Master's Thesis

ICT 활용의 교육학적 접근:

교육방법과 교육정책을 중심으로

The Pedagogical Functions of ICT for Education and the Connection to Policy and Implementation

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Abstract

Thanks to the realization of Moore's Law - computing power will double every two years while the cost decrease proportionately - the price of the ICT infrastructure is less expensive than ever and expected to continue to decline. The effect of this has upended OECD countries' economics, politics, and social interactions. In the backrooms of every stock exchange, massive computers are managing (or mismanaging) the market in ways humans cannot fully understand. Now the rest of the world has joined the revolution. Political leaders of every sort are promoting ICT for education. However, their promises are grand while the details are vague. The role ICT should play in the classroom is often ill-defined, the hoped for outcomes are usually over-defined. Politicians, project managers, and teachers often talk about an extremely wide range of goals and outcomes that ICT will bring without trying to connect the expensive digital device to direct educational or social outcomes.

My research found three common pedagogical uses for ICT4E: teacher, tool, and subject. In the "ICT as a Teacher" pedagogy, the digital devices teach and grow with the students. When ICT is a tool, teachers use technology in order to better teach their lessons. Finally, the "ICT as a subject" treats ICT as subject, like math or English. Furthermore, there are four common rationale for ICT4E:

• an economic rationale: the development of ICT skills is necessary to meet the need for a skilled work force, as learning is related to future jobs and careers;

• a social rationale: this builds on the belief that all pupils should know about and be familiar with computers in order to become responsible and well-informed

citizens;

• an educational rationale: ICT is seen as a supportive tool to improve teaching and learning;

• a catalytic rationale: ICT is expected to accelerate educational innovations.

The pedagogical uses for ICT are never considered when planners are creating new project, partially from a lack of a theoretical framework to work with. Thus, in order build a framework for connecting the pedagogical applications of Information and Communications Technology in education to the expected goals, this paper will try to answer the following questions:

1. Does each function correspond with a certain outcome?

2. What are the project design and policy implications when attempting to solve each of these pedagogical problems?

Rodriguez, Nussbaum, and Dombrovskaia have created a comprehensive framework for evaluating an ICT4E project. By examining each of the pedagogical uses of ICT with this framework, the different policy implications required by each use becomes clear. To illustrate these issues, three different ICT4E organizations – One Laptop Per Child, Intel Teach, and Plan: Ghana Transition and Persistence were be compared. They showed that different pedagogical emphasizes matched with different outcomes.

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Abbreviations

ICT	Information Communication Technology
ICT4E	Information Communication Technology for Education
OECD	Organization for Economic Co-operation and Development
OLPC	One Laptop Per Child

Chapter 1

1.1 Background

Thanks to the realization of Moore's Law - computing power will double every two years while the cost decrease proportionately - the price of the ICT infrastructure is less expensive than ever and expected to continue to decline (Mack, 2011). As a result, computers are already everywhere in rich nations: in pockets, in cars, and even in bodies. The effect of this has upended OECD countries' economics, politics, and social interactions. In the backrooms of every stock exchange, massive computers are managing (or mismanaging) the market in ways humans cannot fully understand (Patterson, 2010). Computer databases have revolutionized the elections of the American president by allowing political parties to have unprecedented amounts of information on individual voters' beliefs, habits, and movements (Madrigal, 2012). Online, proper internet etiquette is still not settled and online faux pas can ruin a career. The ICT revolution entered rich nations' schools in the 1980s. What once seemed like the future became the present. Some people expected computers to transform teaching and learning the way it has Wall Street.

And now the world is welcoming the future with open arms. Political leaders of every sort are promoting ICT for education. In Malawi, the deputy principal secretary in the Ministry of Information was happy to see his nation's schools and health institutions become increasingly connected to the internet (Tikondane, 2003). Colombian President, Juan Manuel Santos, may be one of leaders most excited to bring ICT to his countries students. After seeing students receive laptops, he proclaimed, "in only a couple of weeks students have advance as never before and now their parents have become their students" (elpais.com.co). In Thailand, the three different candidates for governor of the Bangkok province all agreed on the importance of increasing ICT in education (Khaopa, 2013). The actions of politicians are an imperfect measure of how a society truly feels, but few office-seekers are willing to brag about unloved policies or be photographed in unpopular settings. Clearly, in most places, ICT is a winning topic.

The development community is as keen as politicians to promote ICT in education. One Laptop Per Child, by distributing over 850,000 of the XO laptops to the children of Peru, became one of the major players in the effort to bring ICT to the world's classroom. And on the island of Fiji, the government has just started to roll out a program in which select schools receive laptops after creating a specialized computer lab. Again, the laptops came from OLPC. (Amato-Pace). The World Bank just completed a project that brought 4,000 laptops (bought from OLPC) to the students of Mongolia for $680,000 US dollars (World Bank, 2002). In Ghana, the development groups Plan and USAID, spent $32,000 to build an information and communication technology center for a junior high school last July (Business Ghana, 2013b). These are just a few of the development organizations who are involved in ICT4E. Ten years ago the novelist William Gibson said, "The future is already here. It's just not very evenly distributed" (Kennedy, 2012). However, in 2013, price, push, and pull factors have aligned and the move to distribute the future to schools of the world has commenced.

While it is impossible to know how much money is spent on enabling students to use computers during the school day, the world did spend $138 billion on official development aid in 2012 (OECD, 2013). So, it is safe to say that there are at least millions of dollars going towards ICT projects. As soon as extremely large sums of money start flowing, and when many actors over all over the world use or disperse this money, judging efficiency and effectiveness becomes one of the most vital issues. More so than in the business world, where inefficiency is punished by bankruptcy, the aid world can spend enormous sums of money without seeing results. But if a large project fails in a sector like the tech industry, there are few negative side effects beyond the top decision makers' careers. Poorly designed aid projects can increase official corruption while decreasing the opportunities of the people the project was supposed to help.

These three factors - cheaper hardware, pull from national politicians, and push from international organizations - make ICT4E projects almost inevitable. Not only that, they also increase the likelihood of a quick implementation. For example, during the Kenyan presidential election season, soon-to-be-elected president Uhuru Kenyatta promised laptops to all 1.2 million of the nation's children. Making good on his promise, Kenyatta, who took office in April of 2013, plans for the new ICT program begin in early 2014. It will cost over $600,000,000 US dollars (Rawlings, 2013). Clearly, the need for a well-formed theoretical and practical framework is necessary if this ICT4E blitz is to have a large impact.

1.2 Literature review

Keeping in mind the speed, size, and popularity of ICT4E projects, there are several criticisms to the implementation of projects. Brunello (2010), taking a global view of the system, sees the failure of projects as stemming from the structure of the foreign aid “machinery”. First, project management choices reflect the fact that the bureaucracy is designed for developed countries. Thus, the workers actually trying to implement the project find themselves slowed down or searching for unauthorized workarounds to obstacles. Secondly, there are transaction costs. From the donor’s point of view, the bigger the shipment of technology, the better. Shipping hardware is the end of a lengthy, tiresome process. Before schools see any devices, the necessary steps proceed from “identifying local technological needs, to carefully listing hardware technical specifications, to the launching of the international tender, the analysis of the providers’ offers, the choice of the winner, the refinement and signature of the contract, the shipping, the transport in containers, the customs, the delivery and the inventory on site.” Thus, a donor has a strong incentive to avoid the administrative work and red tape by giving large amounts of technology at one time. The third problem Brunello sees is a philosophical one. Donors have a mechanistic mindset that favors “things over process” (Brunello, 2010). Instead, in order to successfully assess, the beneficial use of ICT, we need to measure the number of devices in pupil’s hands.

Heeks (2002) further explores the tension between “things” vs. “processes” by targeting the discrepancy between the project design and what the local users actually want or need. Because the ICT is formed in the context of highly developed countries, there are many underlying assumptions embedded in their design. These assumptions create a disconnect between the designers and the end user in least-developed countries. The disparities in cultural and economic backgrounds can manifest itself in how the designers and end user perceive “information (data stores, data flows, etc.); technology (both hardware and software); processes (the activities of users and others); objectives and values (the key dimension, through which factors such as culture and politics are manifest); staffing and skills (both the quantitative and qualitative aspects of competencies); management systems and structures; and other resources (particularly time and money)." According to Heeks, this "design-actuality gap" leads to the partial or total failure of ICT projects. Full failure occurs when a project dies before it is implemented. Partial failure results when major goals are unfulfilled or unexpected negative outcomes exist. The Asia Development Bank, in a major study of ICT4E in Central and West Asia, found many other partial failures in the form of doubtful cost-efficiency, forgotten teacher training, and inadequate long-term financial planning.

Zooming in even closer, Unwin (2009) spotlights the role of the end users themselves. Namely, they must see the ICT as relevant to real life issues. If the technology is more not appropriate outside an OECD context, any ICT initiative will likely be unsuccessful. Furthermore, the proper technology varies from situation to situation depending on economic, social, political and cultural factors. Thus, for ICT to bring beneficial outcomes in the classroom, it must solve a problem other than the problem of a lack of ICT. Unwin highlights the importance that the recipients play in a project's success or failure. In an ICT4E project, this means that a new computer, printer, or other digital device must be connected to a pedagogical function inside of a school. However, the pedagogical *raison d'être* of ICT in the classroom is often left undefined in journal articles, official announcements from governments, and education sector policy plans. Even though much research has been done on the best practices of ICT in classrooms, the pedagogical goal is often left unstated or there exist contradictory or competing goals (Kozma, 2005). Hence, projects are designed without clear goals for ICT usage. Very often "the specific goals for ICT use in education are, in practice, are often only very broadly or rather loosely defined" (Trucano, 2005). From the very beginning of projects, the precise reasons for implementing ICT based reform are overlooked. The Asian Development Bank in their West and Central Asia study found that computer per student target ratios did not "not result from a clear vision of the learning or pedagogic benefits or possibilities of ICT provision to schools." Furthermore, the policy papers from each country did not try to provide the pedagogical reasoning behind incorporating ICT into the classroom. No reasons were given for the computer-student ratio goals, nor how the ratio was connected to educational outcomes. The ADB recommended an increase in "methodological certainty - and clarity in national curricula and syllabus documents - on how best to use ICT in schools" (ADB).

The problem of ambiguous ambitions is not limited to Central Asia. Rwanda, a leader in the developing world for integrating ICT, showed the same lack of expected outcomes in their Education Sector Plan for 2010-2015. Even more surprising, this plan was released only one year after the nation spent over $18 million US dollars to supply 100,000 students with laptops (Beaumont). The plan mentions the "provision of . . . pedagogical support in schools" and the need for "a more learner-centred pedagogical approach", but does not elaborate how ICT is to be a part of this new pedagogy. Furthermore, the government plans to "integrate the use of ICT into education practices through training of teaching staff on integrations of ICT into the teaching practice, development of ICT standards and competencies and provision of technical and pedagogical support in schools." What the final pedagogical approach should be is not defined (Rwanda, 2010).

While the role ICT should play in the classroom is often ill-defined, the hoped for outcomes are usually over-defined. In fact politicians, project managers, and teachers often talk about an extremely wide range of goals and outcomes that ICT will bring. Hawkridge, as quoted by Tondeur et al., sums up the four common rationale for ICT4E:

> • an economic rationale: the development of ICT skills is necessary to meet the need for a skilled work force, as learning is related to future jobs and careers;
>
> • a social rationale: this builds on the belief that all pupils should know about and be familiar with computers in order to become responsible and well-informed citizens;
>
> • an educational rationale: ICT is seen as a supportive tool to improve teaching and learning;
>
> • a catalytic rationale: ICT is expected to accelerate educational innovations. (Tondeur, et al.)

These reasons are backed up and expanded on by Kozma (2008). The economic rationale is promoted by economists who view ICT as vital to creating future workers. ICT can also increase productivity, leading to faster, greener growth. The social rationale is especially potent in nations with ethnic or group divisions. The hope is that ICT will allow citizens to "share knowledge, foster cultural creativity, increase democratic participation, make government services more widely available, and enhance social cohesion and the integration of different cultural groups and individuals with different abilities". Furthermore, ICT can have a social impact in terms of access to education by bringing learning to the poor, the geographically remote, and those with specialized educational needs. Surprisingly, Kozma does not touch on the educational rationale, even though it is the most obvious and straightforward rationale for ICT4E projects. Instead of mentioning how it could improve teaching and learning, Kozma does focus on the possible consequences for education management. The goal in this case is to improve efficiency, accountability, and management practices. Finally, ICT is justified by the educational reform (catalytic rationale) that it could bring. Sometimes, the technology is supposed to foster "21st century skills" (creativity, communications, critical thinking, etc.) or create a "learner-centred" classroom environment.

While a barrel of ink has been spilled on the function of ICT in the classroom and another barrel on the goals and outcomes, there is little research done on the connection between the two. Projects are designed as if all outcomes are equally likely and, as a result, little attention is paid to the connection between the actually use of ICT in classrooms and the outcomes. This paper will argue that ignoring this connection can have a large effect on the success of an ICT4E project while showing how certain pedagogies are likely to lead to certain outcomes.

1.3 Research Questions

Building on the work of the aforementioned scholars who showed there is a need for a clear framework for connecting the pedagogical applications of Information and Communications Technology in education to the expected goals, this paper will try to answer the following questions:

1. Does each function correspond with a certain outcome?

2. What are the project design and policy implications when attempting to solve each of these pedagogical problems?

By answering these questions, countries, aid organizations, and project designers will have a proper pedagogical framework to guide organizations and countries will help ensure that expensive ICT projects are well implemented. Another reason this research is important is that there is no clear positive connection between ICT usage and student achievement (Trucano 2005). In other words, improved test scores do not always or even ever flow from increased ICT access or usage. The mere usage of ICT is not a justification in and of itself. Rather, how ICT is used in schools and in classrooms (the pedagogical use) is important. Clarifying the connection between the pedagogical uses and project outcomes will be an important addition to the literature. Furthermore, the thesis will show that each pedagogical function has a large impact on how a project should be designed.

1.4 Methodology

This thesis will focus on large-scale projects for implementing ICT in the classroom from the point of view of the policy maker. K-12 education will be the targeted level of education. Chapter two of this thesis uses a literature review to discover what the common pedagogical functions of the ICT in education. Chapter three will explain Rodriguez, Nussbaum, and Dombrovskaia's conceptual framework and explain its use for the adoption of technologically-enhanced learning environments in schools to show how each pedagogical function requires different inputs and leads to different outcomes. To show that each pedagogy is requires some trade-offs and lead to different outcomes, three different ICT4E organizations will be compared.

1.5 Scope of the Thesis

This thesis will maintain a focus on the pedagogical uses for the K-12 classroom. Unfortunately, this means that the use of new technology at the tertiary level will be ignored. In most countries the university system largely faces a different set of challenges from primary and secondary schools. So even though there are important ICT4E issues, like distance learning and massive online open courses, being addressed by higher learning institutions, this thesis will maintain a focus on elementary and secondary education. Furthermore, several other issues are critical to successful outcomes of ICT4E projects but are not directly connected to the theoretical use of devices in the classroom. These issues include how the schools system is connected to and can use the private sector to implement ICT projects and the use of ICT for administrative functions. Other issues vary widely from country to country and should be taken into account by the local designers of each project. This includes problems with connectivity, infrastructure, and the political and social issues that surround ICT4E projects.

Chapter 2

2.1 What are the pedagogical functions of ICT in the classroom?

Through a review of the literature, three common pedagogical applications of ICT in education are revealed. Each one has a series of justification that in turn affect how ICT4E projects should be implemented. By choosing one pedagogy, a country can determine where resources will flow to and which institutional changes should be made. Moreover, by dividing and examining the different applications of ICT4E projects' expected results and educational outcomes become clearer. The three pedagogical applications are:

1. ICT itself is capable teaching students.
2. ICT is a tool to learn other subjects - an enhancer in the classroom.
3. ICT is a subject in its own right, like reading or arithmetic.

Taylor was one of the first academics to create a framework for the pedagogical functions of ICT in his 1980 book *The Computer in the School: Tutor, Tool, Tutee.* He lays out how computers can act as teacher. It presents material to a student, waits for a response, and then reacts accordingly. In the age of the internet, coursework has become more available online, allowing students the ability to teach themselves provided they have the knowledge and the language skills (Tucker & Courts, 2010). Other researchers have focused on the ways different ways computer programs interact with students (Adams, 2004; Mayes & Fowlers 2009). For example, some programs just present information, while others allow student interaction or the ability to examine the finished work created by fellow learners.

Researchers are not the only ones who see ICT as a teacher. After a Fijian primary school received 40 new laptops, the head teacher proclaimed "This is something new to them. They've started doing the activities on the laptop, which is like a new teacher to them" (Naidu, 2013). The direct of ICT for the Sri Lankan ministry of education had a similar response when talking about a pilot project to provide all the children of a selected school with laptops: “these laptops will be like their teacher and playmate at home, during the weekends and holidays as well” (Hettiarachchi, 2009).

Finally, going far beyond Taylor’s original framework, robot scientists are in the process of creating mechanical teachers. This project fuses responsive software into a self-moving, reacting machine body. The interplay between the hardware of the robot and the software running it will all create a new way to educate children. Of course, this technology is still a long way away from the classroom (National Science Foundation, 2012).

Taylor also described the way ICT could be classroom tools. When the book was written, he viewed computers as super-calculators - things that replicated what humans did but faster, without mistakes, and without tiring. ICT could perform a musical composition written by a student or help do the busy work of map-making. Researchers’ views have shifted in the past 30 years from helping students by being better than humans to helping learners by doing things no human could do. For example, Rusby noted that students could learn by creating simulations or models of their science coursework (Adams, 2004). Many others have placed the emphasis on ICT as a tool for the teachers more so than a tool for students (Brunello, 2010; Culp, Honey, Mandinach, 2010; Trucano, 2005; Cabrol & Severin, 2010). The leading international organization promoting this pedagogy is Intel Teach, the not-for-profit sister of Intel. Their goal is to "[help] K–12 teachers of all subjects learn to engage students with digital learning, including digital content, Web 2.0, social networking, and online tools and resources" (Intel Teach).

The last pedagogical method, ICT as a subject, was heavily promoted by Arthur Luehrmann in the early days of ICT. He believed that "[computing] constitutes a new and fundamental intellectual resource." In other words, students must become as literate in using computer as they are at reading. This includes being able to "get information . . . solve problems by using algorithms . . . acquire a laboratory data and analyze it" and much more. The call for technological literacy became more and more common. Soon calls for increased technological literacy were common (Culp, *et al,* 2003). Furthermore, even in countries that want to use ICT as a tool, students are mostly using computers to learn about computers (Tondeur, Van Braak, & Valcke, 2007). Additionally, Brunello believes "ICT as a subject" to be the main pedagogical use in most ICT4E projects in developing countries.

2.2 **Framework for Evaluation**

Rodriguez, Nussbaum, and Dombrovskaia have created a comprehensive framework for evaluating an ICT4E project. By examining each of the pedagogical uses of ICT with this framework, the different policy implications required by each use becomes clear. Theirs is the most comprehensive framework for creating a sustainable ICT4E project. The next chapter uses the framework to explore each of the pedagogies. The framework has four parts: implementation, intervention, transference and total cost. This thesis will only examine the “implementation” components, which are described below.

How they learn: How are teaching or learning processes modified? How are the relationships between teachers and students, students and students, students and parents, etc. affected? Do students learn individually or in groups? How are ICT resources incorporated into existing resources?

Implementation resources: What are the necessary material (hardware, software, curriculum resources, etc.) necessary?

Implementation cost: What is the total cost to the school? This includes buying the equipment and resources and paying for the cost of administration and any extra hours of teachers.

Participants: Who participates within (e.g. teachers, classmates) or outside (e.g. parents and administration) the school, their roles, and the skills and practices which they need to develop.

Specific didactic context(s): Where is ICT being used (e.g. classroom, computer laboratory or home)? With whom (e.g., classmates, parents, online tutors) are they are used?

Implementation outcomes: How are the expected results expressed? For example, are they expressed as “learning results (e.g., scores in standardized tests, learning of specific curricular contents, acquisition of 21th century skills), personalized learning environments, or data collection for monitoring students’ progress?” How will the impact be evaluated?

1.5 Chapter Outline

Chapter 1

This chapter provides a background and literature review on the topic of ICT4E, the research question, research methodology, related issues that fall outside the confines of this thesis, and the outline.

Chapter 2

Chapter 2 explores what the different pedagogies of ICT4E are and explains the framework for investigate the policy implications is.

Chapter 3

Chapter 3 looks at the policy and project design implication of each pedagogy.

Chapter 4

The penultimate chapter explores why an ICT4E project cannot implement all three pedagogies at the same time. It is followed by case studies of three different ICT4E organizations.

Chapter 5

Chapter 5 is the conclusion.

Chapter 3

3.1 ICT as a Teacher

3.1.1 How they learn:

Children and the interactivity of computers are the magic combination. Although each new important technology of the last 100 years was expected to usher in a revolution in education (one proponent claimed television was the "biggest classroom the world has ever seen."), none did. (Wartella & Jennings, 2000) All of the previous technology lacked the interactivity and the personalization possible with a computer. The learning process, on the surface, is simple. The student starts the application they want to use. The computer will then introduce some new learning material. The student responds. This is where computers are unique among other technologies; the computer can appraise the response and adjust the lesson plan accordingly. Information will be repeated for slow students or bright students will get harder coursework. The computer will maintain a record of the students' strengths, weaknesses, and interests. These records will be used for future lessons. Furthermore, according to Taylor, a strong software program would have "an extensive and flexible way to test and then lead the student through the material. With appropriately well-designed software, the computer tutor can easily and swiftly tailor its presentation to accommodate a wide range of student differences*."* (Taylor, 1980)

Within the tailored and adaptable framework, computers can teach students using different methods. Taking their cue from the novel *The Diamond Age*, One Laptop Per

Child's programmers have designed teaching software named "Nell", after a character in the book who is given an interactive "Young Lady's Illustrated Primer." According to its designers, the real life software, attempting to mimic its fictional counterpart, "is a **Narrative** interface using **Direct Interaction** which **Grows** with, and is **Personalized** for the child" [emphasis in the original] (Ananian, Ball, & Stone). Students using their software will learn about music, math, English, and so on by reading stories and solving problems. In their example, a young girl will play as a princess who has to open a dungeon's door by creating a musical tune. The computer can also change the narrative based on the learner's interest. If princesses are uninteresting, perhaps space or dinosaurs will spark their curiosity. Even more creatively, the group has programmed lessons where students will learn fractions through rhythms for the more musical minded children.

Instead of using narratives, another method is learning through "gamification". In other words, software can turn learning into games. Memorizing vocabulary words will give the student points, as will doing one's history and math lessons. Sometimes known as "games with a purpose" or "serious gaming", (Deterding, et al*.,* 2011) the purpose of this software is to increase engagement, interest, and the general enjoyment of learning. The hope is that children will learn more because of the higher levels of usage of educational tools. Other proponents see gamified and interactive narrative software as representing a huge leap in pedagogy. One reason is that the software is supposedly based on what we have learned through "brain science". Nolan Bushnell, founder of the game company Atari, Inc. and game software company Brainrush, believes "One of the key factors here is the adoption of brain science [software]. Getting it involved in the curriculum is massively effective. Not by 20%, not by 50%, but by many multiples of educational efficacy.” (Tack, 2013) He believes that the Western high school curriculum could be cut from four years to six months. (Palmer, 2013) A second reason is that the software will advance at the student’s pace. A human being must teach all of his or her pupils at only one speed. So, advocates argue, smart students will be bored, while less bright children will fall farther and farther behind.

3.1.2 Implementation Resources

The “ICT as teacher” pedagogy implies “one-to-one” learning, which means one device for one student. This ensures that the each child is moving at their own pace. Software is the next key resource. For students to learn, well-designed software is necessary. Overly easy or difficult programs will lose turn-off the student. Furthermore, locally relevant software is important in order to sidestep Heek’s “design-implementation gap”. Kids in Southeast Asia might have no clue or no interest in learning how to read from a dragon, a unicorn, or some other European fantasy creature.

3.1.3 Implementation Cost

The costs of ICT projects can be divided into the fixed and recurrent costs. The fixed costs are the hardware, software, networking, and replacing old or broken devices. The cost in a one device to one student model begins with the number of students times the cost of the device. The number of students, clearly, depends on the country. The laptops designed by One Laptop Per Child costs just over $200 dollars (Rawsthorn, 2013). Some school systems have gone with more expensive device. The Los Angeles school district recently committed to purchasing all 640,000 of their students iPads at the price of $770 per device (Blume, 2013). For a country like Ghana, the government would need to spend at least one billion US dollars to secure the OLPC laptops, which would be over 2% of the country's yearly GDP (Buchele & Owusu-Aning, 2007*).* The second cost will be to design or buy the learning software for the computers. Extra cost may occur if the software needs to be updated or changed. Finally, depending on the country's connectivity levels, there is the cost to increase the internet infrastructure. In Rwanda's case, the government gave each of their students an OLPC device. On top of that, the government plans to spend an additional $140 million US dollars on upgrading internet connectivity over the next three years. (Kagire, 2013) The project was not designed to supplement the educational initiative alone, clearly, but it shows how related a nation's ICT infrastructure is to possible ICT4E projects. The final cost will be replacing the device. Large scale ICT4E projects, like the ones in Uruguay and Rwanda, are still too new to gage the long-term cost of replacing devices. However, the experience of most of the world with technology has shown that electronics last around three to five years.

Another major cost might be designing locally relevant software. If a government or project leaders wants the maximum amount of learning, software that is calibrated to local conditions is necessary. As mentioned above, learning fractions from a princess in a castle may be appropriate for a European context, it may not be appropriate for places in the world with no history of princesses or castles. Therefore, extra time and resources will need to be diverted into creating or obtaining this software. The focus on specialized software is one of the main ways that "ICT as a Teacher" differs from the pedagogical functions, both in design and costs.

Recurrent costs include professional development, paying for internet, and maintenance. In the ICT as teacher pedagogy, professional development will be a minor cost, since the children learn through the devices. Internet costs vary by country. Maintenance cost will require the government, schools, or funding organization to train or hire people to service broken devices. One study in the US state of New Jersey found that the school system spent 40 to 60 percent of the cost of the computer on its maintenance over the device's lifetime (Consortium from School Networking, 2002). Whether this number will apply to ICT4E projects in developing country remains to be seen. Another factor to take into the account is that ICT projects often overrun projections. According to Trucano, "Total cost of ownership" is often underestimated, sometimes grossly, when calculating costs of ICT in education initiatives. Estimates of initial costs to overall costs vary widely; typically they lie between 10-25% of total cost."

3.1.4 Participants

Other than students, educational software designers are key to this pedagogical approach. Their role is to create appropriate and informative programs to engage the children. For each hour of university level content, 200 hours are estimated to be necessary for the development time (Macleod, 2000). The time will increase further depending on the level of interactivity and animation desired. Of course, inexperienced companies may need to put in a far larger amount of work (Adams, 2004). This is especially important for countries that are just starting to implement ICT for education reforms where content tailored for their context is unavailable. Within the team of designers, educators as well as programmers are necessary in order to ensure that the programs will meet the educational requirements. Furthermore, the user interface is very important. The UI is where the learner and the software interact and without intuitive and easy to use navigation users will turn away. (Nielsen, 2000) A poorly done UI decreases the amount of learning.

Another participant is the dealer of the hardware. Countries considering the purchase thousands of devices will need to consider carefully which vendor they want to purchase from. The hardware manufacturer will need to build devices that can survive in the hands of children anywhere in the world.

Teachers play a limited role, because the main argument for this pedagogy is that computers will give better results with or without adult supervision. As Negroponte puts it "When people tell me 'Who's going to teach the teacher to teach the kids?' I say 'What planet do you come from?'" He argues kids are so naturally adept at new technologies that teacher training is not necessary. The miracle of higher efficiency through ICT is made possible by more intelligent software.

3.1.5 Specific didactic context(s):

The "ICT as teacher" pedagogy allows for the possibility of around the clock learning. As long as learners have a powered-up computer, they can learn at home, at school, or on the street. Who the students learn with is determined by the software. OLPC's Nell program is meant for a single user, but with a different design, multi-user educational programs are possible.

3.1.6 Implementation outcomes

According to Brunello (2009) success will be measured by the number of children with computers. Project outcomes, too, will be measured in percentage of students with access to a device. With access being the key component, measurement will be relatively straightforward. A second measurement can be divided into terms of "things" and into terms of "processes". The 'ICT as a Teacher' pedagogy falls heavily on the side of "things". One Laptop Per Child promotes the notion that "Children need to learn learning, which is primarily acquired through the passion that comes from access, the ability to make things, to communicate and to express." (OLPC: Learning learning) How much a child has learned about learning is much more difficult to measure. An appropriate outcome measurement will be how many hours of educational software were created for this country's specific context.

Considering Hawkridge's four rationales, "ICT as a teacher" is most connected to the social and educational. The positive social outcomes might include bring learning to remote populations or groups of citizens traditionally denied or excluded from education. Chile, for example, heavily promoted ICT in schools in an attempt to address inequalities after 17 years of the Pinochet regime (Cox, 2006). Or, as in the case of Ethiopia, it may be the only access a child has to an education. The "ICT as a teacher" method other hoped-for outcome is educational improvement. Though, there is still not any consensus of its effectiveness, despite what Bushnell and other say. As time passes, it will be easier to resolve this debate, because there are many ways to measure educational attainment. Standardized test are always popular, of course. Or, with ICT devices connected to the internet, education could be measured by how far a student has progress through their device's software.

Project designers and education ministers should focus on the social and (possibly) educational rationale of "ICT as a Teacher" pedagogy. Keeping in mind that most hardware and software will have been built and designed by people from developed countries, the educational benefits are still uncertain. Moreover, the economic benefits are indirect and my never be enough to recoup the initial outlay. It is well know that educational levels and development are connected, but whether or not a computer provided education will lead to economic results down the line is unknown. Furthermore, the high-cost of computers might not provide enough development to justify itself economically.

3.2 ICT as a Tool

3.2.1 How they learn:

Under this pedagogy, the focus of change is moved onto the teacher and her choices in the classroom. There are four common changes made: enhancing presentation and information gathering, shifting towards active learning, shifting towards collaborative learning, and the incorporation of "21st Century skills." ICT is critically important to making these changes and in many cases are fundamental to implementing innovative classroom practices (Voogt & Pelgrum, 2005).

The idea that teachers can use ICT to enliven their presentation is obvious. Using subject based resources, say interactive maps for geography class or videos of performances when studying plays, teachers can represent the subject information in a new way. This is the simplest way to incorporate ICT into the classroom. Classroom dynamics are not necessarily changed very much. Teachers still stand up front and deliver information to the student recipients. On the other hand, computers and the internet will change the relationship between students and information in developing countries.

Foremost, ICT allows for an unprecedented access to information (if one can read it). Most of humanities knowledge is on the internet somewhere. No longer does a student need to be physically near books or journals to discover new things about the world. The internet has a democratizing effect in this sense. The students in certain areas of the world no longer have access to an extremely disproportionate amount of the world's information. Students of rich nations are no longer an "information elite", when the information can flow to all of the world's populace. Furthermore, before the internet, students used to have access to only one viewpoint, that of their textbook. But online, they can explore many different sources and opinions. And unlike libraries and teachers, the internet never shuts down or goes home. This new relationship between students and information also expands a teacher's options. She can assign research assignments outside of the textbook or require the use of certain software as homework. Or, the teacher can use the computer in class to add multi-media presentations and interactive lessons. Finally, a teacher also has the same access as the students to nearly unlimited information. If a teacher does not know or forgot a fact, the answer is just a few clicks away.

Active learning is learning through doing. One example of active learning comes from a Vietnamese teacher who shifted her teaching techniques to involve her students in her lesson planning. In years past, she would include the important information from various countries in her PowerPoint presentation on Asia. All the research was done by herself. After some teacher training, however, she asked her students to use the internet to investigate the facts and then email the finding to her. Not only is this a clever way to reduce her workload, she also incorporates the students into the project of knowledge discovery (Intel). Active learning also allows the teacher to mimic real life problems in order to make the ideas more concrete and relevant to the students (Tinio, 2003). For instance, software allows teachers and students to create physics simulations that mimic real life engineering problems or form and manipulate geometric figures (OECD, 2009; Voogt, et al., 2005) Or, economic concepts can be taught through games where students buy and sell goods. The teacher no longer stands in the front and writes the important facts on the board, expecting the students to memorize the information. In this model, children either search out the information for themselves or use the information to solve another problem. The goal is to engage the learner in the process of learning and information creation and use.

ICT allows for collaborative learning in new ways. Of course, students have always had group projects inside the classroom, but ICT allows for collaboration outside the classroom. In this way, through the guidance of the teacher, students are also using ICT as a pedagogical tool. Learners can interact with people from other cities, nations, and cultures. This helps "to enhance learners' teaming and communicative skills as well as their global awareness (Tinio, 2003). In a Czech school, students joined together to create websites for local villages. Students found that the increased responsibility taught them how to communicate with people better (Voogt et al, 2005). Also, when students discuss online conversations between learners can be more thoughtful, as well as permanent, because students have a chance to think before they respond allowing more thoughtful replies (Sanyal, 2001). When devices are limited, educators need to create activities that allow students to switch between digital and non-digital exercises. In this situation, since teacher want to use ICT but cannot usefully monitor and teach the entire class at the same time, collaboration allows devices to be used instead collecting dust in the corner (Leach, 2008).

The curriculum which uses ICT as an enhancer incorporates what many researchers term "21st century skills. Every researcher and organization has their own concept of what "21st century skill" is. The North Central Regional Education Laboratory lists the 21st Century Skills as digital-age literacy, inventive thinking, effective communication, and high-productivity. The Partnership for 21st-Century skills lists them as the 4 Cs: critical thinking, communication, collaboration, and creativity. Kozma shows that most definition include some combination of "creativity, information management, communication, collaboration, and the ability to direct one's own work and learning." The point of learning these skills are to allow students to find jobs in the new "knowledge economy" that favors high-skilled workers who know how to use the new information and communication technology and solve complicated problems in the real-world (Kozma, 2005; Brown & Cocking, 2000; Intel). Using ICT to key to creating these skills, in that ICT allows the teacher to create a student centered and student led classroom. 21st century skills are not only valuable by themselves, but also aid in the acquisition of knowledge from traditional subjects. Thus, students learn a subject best when they study the basic content along with problems solving and critical thinking skills (Silva, 2008).

In all of these changes to the classroom except the first, teachers have shifted from the "sage on the stage" to the "guide on the side" (Tinio, 2003). Tinio described the teachers' new role as a question maker and guide instead of a talking textbook. The teacher would formulate the question ("What is the important information about this Asian country?") and facilitate the search for information. The teachers then continue to mentor the students on how to appraise the validity of the information and their conclusions. The Intel Teach ICT teacher training program promotes a class time that is "90 percent facilitation and 10 percent delivery" though they admit that this is often an unrealistic aspiration (Intel).

3.2.2 Implementation Resources

The "ICT as a Tool" is exponentially more complicated than the previous pedagogy. This is because the type of the teacher training must be decided together with the new tools introduced into the classroom. To put it another way, an organization would never teach a person to drive a bus and then give them a motorcycle. Tools and training have to go hand in hand. If the Ministry of Education, principal, or project manager wants to implement one-to-one learning, then the teachers require the proper training on how to incorporate the devices into the classroom. In the Vietnamese and Czech cases above, one-to-one learning is not necessary. However, there are many other ways an educator can teach when all of the students have a device. If a classroom gets one computer, a printer and a digital camera, a completely different set of pedagogical options open up for the teacher. On top of this, teachers will also need access to the proper educational software in order to fully exploit the computing power of the new ICT.

3.2.3 Implementation Cost

The fixed costs will be similar to the "ICT as Teacher" pedagogy. The price tag of hardware, software networking, and replacement will be determined by the amount how much ICT is purchased. The recurrent costs are much higher, though, because of the need for extensive and ongoing professional development. Training costs vary from country to country depending on many local conditions. Furthermore, teacher training costs do not decrease over time, in contrast to ever cheaper ICT and software. As time goes by, a larger and larger percentage of the ICT4E program's total cost will be maintenance and training (Trucano; Perraton et al).

3.2.4 Participants

The irony of the "ICT as Tool" pedagogy is that it shifts the focus of the classroom to the students while shifting the use of the ICT onto the teacher. As discussed above, in lessons using ICT, the role of the teacher is to guide the students as the students learn with the device being used. Before the teacher even steps into the classroom, ICT has changed her job. In a poll of teachers in South Africa who were participating in an UNESCO ICT4E project, 77% of respondents reported that ICT had a "high" impact on their ability to plan lessons. A large majority used ICT "to obtain resources (77%), prepare teaching materials (62%), prepare lessons (62%), produce teaching resources (51.5%), and for administration (34%)" (Leach, 2005). Teacher must learn many new schools. Basic digital literacy is the first step for some teachers. In Chile, two-thirds of the countries teachers were initially provided with training in how to use email, internet, and productivity software (Kozma, 2005). As ICT becomes more prevalent, more professional development is necessary (UNESCO, 2008). Using ICT, teachers can bring in expert voices from the community or from around the world. The classroom participants are no longer just the students and the teachers, rather anyone with an internet connection and a connection to the teacher.

Another important participant is the higher level policy makers who are designing the new system. They must convince teachers, many of whom have been teaching for decades, to change their classroom style. For educators who are used to the "sage on the stage" model, a complete rearrangement of their teaching paradigm will not be welcome (Niederhauser & Stoddart, 2001). The higher-ups have a two-fold job. They must convince the reluctant teachers that more professional development will lead to increased student achievement, while providing a training program that centers on classroom practices (Guskey, 2002; Kozma, 2005). Even if no one is actively resisting the change, teachers will often not alter their classroom practices just because the classroom has a new computer.

The interaction between the agenda-setters and the teachers is also crucial. Together they design and implement the new processes about the ICT. Processes can be many things. Guidelines on when laptops may be used are a process. Teacher training on the creative ways to integrate ICT into a lesson is a process. Even setting up a homework regime revolving around the use of a software program is a process. To put it another way, processes ask *how* computers are being used instead of whether computers are being used. Both sides must be involved in the creation of the new processes. One side has to oversee implementation in the classroom while the other has to oversee implementation on wider (possibly national) scale.

Finally, there are the students. Their role has changed from a traditional classroom. First, they must actively engage with the ICT and the new information and learning methods. Secondly, they will be expected to sort, criticize, and examine the information they have found. Students will learn new skill under the guidance teachers, giving them the skills for life-long use of ICT.

3.2.5 Specific Didactic Context(s):

Since the “ICT as Tool” pedagogy is most concerned with classroom dynamics that is most important didactic context. However, depending on the curriculum, students may need after school or at home access to computers. Once again, this shows the importance of designing a holistic ICT4E program that ponders what the teachers are teaching as much as what technology should be bought.

3.2.6 Implementation Outcomes

The “ICT as a Tool” pedagogy outcomes fall more heavily on the side “processes” instead of “things” (though equipment is still important). Among processes, there are three expected outcomes: learner centered classrooms, the acquisition of 21st century skills by students, and, as always, improved standardized tests scores. Learner centered classrooms are difficult to measure without observing hundreds or thousands of classrooms. Since teacher training is crucial to the implementation of the pedagogy, professional development can act as a stand-in for learner centered classrooms. Thus, it is important to measure the hours of professional development provided. In addition, the creation of a new set of processes should be considered when evaluating the impact of the ICT4E project (Brunello, 2010). Measuring 21st Century Skills is also difficult. How can creativity and critical thinking be measured? There is no consensus yet. However, tests are being designed. One example is the College Work and Readiness Assessment. Instead of a multitude of multiple choice questions, students are given one question relating to a real-world problem and 90 minutes to craft an answer using everything from newspaper editorials to research reports. Several other experimental tests are being designed. These tests can cost up to $40 per student when implemented in the West (compared to $7 or less for other tests) (Silva, 2008). Even if the price was much cheaper in a developing country, measuring outcomes in such a manner would require a significant commitment of resources. This is important to consider when designing an ICT4E, because every dollar spent on processes and measuring process is a dollar not spent on devices. The trade-off between paying for equipment and paying for processes is a serious division between "ICT as a tool" and "ICT as a teacher."

In the Hawkridge framework, the educational and, especially, the catalytic rational are heavily emphasized. Focusing on the latter, ICT as tool has great potential to reform the educational system. The catalytic nature of ICT as a tool is one of the reasons that digital devices receive a high level of push back from teachers who are not comfortable with ICT or the pedagogical changes that ICT brings (Trucano, 2005). Thus, any government, schoolmaster, or project designer should expect, plan for, and want real and large changes in the classroom.

The 21st century classroom will likely be filled with ICT devices. Computers, the internet, smart phones, and wearable technology offer teachers a new way to present information and connect the classroom to the outside world while restructuring the focus of learning. These are possibly huge changes. Whether or not this change comes to pass will depend on the interaction of teachers, administrators, project managers and policy makers and how they bring ICT into the classroom.

3.3 ICT as a Subject

3.3.1 How They Learn:

In the “ICT as a Subject” pedagogy, computers become a core course alongside mathematics, reading, science, and history. Students must become digitally or technically literate. Digital literacy can be divided into two levels. The first level is having the capability to use computers in a workplace or home setting. Oliver ties digital literacy to a specific set of skills : “[the] ability to independently operate personal computer systems, (as might be found in the home), an ability to use software for preparing and presenting work, an ability to use the Internet and its various features as a communications device, and an ability to access and use information from the WWW”. On the other hand, Simonson et al. (1987) described digital literacy as having “an understanding of computer characteristics, capabilities and applications, as well as an ability to implement this knowledge in the skillful and productive use of computer applications suitable to the individual roles in society.” Therefore, what qualifies as digitally literate will vary by occupation. Students will not need the same skills as business owners. Farmers will have a different definition of digital literacy from both. Under this paradigm, engineers who are using very complicated rendering software are judge differently than a 10th grader who needs to find information for a report.

The second level of digital literacy is the professional one. Rwanda may train 100 percent of its population to meet Oliver’s or Simonson’s criteria and still not became any closer to President Kagame’s goal of 50,000 programmers by 2020(The Economist, 2009). To accomplish his ambition, a generation will need to be trained in creating new programs and software applications. Thus, the focus of ICT4E becomes classes on computer science, coding, and software development. A second specialty is computer maintenance and repair. Like programming, this is outside the normal skill set of a digitally literate person. Furthermore, with the continuous increase in the number digital device computer maintenance will be an important area of job growth in a country's service sector.

3.3.2 Implementation Resources

The resources needed differ whether the goal is to reach the first or second level of digital literacy. If the goal is to create a populace that can at minimum use ICT (the first level), the key is access to digital devices. This could range from a computer lab where students learn to do things like type and email to 1-to-1 learning. Rwanda has developed a unique solution - ICT buses. The buses, filled with two rows of computers, travel the country side allowing citizens to learn about computers. The villages of Ghana are being filled with specialized ICT centers for the use of local teachers and students (Business Ghana, 2013). These centers are solution unique to solving the problem of digital literacy. When ICT is a subject, these buses and centers are logical outcome. On the other hand, these centers are not as well suited to the "ICT as teacher" or "ICT as a tool" pedagogies.

For the next level, specialized teachers are also necessary. Just as math teachers teach math, programming teachers teach students to become computer programmers. These teachers need a classroom space and the software to train the learners.

3.3.3 Implementation Cost

Again, the fixed costs will depend on the amount of hardware and software purchased for the project. However, a significant cost can come from creating the physical building (or bus) to house the hardware. Unlike the other pedagogies, funds will likely need to be redirected towards a specific computer space. The recurrent costs are the usual maintenance and connectivity fees. However, specialized educators are necessary for the second level of digital literacy. One cost will be from training these new teachers (especially in countries starting with a low-level of ICT competencies) and another cost from their salary.

3.3.4 Participants

The participants unique to the "ICT as a subject" pedagogy are the computer programming teachers. They play a role similar to instructors of more traditional subjects. They hold the knowledge and are expected to communicate it to their pupils. Their skill should include a mastery of the subject as well as the classroom management techniques. This exposes another large difference between "ICT as a subject" and the other pedagogies. "ICT as a teacher" required no teacher training and "ICT as a tool required training teachers how to integrate technology into other subjects. Each one requires a very specific use of a society's resources of time and money. Then, for the student, their role is to learn the new skill in order to access the job market in the new knowledge society.

3.3.5 Specific Didactic Context(s)

In order to teach ICT as a subject, especially higher level usage of computers, computer laboratories must be set up for the specific purpose of conducting lessons. Of course, students being able to study the subject of ICT outside of a classroom setting is beneficial if possible.

3.3.6 Implementation Outcomes

Preferred outcomes can range from basic computer and internet skills to being able to design and create a new smartphone app. In this sense, "ICT as a subject" sidesteps the "things" vs. "processes" debate. For the first level of digital literacy, there is a debate on how to measure outcomes. Oliver attempted to provide a way by a surveying students on their use of ICT to discover which skills and task were most useful and appropriate in their educational life. Then, he divided the skills into separate categories, including computer operation, internet skills, and software application. He used self-reporting surveys to determine the student's levels. However, a test could be made where in a testee had to perform a series of tasks to show their skill level.

For the second level of digital literacy, a rise in computer programmers would be a measurable outcome. However, this method takes years to discover whether the ICT4E project worked or not. It can also be measured by the number of new computer classes in schools and or ICT teachers trained. Projects can always be measured in terms of computer labs created and computers bought.

Under Hawkridge's rubric, the focus is on the economic rational. Preparing students for the future job market is a common justification for this approach. Since the future economy is expected to be increasingly focused on ICT, schools should incorporate computers into the curriculum. Many countries hope to become an ICT hub for their region and increase digital literacy is key to this goal. By mastering the new skills that are considered most valuable in a knowledge society, the students, when grown, will be able to find employment in burgeoning new fields (Perraton & Creed, 2000).

"ICT as a Subject" is the only pedagogy with direct ties to an economic outcome, as computer skills are directly tied to jobs. On the other hand, these projects do not change anything about the classroom nor does it necessarily address any social problems. In fact, if computer classes are directed only towards the elite children of the country, the disparity between rich and poor could be further widened and calcified. Alternatively, wide-spread computer classes could help lesson social and economic divides.

Chapter 4

4.1 Why not all three pedagogies at once?

What is preventing countries from creating a system that addresses all three uses of ICT? There are three constraining factors: the importance of computer placement, human capital, and the cost. Each of the three pedagogies uses ICT in different contexts. As has been shown, the placement of digital devices varies according to their uses. For instance, the placement of computer has been shown to have a large impact on their usage in the classroom. For certain goals, a separate computer laboratory is important. Whereas for other goals, a smaller number of computers, but in the classroom, are preferable (Trucano). Secondly, each pedagogy requires a shift in the way teachers and administrators structure the expected educational outcomes. Also, each requires a different set of skills from educators. With limited time, it is very difficult to hire or retrain teachers with the needed experience to cover each pedagogy. Finally, and probably most importantly, is the cost. Each pedagogy has different set of cost accompanying it. While many of the costs do overlap, trying to cover all three would be prohibitively expensive in a developing country. Even if the cost could be covered, spending all that money on ICT would not be a cost-effective use of those funds (Harris, 2009; Margolis, Nussbaum, Rodríguez, & Rosas, 2006). Since resources are limited and trade-offs are a very real consideration projects must it is important to have a clear understand of what the ICT is to be used for, because that will determine where the resources will flow to.

The following section will examine three different, large non-governmental organizations that are promoting ICT4E: One Laptop Per Child, Intel Teach, and Plan. The NGOs have many similarities. All three are large, though Plan is by far the largest, since they are not only an ICT4E group. The three NGOs work in developing countries through local government institutions. Each organization has taken a different route in promoting ICT. OLPC's name and policy are conveniently the same. They correspond with "ICT as a Teacher". Intel Teach focuses solely on teacher training and integrating computers as a classroom tool. Lastly, Plan recently completed a project that built ICT centers into schools in Ghana. The three examples show the option available to local education official. They also show that the different pedagogies have different costs, methodologies, and seem to be tied to different outcomes.

4.2 One Laptop Per Child

One Laptop Per Child is a major player in the world of ICT for education despite being recently created. As the name implies, the group's original mission was to provide every child in a country a laptop, specially designed by OLPC, at a $100 price point. Since 2004, when the group was founded, OLPC has attempted to achieve this designing their own laptop and software, termed XO and Nell respectively. That year Nicholas Negroponte, OLPC's founder and head of the MIT Media Lab, unveiled a prototype at the World Summit on the Information Society. Negroponte then partnered with the United Nations Development Programme to begin distributing the devices to children in developing countries and to ensure the economical creation and delivery of the device, the organization first asked for minimum orders of one million of the XO laptops, a number which was eventually dropped (Fildes, 2013). In the end, the group was not able to accomplish their original goals. The ruggedly designed devices, which were made to keep out dirt, be seen in sunlight, and run on low power, currently cost around $200. Included in the brightly colored, solar powered computer are specialized educational software, again designed by the group, that can instruct children in English, math, and science. Since its founding, over 1.7 million device, which are labeled XO, have been delivered to children all around the world (OLPC Countries, n.d.).

Relating to the pedagogical function, the organization firmly believes that ICT can be and should be a teacher. Under the OLPC model the laptop “takes learner beyond instruction". In a video by One Laptop Per Child, an announcer asks “Why give a laptop to a child with no electricity or even running water?” The response comes “If you substitute the word ‘laptop’ with ‘education’, the answer becomes clear.” “Laptop” and “education” hence are considered to be synonyms. OLPC believes that the laptop and software is provides children with opportunity to “unlock their potential” (“Mission”).

The organization’s vision grew out from the work of Seymour Papert, who Negroponte has collaborated with for decades. Papert believes that children best learn by engaging in the subject directly. For example, it is better for students to learn a language through conversation than from listening to a teacher. Working from this rationale, OLPC believes that the educational focus should be place on students and the laptops. Teachers have neither a substantial nor critical role to play in their vision. Their website demonstrates their attitude and mindset by making no mention of teachers in the “mission” or “education” sections. Negroponte dismissed the notion that teacher training as necessary, saying, “And when people tell me, "Who's going to teach the teachers to teach the kids?" I say to myself, "What planet do you come from?" (Negroponte, 2008).

One Laptop Per Child is conducting pilot programs to see if their computers can completely replace a human educator. In 2011, the group delivered several cardboard boxes, taped shut, to a predesignated small village in Ethiopia. The village was selected on the basis of the lack of educational resources and schools available to the inhabitants. The mystery boxes had no instructions and no human being to explain the contents. OLPC wanted to know if the children would learn how to read English through a computer alone (Ackerman, 2012). There would be no teachers, no principles, no classrooms and no guidance. Here was a case of laptops being used as teachers. For data gathering, OLPC sent trained technicians to the village to change the memory cards in each device. By swapping memory cards, the organization could see how the children were using the laptops. Negroponte, talking to a conference in the United States, marveled at how well the children adapted. The local children were the first ones to open the boxes and remove the digital devices contained inside the children were using 47 applications per day and the technicians brought back reports of the children singing the ABC song (OLPC, 2012).

Since in both theory and practice OLPC is firmly committed to the ideal of utilizing computers as teacher, if education policy makers do disagree with organizations, they must find additional funding on top of the hardware. Furthermore, such an extensive and expensive hardware expense must be able to justify itself. A project trying to sell such a project will have a hard time, if she has to admit that the project will not be effective in classrooms where teachers are resistant or untrained. Increasing the educational outcome is OLPC's main selling point.

In 2007, Uruguay became the first country to extensively purchase and distributes the XO laptops to its citizens. The policy was promoted by then president Tabaré Vázquez with the support of local businesses and NGOs, including local education organizations such as the Primary Education Council (CEP) and the Technologic Laboratory of Uruguay (LATU) (Bowden, 2011). Commencing in the western and central areas of the country, computers were disbursed to students. Over the first three years, the total expenditure reached $100 million dollars. The individual price for the initial device came to $188 for the laptop and $60 for spare parts, servers, support, and networks. On top of these figures is another $75 dollars per year for maintenance and upkeep. By 2008, 380,000 students and teachers had received the laptops (Psetizki, 2009). Furthermore, unexpected expenses arose. The Uruguayan government did not anticipated that families would be reluctant to send the laptops to central repair centers for free maintenance. Only one-third of families were willing to send away their valuable device. As a result, Montenegro implemented a system of mobile repairs truck to travel the countryside to perform maintenance or replace the broken devices. Even with these measures, over one in four laptops were unusable in April of 2010 (Bowden, 2011).

Many positive outcomes were reported. Teachers viewed an increase in time spent on math, reading, and science activities by students than before. Unexpected social outcomes were also discovered. Because students had to register with the government in order to receive the laptops, the capital discovered unregistered children (Derndorfer, 2010).

No teacher training was performed before the initial distribution of the laptops. During the next year, 2008, a policy was implemented to increase the number of informatics teachers who would then retrain other teachers in the country. The training predominantly focused on how to use the devices and little on how to implement new lessons in the classroom. The next two years each brought reform to the training curriculum, but neither reform had the intended effect of increasing usage of the laptops in the classroom (Derndorfer, 2010). As of 2010, only around 20% of teachers used the XO in classrooms on a daily basis. Only 13% of educators assigned group work and less than 4% assigned homework to be done on the laptops (Bowden, 2011).

Several conclusions can be drawn from the Uruguayan experience. Primarily, teachers will not use adopt technology into their lessons just because the devices are in the classroom. Teachers with their individual pedagogical methods do not automatically adjust. Instead, they must be extensively trained to not only understand how technology works, but also how to rearrange lesson plans around the use of devices. Teacher training is an ongoing expense and could possibly deplete the educational budget of unprepared school districts. Furthermore, properly training an entire school along with purchasing and supplying new laptops may be an too expensive for many developing countries to handle. Uruguay shows that “ICT as a Teacher” and “ICT as a Tool”, which would be evidenced by usage in the classroom, are not naturally overlapping categories. Instead, separate sources of financing must be provided for the technology and to help the education system adapt to the technology. This lines up with research from other nations that demonstrate teacher training is key to improvement in core subjects (Derndorfer, 2006). For example, another OLPC country, Rwanda, witnessed classrooms where students would use the laptops on their own time while teachers ignored the devices (Anderson and Norman, 2010).

Any educational outcomes came from outside the classroom or tangentially through increased attendance or interest. The social effects included the inclusion of unregistered children into the government's database which allowed the youth access to government services. The program also bridged the digital divide between rich and poor students - 70% of the students did not have a computer at home before the XO (Psetizki, 2009). Finally, a one laptop per child policy requires constant funding and upkeep from the central government "maintenance, training and support would hastily go down and the project would "die out" in a short time" (Anderson and Norman, 2010). The policy locks policy makers down a certain path with high fixed costs that can be difficult to accurately predict on account of unexpected expenses. Time, effort, and money directed towards implementing the OLPC's "ICT as a Teacher" leave few monetary and mental resources to be directed towards creating an "ICT as a Tool" mentality within an education system. The experiences of Rwanda and Uruguay show that attempting both at the same time is an extremely difficult task to achieve.

4.3 Intel Teach

Intel Teach, an organization focused solely on training teachers in the use of ICT in the classroom, is located at the opposite end of the spectrum from One Laptop Per Child. The case of OLPC showed that catalytic outcomes are not inherent to one-to-one learning and the “ICT as Teacher” pedagogy. Instead of worrying about getting as much hardware into the hands of students as possible, the Intel Teach is concerned with the creating teachers who are comfortable with using ICT in the classroom. Additionally, the group wants to train enough teachers in any given school district that the ICT-knowledgeable teachers attain a “critical mass” in order to have significant influence over the district’s policies. They plan to achieve this goal includes a two-tiered training process. The company trains teachers who return to their school districts and run ICT training seminars (Martin, et al., 2003). This process has educated over six million teachers in using ICT in the classroom.

The organization partners with countries to run professional development seminars for teachers. The program material is tailored to the each country. For example, a section on holidays will use a holiday that is important to that nation, but is perhaps unknown in the United States where the program was designed. During the sessions, “Participants learn to plan, develop, and manage student-centered assessment to benefit students learning” and to “develop units that integrate technology into existing classroom curricula to promote student-centered learning”. This is done by convincing the teachers to “embrace project based learning.” (Intel Teach Program Portfolio). Intel Teach discovered a change in the participating teachers’ attitudes and beliefs. First, the teachers believed that they could create content that harmonized with their students’ lives. Secondly, they believed that the new method of project-based, student centered teaching require more mental effort on the part of the students, leading to greater learning and retention. Teachers described themselves as shifting their personal style from “stand and teach” to facilitating discussions that allow students to share their own knowledge (Alverado, 2009). Overall, the teachers had very positive reviews of the program, with 97% claiming that they had learned how to better integrate technology into the classroom. The vast majority of teachers also believe that they had the computers skills to effectively lead any lessons requiring high levels ICT. Back in their classrooms, teachers created new lessons. One math teacher required her students to use online databases to determine the average rainfall of various locations around the world. Another teacher had her students find and evaluate online historical photos. Unlike teachers involved in the One Laptop Per Child, teachers trained by Intel reported high-levels of ICT usage and rearranging their classes to include more student-centered activities. The teachers also confirmed that technology based lessons led to more involvement from the students and that students were communicating their ideas with greater confidence (Martin and Simon, 2006).

The trained teachers then return to their schools to implement professional development seminars in their local school districts. Each teacher-trainer is expected to educate 60 more teachers in the three years after their training. These training session consist of ten modules, each lasting four hours. Back during normal school days, the teacher-trainers were viewed as tech-gurus, often being called into rooms to do trouble shooting. Furthermore, the school districts are supposed set up a system of recruitment, incentives and certification (Martin, et al., 2003).

For the lessons Intel does not charge for the training or require nations to buy their products. The teacher-trainers believed that one 40-hour session was not enough to permanently adjust the beliefs, attitudes and teaching-styles of their coworkers. They saw a need for more professional development in order for the training to become established practice (Alverado, 2009). After Intel has finished its training courses, it falls to the education policy makers to ensure continuing teacher development. Continuous training and courses cost time and money. Getting teachers to accept ICT in the classroom is not free however. Research suggests that the greatest success comes when teacher have incentives. Additionally, it often takes years to fully adjust teachers and classrooms to new methods of teaching and requires ongoing professional development (Trucano, 2005). This is money and effort that is not spent on creating country specific education software or designing curriculum that encourages educators to use ICT as a teacher. Unfortunately, a country cannot use OLPC for the hardware and use Intel Teach to completely retrain the nation's educators at zero cost to the government. Policy makers who believe strongly in teacher training will have to sacrifice hardware or raise additional money.

If a nation partners with the organization, they know which outcomes to expect. Intel does not emphasize economic gain or claim direct monetary impact. Instead, they group focuses catalytic nature of their program. They promise the enhancement of 21st century skills such as problem solving, critical thinking, and collaboration among students and teachers" (Intel). The catalytic nature of their program is supposed to lead to better learning outcomes. The research done on the "Intel Teach" program does not attempt to measure educational outcomes. However, they have found that the best use of new hardware does come from a total restructure of class time. This requires changing attitudes and beliefs of educators and their superiors. In successful cases, there was a notable change in the relationships between and among students, teachers and the community. Students, meanwhile, had increased and new responsibilities (Alverado, 2009).

Intel Teach is the first step in a long restructuring of the classroom. The entire process requires considerable amounts of a teacher's time. Organizing and conducting professional development, along with the cost of incentivizing teachers to attend and implement the changes, is not free. Fortunately, even in the United States, schools that participated in the Intel Teach program did not have a large number of computers in the classroom. Even highly stocked rooms averaged less than five computers (Martin and Simon, 2006). Finally, there seems to be a psychological divide between school systems that implement a one laptop per child policy and ones that go to Intel Teach. This is another expression of Brunello's "things" vs. "Processes". OLPC promotes high levels of things. Procurement and distribution alone is an enormous task, but education policy makers must also set up systems to repair the device and connect them to the internet. With so much necessary effort going into making the things functional, it is not surprising that teacher training and other processes gets less attention. While "ICT as a Teacher" and "ICT as Tool" are not *per se* exclusive, proper implementation of both pedagogies may be. Furthermore, the Intel Teach program will not work well as "ICT as a subject." Students will learn many computing skills. However, the teachers trained by Intel are not prepared to teach any higher level computing skills. This is especially true in countries where the educators are not far ahead of the students in terms of computers knowledge. In the end, Intel Teach show the limits of what the "ICT as a Tool" pedagogy can accomplish.

4.4 Plan: Ghana Transition and Persistence (TAP) Program

ICT as a subject is the easiest to imagine because it looks the most like a traditional classroom. There is the subject teacher, in this case a computer science or programming teacher, and rows of students studying a subject. Like math class or science class, the students have a certain subject to study and master. After the class is finished, the students file out and a new group of students will come in. Plan, in part of their 10 million dollar Transition and Persistence program, built 13 such ICT centers for schools in eastern Ghana (Sottie, 2013).

Plan is a huge organization. They conduct programs in education, health, water provision, and emergency services. Last year they received 68 million dollars in contributions and worked in dozen of nations on every continent. In Ghana, the group has three focuses: quality education, economics, and child protection. The TAP program falls under the first focus and was created in order to help Ghana meet the UN's Education for All goals.

The ICT centers including construction and repairs, upgrades to the school's toilets, and scholarships and teacher training. According to the Ghana News Agency (2012), the cost for one center was $132,000. While the center was free for the local government, Grace Adzo Obodai, the acting Gomoa West District Director of Education, worried that the project would not be sustainable in coming years. Her concerns about limited future financing are common in ICT4E projects, since local money is limited.

In Ghana’s case, they have started down a path that will be hard to change. Most of the money raised by the school district for ICT will go to the centers maintenance and the salaries for the ICT subject teachers. Without outside sources of funding, it is unlikely that the schools will change to an "ICT as a Teacher" or "ICT as a Tool" pedagogy. Such a switch would require a large amounts of new money or the defunding of the ICT centers.

Why cannot these centers act as teachers or a tool? They will not work as a teacher for three reason. First, standard off-the-shelf computers do not come with educational software. Purchasing the programs is possible, obviously, but would be a further strain on the districts' budget. Secondly, the purchased educational software is not designed for the local Ghanaian context. If the schools wanted software specially designed for their student's the price would go up precipitously. Lastly, the ICT centers will be occupied by students learning ICT during the night and locked up during the night. As for the using ICT centers as a teaching tool, there are several problems. Foremost, it is unlikely that teachers will spend the time to take their classes to the centers (Trucano, 2005). Second is the usage problem seen before. Even if teachers wanted to use the centers in their lessons, teachers will have to find a time between ICT classes to shuffle their children down to the centers.

As it stands, the 13 schools are locked into a certain pedagogical path. Under the framework of 'path dependency' theory, the ICT center can be thought of a new institution. Institutions are the "focal point of the activity of public policies." (Trouvé et al., 2010) In other words, they bring together a set of organizations, ideas, processes, and behavior into one path. All further decisions will be partially determined by the past decision to create an ICT center instead of a doing one to one learning or spreading out a few computers to each classroom and focus on teacher training. Furthermore, path dependency theory states that it will become harder and harder to change the path that the schools are on for two reasons. First, the processes become reinforced and standardized over time (Thelen, 2009). Thus, the ICT centers and the "ICT as a subject" pedagogy that they bring along become an ideological foundation within the school district. Changing pedagogies would require more than just rearranging computers and funding additional teacher training. It would require a change of mind as well. Secondly, any large change to the process will incur a new set of costs defined not only by money but also by learning and coordination (Pierson, 2000). A school district that wants to implement a one laptop per child policy will need to find or create a major source of financing and people who understand the new pedagogy.

The lessons of path dependency are applicable to the other pedagogies as well. With the high level of investment required to work with OLPC, education system become locked into the "ICT as teacher" pedagogy and concurrent justifications. The same applies for Intel Teach and the "ICT as a Tool" pedagogy. The path dependency theory suggests that the initial choice of pedagogy loads a schools system with certain financial burdens, institutions and outcomes. There exists a cost for any school that wants to change paths or create a new path by attempting to merge two pedagogies. As a result, path dependency creates a barrier between three pedagogies.

Finally, in the project design of these ICT centers, outcomes are not highly emphasized. Nowhere is economic, catalytic, or social outcomes mentioned. The project designer solely promotes the expected educational benefits of the centers. The entire TAP project was designed to increase enrollment rates and provide students with educational opportunities (Ghana Ministry of Education, 2013). In the short term, such centers could easily raise attendance, as the students are excited about the new hardware. However, there is little evidence that increases in hardware lead to increase attendance in the long-term

(Trucano, 2005).

Chapter 5

5.1 Conclusion

As computers become cheaper and more ubiquitous, ICT4E initiatives will become more common considering how politically popular such projects are. Two things are of great concern, however. First, projects are being designed without any clear idea of what educational problem ICT is supposed to solve, even though much research has been done on how to best integrate ICT into the classrooms. So, instead of delineating between the uses of ICT as a teacher, a tool, or a subject, planners often do not think about the exact reasons why they are buying digital devices. As a result, planners often distribute hardware haphazardly.

The thesis found three common pedagogical uses for ICT4E: teacher, tool, and subject. In the "ICT as a Teacher" pedagogy, the digital devices teach and grow with the students. When ICT is a tool, teachers use technology in order to better teach their lessons. Finally, the "ICT as a subject" treats ICT as subject, like math or English.

In addition to unclear pedagogical uses of ICT, project leaders expect ICT to satisfy an impossibly wide array of outcomes. One ICT center in Ghana (not the TAP project) was justified because ""the medium for accelerated development today is ICT. Therefore ICT studies in our schools are crucial" (economic rationale) and "ICT had become a formidable force for driving . . . and every sector of the global community irrespective of geographical location" (social rationale). Furthermore, this ICT center would "enable [teachers] to teach the subject to pupils in the district" (educational) and "ensure . . . that academic instructions would be conducted by means of ICT rather than by chalk and chalkboard" (catalytic rationale) (Business Ghana, 2013a).

Despite the fact that there is considerable research on how to best integrate ICT into the classroom and that there is considerable research on what are the benefits of ICT4E programs, there is little research connecting the two. This paper has argued that the pedagogical function of ICT in the classroom is directly connected to the outcomes. And as a result, design and outcomes cannot be separated. For example, the ICT as a subject pedagogy is most suited for President Paul Kagame's goal of 50,000 computer programmers by the year 2020. And while the Fijian headmaster may be amazed that computers "is like a new teacher", there is no indication that the project was designed with long term teaching and learning goals in mind and that the software can grow with the students. As a result, the laptops are unlikely to become "teachers" for an extended period of time. This thesis showed that each pedagogical use for ICT was more related to some outcomes than others. As a result, ICT projects cannot do everything. There is a trade-off between the positive outcomes that any one ICT4E program can accomplish. This thesis showed that more attention needs to be paid between the key justifications for ICT4E projects and their connections to long term results, because, in the end, design and outcome cannot be separated.

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초록

매 2년마다 연산력이 2배가 될 거라는 Moore의 법칙 덕분에 정보통신기술 기반 시설의 가격이 점점 더 저렴해지고 있습니다. 그리고 앞으로도 더 저렴해 질것이라고 예상합니다. 이 정보 혁명은 OECD 가입 국가들의 정치, 경제, 사회에 큰 영향을 미치고 있습니다. 현재 전 세계의 모든 나라들은 정보통신 교육을 촉진하려 하고 있습니다. 하지만 정치인과 교육자들이 큰 약속을 만들거나, 확실한 목적과 교육학의 내용은 아직 사실 많지 않습니다. 정보통신을 사용한 교육이 필요한 이유는 세 가지가 있습니다: 경제적, 사회적, 교육적, 촉매적인 이유입니다.

제 연구는 다음 세가지를 교육학적으로 사용할 수 있는 것을 발견하였습니다; 선생님, 도구, 과목. 선생님이 컴퓨터로 대체될 때, 선생님들이 과학이나 수학 같은 과목에 대하여 더 좋은 교수를 하기 위해서, 정보통신기술을 쓸 수 있습니다. ICT의 교육학적 사용은 정책 입안자들이 새로운 프로젝트를 생성해 낼 때, 고려가 되지 않았습니다. 따라서 제 논문은, 교육적인 면에서 ICT 적용을 성공적으로 만들려 할 때 따라오는 다음과 같은 질문에 대해서 답할 수 있습니다.