinated the project for the training of the chemistry and physics teachers that involved ESECS-IPL. The benefit of the program had to do with the lack of adequate training that the teachers had "Teachers lacked adequate training to teach the 2nd cycle of the secondary level. The additional training was therefore an asset." As for the educational technology that could be applied in the classroom, people enjoyed it immensely but due to lack of resources there would be lack of implementation.

> Teachers learned a huge amount and I could experience the satisfaction of some of them. Your work had no doubt that great merit. But, in our schools, both teachers and students continue to lack access to computers and the Internet. I fear that for this reason, your work will not have the expected result.

William and Xana: were in STP throughout the process of the curriculum change where they supported the teams which were responsible for this change. Round about 2008 the laboratories were rehabilitated by the USA, which had the labs remodelled and equipped with lots of equipment and reagents that were taken to Alda Espírito Santo school and locked up. People started speaking of experimental teaching and William and Xana became involved with experimental teaching then. Experimental teaching started at the moment the curricular revision was implemented,. A resource centre was created and they received school manuals with the adapted curricula which was prepared in conjugation with Portugal and a São Tomé, the technical support was provided by the head of the physics department at the ISP. When William and Xana signed their contract with IMVF they were informed that the changes in the curriculum needed to be accepted by the São Tomé specialists because if not these programs faced the risk of being abandoned as soon as the Portuguese cooperation agents left “for us to be able to implement the change we need to implement the curriculum that could actually be accepted by the other specialists in São Tomé and that could last for years.”

Then computers were installed at the Kemese which had Internet access When asked if they noticed a change in terms of the use of technology after the training by the teachers who participated in the program they said that these had started using technology. Xana said that there were teachers who searched the Internet for simulations and other materials but that it was difficult to implement this in the classroom because there were no resources such as projector and computer “searched the Internet for, simulations, materials for hours only that it was difficult to implement in the classroom, because there was no computer to take to the room, there was no way they could project these materials in the classroom.” When asked about the inexistence of projector at Alda Espírito Santo school they answered that these were only available for the cooperating teachers and for the teachers in the professional courses “The cooperating teachers and those São Tomé teachers in professional education had access to the projector and had rooms with projectors.” S#3/4IMVF said they had started implementing simple experiments “which could be done in the classroom and they liked these little things.” They started having educational conferences at the Kemese where they were able to participate in various areas and where they used PowerPoint presentations

> Yes they already used PowerPoint, only it was hard, they could already do these things but then they couldn’t take them to the classroom.

The science week was implemented where they showed various different interesting experiments “The concept of the science week was interesting because it contradicted what they were accustomed to” and “experimental sciences in a more playful manner.” The teachers started searching the Internet for their own experiments for the science week “they were seeking the sites, they were looking for their own things” … “on the Internet an enormous amount of sheets which he printed with experiments, those experiments were the ones used during the science weeks.” Another teacher dedicated himself to researching adequate food for various deseases “spent his days in Kemese researching things that I had never even heard of.” When asked if they thought the program had been beneficial and the outcomes they answered “ I think it is difficult to go back unless there continues to be a lot of limitations in terms of facilities and then of course, the person starts abandoning.” William said that once he had spoken to Hunter and said that he himself would not do a certain part of the work because the students would not be able to visualize it to which Hunter answered "look in my class I turn around the computer and they are all sit quietly to watch it.” William also said that the students had started to do research as well “students in the more advanced classes began researching and started going to the Internet. While teachers were also going we started to see a big change in the students.” Xana added that the teachers researched the simulations and would come to show these to them. William worked more directly with 2 physics teachers and Xana worked more directly with 2 chemistry teachers and these chemistry teachers were themselves limited to simulations.

> Those who worked most directly with us were the Oscar, Hunter, and in chemistry were Jack and Francis. They were also a bit limited to the simulations due to the fact that they did not have access to or even had a lab.

William and Xana have left STP and are concerned that they did not have sufficient time with the teachers to cement the habit of performing laboratory experiments “there is no one in the project to support the management of Alda Espírito Santo school and soon, labs could get lost again”… “Even in terms of work, we know that the work there is different if they had contact with someone who always worked in a different way they would start following.”

Rebecca: was the Atomic Physics and History of Physics teacher in the training program. She recalled the format of the training sessions, half of them were in person and theoretical while the other half were autonomous work and synchronous videoconference sessions. Rebecca used some of the PhET simulations with the teachers to help them understand some contents and she also saw that between the first and the second training program she provided they had bought computers for themselves and presented their work written on the computer instead of hand written as had happened during the first of the two courses "I noticed that instead of handwritten it was written on the computer." In terms of resources she said that everything she needed was provided "I cannot complain because it was there all the equipment I needed to give my class to provide my training." On the occasion of the videoconferences Rebecca said that they were very challenging as sometimes she would not see the teachers, then they would not see her, so we decided to start using skype and that was when the communications became better "I used Skype for the first time to work with them in one of the sessions because the program we used did not work." Rebecca agrees that these teachers possess the capacity to have online training although she thinks that they will always benefit from a few face to face sessions before they have the online sessions.

> They are aware of these new features of these new materials, this new knowledge and I think the way it is done is a good way. So yes with a face to face section with the teacher where they can contact him ask all the

questions and then a more autonomous process so they can reflect on what they have learned and confronted. It may well be taught through videoconference.

This solution would also resolve the problem of people needing to travel to STP to provide training which at times is quite challenging. Rebecca suggested that simulations be prepared and that a list of these and other online activities be prepared for the teachers to use with their students “And maybe using these features might be a way to at least at first overcome this experimental gap that exists.”

Sharon: During the first year of the Project Escola+ the lack of scientific knowledge of the teachers was identified, something which had not been contemplated when the project Escola+ was developed. A training project for chemistry, physics, biology and math teachers was designed. This training was comprised of a pedagogical component, and an underlying scientific component. The funds that had been intended for the training of supervisors and directors were allocated to these teachers training programs. Sharon lectured “Research in Education” to these teachers. The benefits of the program were development of scientific competencies, educational competencies and acquisition of the *licenciatura* degree which would impact their lives a greatly. They were automatically repositioned in their career, had a salary raise, got a diploma, all these in the São Tomé context are very important. This did not only bring benefits to the people, but to the system as well. With these graduates the number of graduates in physics and chemistry in São Tomé increased greatly "in terms of improving the system here is a great improvement on the scientific quality of the educational system" although this is very difficult to measure. The features applied in these programs showed that it is possible to do modern and innovative things in São Tomé "People at first did not believe that it was possible to do this with such elaborate technological resources and with students which lacked digital skills etc. people did not believe this possible" with a lot of effort because of contextual difficulties. Sharon warned that the sustainability needed to be solved "But sustainability is mainly related to organization and work which are still needed in this case." The group consisted of people with different levels of investment, and different skills, and there should be expectations on the teachers who invested more than the others. In smaller schools with less confusion and with resources it would be easier to have people integrate the technology. The *Liceu National* was a heavy structure which most likely crushed people who ventured on doing things differently. Then there was also that pressure, people lectured on three different schedules. These constraints hindered the work of teachers who tried to introduce innovations.

> It is this, further training was one point of the Project Escola+ and it had a first cycle of change of procedures, of acquisitions, and then should have the second consolidation cycle and the second cycle of consolidation is not happening.

This consolidation was not happening because “there are no physics or chemistry teachers in the project at the moment and other people who were close did not follow the training and are in a different cycle.”

Four or five of these teachers were individual success cases of the project and were teaching in a completely different way and Bernard had a big impact on ISP “got his degree, this caused him to enter the ISP, the relationship he has with students in ISP, so if we think that way the impact is very big” and he therefore has the power to impact the system. When asked about the methodologists Sharon explained that these were the people who were responsible for the subjects nationwide, “they should prepare the national exams, prepare the correction matrixes, monitor the teachers, plan with teachers, and some will do a little while others do not.”

There were also the Heads of Departments in each school. When Project Escola+ arrived in STP there were Heads of Department for each subject and each school year, which was a big confusion. The project managed to suppress these so that each subject had a Head of Department per subject, per school. This was a complicated situation “You're here to look at the issues of digital innovation but the others are all far behind are far behind” which makes impact difficult and therefore the importance of consolidation “introducing something is easy, but then consolidate, make it stay, there lies the difficulty of the matter.” Portugal was not sensitive to the importance of consolidation “Consolidation, with small steps, but the consolidation so that things become sustainable.”

Sharon emphasized the motivation of these teachers who participated in this innovative training, she had witnessed their interest and motivation and ended the interview with "despite the constraints it is possible to do innovative things and you can monetize the potential of digital in São Tomé. So these are all positive aspects. The constraints are many, and among them were the functioning of institutions whether in secondary school or in higher education."

Theresa: The experience was remarkable and it was important for the physics and chemistry teachers because they had many gaps in their knowledge. The initial program needed to be totally readjusted because it was too demanding**.** Theresa reshaped the program while in STP where there were no books and weak Internet which was a real challenge "I was many times in the hotel at night researching for materials to be able to find things online to fill the gaps that resulted from the unpredictability of this reality." The distance learning classes did not go well at all because at the time they still did not have good Internet facilities and the calls often fell, and either she could not see the student teachers, or they could not hear her, or see her "the distance learning classes worked very badly because the connection was very bad. In general the call fell, in general I was not heard or could I see, or it was noisy, the communication was very bad." According to Theresa these teachers should have follow up training and in her perspective.

> I guess it should have been a more continued education because the gaps that I identified were indeed many and too deep, and if this is not possible for temporal reasons that at least they had, you know, training programs,

whatever. Things like returning to revisit things, returning the update, because of the difficulties that they have are also related to lack of resources.

Regarding technology Theresa was surprised to see that the student teachers had acquired computers between the time she lectured Didactics I and Didactics II and that they were enthusiastic about the technologies "I noticed that almost everyone had a personal computer, something that had not happened in Didactics I and they were all very enthusiastic about the new technologies that were PowerPoint presentations, interactive videos, laboratory simulations." This was after their introduction into Educational Technologies "I realized the enthusiasm, and change, the big change in attitude towards new technologies that had resulted; I think that the discipline you taught."

On the human side Theresa had an unforgettable experience; the student teachers would stay after the lesson had ended just to have the opportunity to learn more. "They felt the importance of what they were learning, were all extremely emotional, workers, workers were not much because they were too busy during the day. Very receptive, I was received with great affection and it struck me too."

Patrick: Regarding the information technology in the training program for physics teachers, it was very important for the teachers as they had difficulty taking experiments into their classrooms and the knowledge they acquired in the program provided them with the opportunity to do something different with their students "very important for teachers and for the teaching of physics, firstly because physics teachers, especially here in São Tomé have had some, certain difficulties in implementing practice into the teaching of physics." Because of the lack of resources they are limited in the use of the technology but nonetheless it is very useful "this program has brought some added value for teachers taking into account they can use other tools that may be, that are useful for the teaching-learning process, for example, some simulations" making education easier and more enjoyable. When asked about the benefits of the program Patrick pointed out that the benefits were that the teachers had become better prepared to teach " visible because teachers were more prepared for teaching" and one of the challenges had to do with the different perspective which required technology

> This perspective requires the acquisition of some means of simulations for teaching because we have to use new technologies, right? This requires some investment in schools. Have computers available, Internet access, projectors, video, ... these are materials that are indispensable for this process of teaching learning.

Patrick believed that the teachers should train continuously with the use of the technology or else they would forget "They need to continually maintain themselves updated. With constant practice not to lose that bond they already have with these tools that are indispensable." According to Patrick distance learning was an option in the areas that were not covered by the ISP "distance learning can support in the areas that in STP they do not have at the ISP." The training program for physics teachers did not had enough candidates to justify its repetition at the ISP, only two groups of teachers were receiving training. These were the History and Geography teachers and they did not have the technology integration component within the program. Before including other groups in the program Patrick wanted an intervention with the physics and chemistry teachers who did participate in the program so that they would all start using technology properly because he did not believe they were all doing this “from my perspective not all are properly using these resources. This is the first phase, then it would pass to the second stage would be to generalize this for teachers of other areas, it seems to me very important.” Patrick also believed that the heads of department and the subject methodologist should monitor these teachers.

Quinn: As a lecturer at the technology department at ISP and also a member of the National Regulator for Comunications, had not had any contact with the teachers in the program, she did also not have any knowledge of the content of the training that had been provided in terms of technology for the integration of technology in the science classroom. She spoke in general about the use of technology in STP and how was being introduced. When asked about distance education Quinn responded that she had participated as a trainee in distance education programs and that many people in STP were starting to pursue their studies online, even the masters degree. About the procedures for continuation and expansion of the project Quinn said that there were two major steps, the first had to do with preparing a list of what existed and the rehabilitation of the equipment that needed to be repaired, and secondly the preparation of a list of what these teachers needed so that they could get these materials for the schools providing the teachers opportunity to work properly "make a survey of what is necessary to be substituted or to acquire for the best functioning of these classes." ISP is providing small training sessions during the holidays for teachers and students at the ISP in the area of technology. Quinn spoke of the Internet and the difficulty that there was in getting Internet for home because it was expensive so people need to access it at the workplace, for example the ISP or the schools they worked at "Only at work, for work or services all have good Internet so you can actually do at school, distance training as you want." Quinn asked which tools the teachers had learned to use and was impressed with them. She said that people in STP when they became motivated they moved forward and that sometimes when they did not it was mostly due to the fact that they did not have the resources. Quinn also spoke of the tablets that the World Bank was thinking of offering the students in STP

> It is a project that the World Bank wants to implement and has to do what is the best way for the two to come out winning, the teachers and students because if they give to the students and teachers do not have, and do not know how to work it, I think they will not use it in the class.

Bernard: Also lectures at ISP, and has subjects such as Mechanics and Vibrations. The traditional form of teaching using a blackboard has been substituted by the computer. "We use Modellus, for example to make modulations, so I try to take the greatest amount of technology to the classroom", teaching in a more interactive manner.

Appendix R: Minister of Education's Reflective Summaries

Information technology was important in education both in the school management, organizational management, and integration of technology as a pedagogical element to facilitate teaching. The Former Minister of Education remembered the training program and recalled some tools and the edu2.0 portal that was used in the program as well as the satisfaction felt by everyone involved in the program. Information technology was the key element incorporated into the Educational Forum and was part of the strategy developed for education from 2012 to 2022. When in office he tried to develop the technological plan which did not happen, currently under the scope of the optical fiber project a team was working on the acquisition of 15 to 20 000 tablets for students which he felt needed to be complemented with teachers training for the effective use of this technology.

Therefore they need to rethink the issue relating to the financing and allocation of some projects because if there is not a policy where people realize the importance of these elements in education, the resources, even if they are there they are ineffective. Students could take the best advantages of technology using tools which could assist them and let them understand certain concepts as most did not have laboratories "the student can have access to some experiments, thus virtually experimenting to know what happens."

According to Yves the state could create incentives with companies which import computers so that they could sell them cheaper, which could make it easier for people to buy computers. While in office he tried to have the teachers training center (EFOP-Escola de Formação dos Professores e Educadores) work on a program to provide distance training for teachers who lived in Kauê, Lembá and Príncipe but this did not happen "We did not have the opportunity to conclude." He spoke of situations in which technology had regressed in the past couple of years "in the past the Ministry had a site, today it longer has a website." In 2012 a project launched by Yves was responsible for the creation of computer laboratories in secondary schools and the equipment arrived last year at the schools but these have not been used to their maximum educational potential

The equipment was set up but they did not prepare the people, we also had this project in our dimension, that is, we would also train people so that they could train others to use such equipment and teachers would learn how to use various tools that exist today within education so that they could improve, their are even specialized sites in their subject are, mathematics, physics, so there are social networking groups and that, so that can help students and teachers improve their performance.

Yves believed that in a short period of time STP could start using technology in schools at the level of any developed country "this can be done in a short period of time, in a short time span. There just needs to be a leadership that believes this, that prepares staff for this, and we have already created the foundation for this to happen." There are interested partners which get unmotivated when they see the lethargy in that area **"**Brazil itself has funded some projects in this area but I think they have not moved forward. Taiwan also etc. so this is tricky." Yves, since having left office, has dedicated himself to serve as an example of good practices in the area of technology in education

We apply it, we also created a multimedia company, to make people see what is possible. If a small group of people, we are only three people here, and we do it, so imagine if the state wants to put together a team and decide to move forward it is possible to do. It is possible.

According to Yves, distance education could be an essential tool in STP.

In a country like ours where there are few resources, distance learning would be a tool. Then we have difficulties to create physical libraries, so in high school with digital library, today there are thousands of books available to students starting to use virtual libraries in schools and there are databases available.

Yves is currently pursuing his PhD in the context of innovation policy and his younger brother pursuing his masters, both online. With the broadband Internet that is already in STP many teachers are pursuing their undergraduate and graduate degrees online. “But individual people are writing themselves into online programs to pursue *licenciatura* and master's degree.”

Appendix S: Letter of Consent to Conduct Research From Minister of Education STP

REPÚBLICA DEMOCRÁTICA DE S. TOMÉ E PRÍNCIPE
(Unidade – Disciplina - Trabalho)
MINISTÉRIO DA EDUCAÇÃO, CULTURA E FORMAÇÃO
Gabinete do Ministro

N/Refª S.Tomé,

Excelentíssima Senhora
Dra. Maria Dolores Rodrigues Jardim

Lisboa – Portugal

ASSUNTO: Carta de Autorização do Ministério da Educação, Cultura e Formação.

Em sequência da análise da sua proposta de pesquisa, e correspondendo ao seu pedido, somos a permitir a realização do estudo, designado por "Estudo de Caso de Integração de Tecnologia Educativa nas aulas de Ciências num País da Primeira Vaga" nas escolas secundárias de São Tomé e Príncipe.

Fazendo parte desse estudo, autoriza-se que entre em contato com diretores de escolas públicas, professores e representantes do ISP – Instituto Superior Politécnico. A participação das pessoas será voluntária e feita à sua própria responsabilidade.

Fica entendido que as responsabilidades do Ministério são as de proporcionar o acesso aos participantes para a pesquisa. Reservamo-nos o direito de nos retirar do estudo alterando a nossa posição de cooperação a qualquer momento, se as circunstâncias se alterarem.

Confirmamos a autorização de aprovação a pesquisas com essa configuração.

Fica ainda entendido que os dados recolhidos permanecerão inteiramente confidenciais e não poderão ser fornecidos a ninguém fora da equipa de pesquisa, sem a permissão da Instituição a quem serão apresentados, a Walden University IRB .

Atenciosamente,

Appendix T: Comparing Results

The data from the different sources: teachers (interviews and confidential narratives); stakeholders (IMVF, ESECS-IPL, ISP) and School Principals and Head's of physics and chemistry departments.

	Experiences/Perceptions	Benefits	Challenges	Further Education	Recomendations
#T	Specific tools Games and simulations Summarized content Student motivation Promoted Research Implementation Opened a new world No difficulty in use Improved computer skills Improved teacher skills Use for Physics/Chemistry Connect practice to theory Obtained higher degree Value attributed by others	Facilitated Teaching Facilitated student understanding Substit. laboratories Reduced time to explain	New Curriculum Insecurity with technology use Internet connectivity	Pursuing Masters Degree	Expand program Teacher investment Tutorials Science Center Distance learning Responsibility on Department heads and Methodologists
S#	Teachers acquired laptops Teachers used technology Teachers researched on the Internet Changed way of teaching Presented work written on the computer Researched on the Internet Students used Internet Show simulations on Laptop Student motivation Teacher satisfaction Did not implement Practiced simulations Modern Innovative things can happen in STP Distance education was very positive Limited to simulations People did not believe it was possible Success cases	Developed scientific competencies Developed educational competencies Provided tools for lessons Distance learning contribute educational improvement Facilitated Teaching Facilitated student understanding Minimized lack of laboratories Reduced time to explain Teachers repositioned after training program Contributed for digital inclusion Broadband Internet Change in attitude Summarize Change agents Resource Center	Lack of resources to implement technology Synchronous sessions Web conference tool Insecurity technology Many constraints Alda Espírito Santo school lessons like methodologist said No access projectors No consolidation No computers No access to computer labs Classes are theoretical	Pursuing short courses Pursuing Master's Degree Pursuing PhD	Science Center Distance learning Responsibility on Department heads and Methodologists Tutorials Expand program Teachers need more training Consolidation Leaders must know Organization into small groups Internet for all
	Experiences/Perceptions	Benefits	Challenges	Further Education	Recomendations
ME	Educational management School Management Technology integration Pedagogical context Technology is a key Technological Plan 2012-2022 Fiber Optic Project 1500-20000 tablets Teachers training in technology	Virtual libraries Virtual laboratories Internat. partnerships Access to information Educat. Improvement Distance Learning Distance training for teachers in remote areas	Leadership problem Bad use of resources Do not use partners	Pursuing PhD Many pursuing bachelors and master's degree online	Use created foundation to implement Technological Plan Prepare teachers and leaders