

# Crucial Considerations in One-to-One Computing in Developing Countries

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**Abstract:** One-to-one computing has lately become one of the buzzwords in the educational technology initiatives in developing countries. Various versions of one-to-one computing have recently been implemented around the developing world. Governments and educational organizations have often felt a pressure to acquire new technology as an effort to leapfrog development, but this has in most cases been done without any deeper analysis of the complete framework that successful one-to-one computing initiatives require. A number of One Laptop Per Child (OLPC) projects have subscribed to the view that one-to-one computing should not delve into non-technical areas like teacher training, curriculum development, or content development. We, however, consider the non-technical issues to be of great importance for the success of computer-enhanced learning in primary schools. This paper presents and analyzes nine crucial and often neglected considerations for successfully implementing one-to-one computing initiatives: a pedagogical framework, teacher training, a support model, content in local languages, adaptation to local conditions, parental agreement and support, monitoring and evaluation, administrative support, and sustainability. We disagree with the view that one-to-one computing is only about leveraging the children themselves. By properly considering our nine propositions, one-to-one computing initiatives can increase their positive impacts in primary schools in developing regions.

**Keywords:** One-to-one computing, e-learning, computer-assisted education, ICT4D, ICTD, OLPC, XO-1.

## 1. Introduction

One-to-one computing has been raised to the limelight in discussions about information and technology for development (ICT4D), as well as in educational technology in general [10, 21]. One-to-one computing refers to the idea of equipping each student with a personal computer (usually a laptop, handheld, or tablet computer), access to Internet, and various kinds of software for educational purposes. One-to-one computing initiatives often come bundled with wider educational reforms, such as a shift to self-directed learning, project-based learning, or other constructionist pedagogical initiatives.

However, none of the one-to-one computing initiatives that we are familiar with are holistic in a sense that they would explicitly look at whole educational systems. Yet, in educational reforms, a systemic approach is needed, as a country's educational system is irrevocably intertwined in a larger socioeconomic, cultural, and technical system. In this paper we present a systemic view on one-to-one computing by describing nine cultural,

educational, socioeconomic, and technical elements that we have found to be crucial for the success of one-to-one computing initiatives in developing countries.

There is very little academic research on the latest one-to-one computing initiatives in developing countries. One reason for this might be that the phenomenon is quite new and results are not yet ready for publication. Another reason might be the difficulty of selecting a methodical research approach, as the projects are large in scale but the aim is mental change. A third reason that researchers are not invited could be fear of criticism: evaluation-oriented researchers have a tendency to ruin the technology party. Fourth reason might be that funding in these projects is provided for technology development, and not evaluation of outcomes. Due to the lack of rigorous research studies on this topic, (see also [2, 25]), we have differentiated between our sources from popular media and proper academic articles by inserting references to news articles into footnotes and referring to academic articles and official documents using the standard bracket notation [ ].

## 2. Background

Proposals for educational uses of computers date back to the birth of modern computing, and new ideas for educational technology have been presented ever since. The 1960s saw a number of serious attempts towards using computers to educate young children; those attempts include, for instance, Alan Kay's Dynabook and Seymour Papert's Logo programming language. One-to-one computing started off as a serious, practicable, and scalable idea in the early 1990s, when a number of pioneers, including Seymour Papert [22] and Alan Kay, proposed the idea of equipping students with laptop computers.

Early 1990s experiments on one-to-one computing took place in, for example, Australia and the United States, and in the mid-1990s Microsoft's and Toshiba's *Anytime-Anywhere-Learning* program (earlier *Learning with Laptops* program) supported a number of one-to-one computing initiatives in the United States [27]. In the early 2000s, Apple made a push towards one-to-one computing, too, by equipping a number of school districts in the U.S. with Macintosh computers to schoolchildren. But despite a good number of positive reports on one-to-one computing in schools, scientific evidence on the educational benefits of one-to-one computing has not escaped the "no significant difference phenomenon", which has haunted educational technology since the 1920s [28].

In today's one-to-one computing initiatives the computers range from very cheap and small PDAs to laptops and multi-user desktops. When it comes to projects in developing regions, cost effectiveness is an important factor, and the focus has been on using relatively cheap and simple computers [21]. Earlier attempts at providing affordable computers to developing countries include the late 1990s' Simputer project [21].

The first large-scale push towards fixing the educational problems of developing countries using low-cost one-to-one computing gained momentum in the mid-2000s, when Nicholas Negroponte pulled together an impressive number of partners and funding to start the One Laptop Per Child Foundation [8]. The other players got anxious and entered the market quickly with their competing products: Intel Classmate and Asus Eee PC adopted the "netbook" form factor and produced their own versions of the low-cost computer [21].

### 2.1 Motivations, Expectations, and Opposition

The promises and expectations of one-to-one computing strongly depend on from whom one asks. One-to-one computing is driven by a wide array of motivations, some of them altruistic, realistic, and philanthropic—but many others conflicting, exaggerated, opportunistic, or just plain greedy. First, there is the hope that one-to-one computing will improve students' performance in the class. There have indeed been some inspiring results that suggest improvement in students' achievement [17].

Second, however, the strongest advocate group for one-to-one computing does not seem to be teachers, but the computer industry and computing professionals. For instance, the OLPC Foundation advocates its own educational solution on merits of price and technical sophistication first, and pedagogical arguments second<sup>1</sup>. Similar to the OLPC Foundation, the other children's laptop manufacturers focus on the technical qualities of their products and pay very little attention on their educational uses. Manufacturers see one-to-one computing as another area for market competition. It has been argued that the burst of interest in developing world among technical experts was, in fact, pivotal for creating the wave of one-to-one computing initiatives in developing countries [21].

Third, educational reforms on a grand scale always entail political motivations. In Nigeria one government embraced the OLPC initiative, whereas the next government scrapped it. There again, strong governmental support has been instrumental for the success of our own OLPC project in Tanzania. Fourth, one-to-one computing has often attracted grand social rhetoric: it is not uncommon to hear references to national development, growth of democracy, free speech, and poverty reduction. For example, the OLPC Foundation's Chairman stated in a speech given in November 11, 2009 at TED<sup>x</sup>Brussels: "*I've always said [that] the mission of the one laptop per child is to eliminate poverty*" [18:14.00-14.30]. There is also considerable criticism of one-to-one computing projects. The criticism is fueled by the media hype around children's laptops—and that hype seems to dominate the public discussion. The news and media pieces usually focus on the new tool only, and hardly discuss one-to-one computing as a complete framework [11]. Furthermore, some of the motivations listed above are in clear conflict between each other: For example, the altruistic "getting the children the cheapest possible price" motivation is in contrast with private companies' need to make profit.

Kraemer et al. wrote that "*expecting a laptop to cause such revolutionary change showed a degree of naïveté, even for an organization with the best intentions and smartest people*" [14]. The critics say that computers in classrooms have not worked in the industrialized countries either [5], so it would be excessively optimistic to believe that they would "reform" education in developing countries. In fact, the OLPC Foundation's central statement "*It's an education project, not a laptop project*" is in direct contrast with the OLPC Foundation's focus on laptop development and with their open disregard of content development and pedagogical development.

Having these conflicting viewpoints and very vocal proponents and opponents of one-to-one computing, we decided to investigate what are the crucial elements that one-to-one computing projects in education should involve. We found nine considerations, which are mentioned in the literature, and which resonate well with our own experience with one-to-one computing projects in Tanzania, Uruguay, and Sri Lanka.

### 3. Crucial Considerations

In 2007, the father of the OLPC Foundation, Nicholas Negroponte, publicly detached his foundation's aims from teacher training, infrastructure development, curriculum development, and construction of learning content: "*It's not about training teachers. It's not about building schools. With all due respect, [to HP's e-inclusion efforts] it's not about curriculum or content. It's about leveraging the children themselves*"<sup>2</sup>. However, experiences around the world have shown that one-to-one computing initiatives without a holistic view tend to fail. In this section we present nine broad aspects of education and technology, and we establish why all of them are crucial for the success of one-to-one

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<sup>1</sup> "The OLPC Mission Statement", *The OLPC Foundation*, retrieved from <http://www.laptop.org/>, November 24, 2010.

<sup>2</sup> "Nepal Creates Content While Negroponte Dismisses", *OLPC News*, January 31, 2007, retrieved November 22, 2010 from [http://www.olpcnews.com/countries/nepal/negroponte\\_curriculum\\_content.html](http://www.olpcnews.com/countries/nepal/negroponte_curriculum_content.html)

computing projects. Those aspects are, in order: a pedagogical framework, teacher training, a support model, content in local languages, contextual understanding, parental agreement and support, monitoring and evaluation, administrative and political support, and sustainability.

### 3.1 A Pedagogical Framework

Similar to traditional education, a laptop initiative without a pedagogical model risks to fail, and the computers may end being toys rather than tools that support the learning objectives. There are accounts of how computers have been banned at schools when teachers have become frustrated with the disturbing influence of laptops on the class<sup>3</sup>. From the educational point of view, a more credible strategy might be to start with learning objectives on mind and to select a pedagogical approach and technical solutions that facilitate each other in reaching those learning objectives.

In an early stage of the OLPC Foundation's initiative, Seymour Papert was consulted to discuss and include his constructionist ideas in the OLPC initiative. One of the central ideas in constructionism is to get *students* doing instead of the *teacher* talking. Papert's constructionist ideas [22] are described as an art of *learning principles* in contrast to the traditional instructionist position where pedagogy is seen as the noble art of *teaching principles* [9b]. The OLPC initiative, however, fails to demonstrate how should one take the constructionist pedagogy into account in one-to-one computing with children.

When the OLPC initiative was launched in 2005 there was a dual aim: firstly, there was the technical goal of designing a low-cost (\$100) computer, and, secondly, there was the goal of involving the constructionist model in OLPC projects in developing regions. Both aims failed. The cost of the XO-1 computer is closer to \$200 than \$100. And there are very few traces of constructionism in the picture. Interestingly, in the OLPC organization it has been suggested that the ebook works a Trojan horse that cunningly leads learning from instructionism towards constructionism. But considering computers merely as electronic textbooks ignores the real power and capacity of modern laptops, and it is also doubtful from a pedagogical viewpoint. The ebook as an educational solution may strengthen the teacher-centric instructionist approach to be even stronger than it is in traditional teaching and learning [9b]. Yet, what is worse than latent instructionism is launching an educational project without concrete pedagogical ideas at all.

### 3.2 Teacher Training

Without appropriate teacher training and acceptance by teachers, any educational project is bound to fail. Because introduction of computers to all pupils in the classroom significantly changes the role of both the teacher and the student, there are also emotional and value attitudes involved on part of the teachers. The way the project is introduced and implemented plays an important role on teachers' acceptance and willingness to change their teaching style and to embrace new interaction patterns with students. It is necessary to involve teachers early in the decision process using, for example, some variant of the participatory design model [16, 29].

A participatory approach enables teachers to be active participants also on the policy level and to tailor and adjust the initiative to their needs. In large-scale projects such as the Ceibal project in Uruguay [23], the teachers' involvement in policy making are facilitated by representatives from their labor unions. Surely, a top-down strategy is not enough, and also on the classroom level teachers need to be involved as influential actors who have the

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<sup>3</sup> "XO Laptops are Banned in OLPC Ethiopia Classrooms.", *OLPC News*, June 16, 2010, retrieved November 18, 2010 from [http://www.olpcnews.com/countries/ethiopia/xo\\_laptop\\_banned\\_from\\_class.html](http://www.olpcnews.com/countries/ethiopia/xo_laptop_banned_from_class.html)

freedom to adapt technology to their teaching styles. However, in order to be active participants, teachers need to acquire basic ICT skills and find about the best teaching practices in order to understand the potential of the new tools, and in order to be able to use them in a creative way.

One of the best ways of convincing teachers to use ICT in their teaching is to use frontrunner teachers—innovators and early adopters—as role models and generators of good examples. Also the enthusiasm shown by pupils using computers is a strong convincing factor for teachers that computers can potentially be beneficial and useful in the classroom. The teachers' involvement and attitudes towards the one-to-one computing project will greatly affect their willingness to cooperate and revise their teaching, which are major determinants of the success of training programs and one-to-one computing projects. In addition, training of teachers to use new technology and digital information needs to be done using a cyclic model in order to incrementally improve skills to more advanced level and in order to update their existing skills.

### 3.3 A Support Model

Like all technology, computers need updating and maintenance. Some of the laptops in one-to-one computing are low-cost products where robustness has not been a prioritized feature (although the XO-1 computer has been designed for durability, too). The OLPC initiative has primarily focused on the design of the XO computers, while strategies for deployment and support have been given less focus [14]. For example, the entry for *support* in the OLPC *deployment guide wiki* consists of only 170 words<sup>4</sup>. The deployment guide lists seven support resources, which form a good skeleton to build on, yet each of the bullets would deserve a handbook article of their own:

- Regional support
- National support
- International support
- University/Secondary school support
- Grassroot organization support
- Peer-to-peer support
- Free and Open Software organizations support

One leading design idea for the XO computers was to modularize them in user-replaceable components, and let the children do the repairs. XO laptops are shipped with an extra 1% stock on top of the order. These extra computers are intended for replacing components in defective devices<sup>5</sup>. However, if this modus operandi is not combined with measures against fraud and corruption, problems may arise [15]. In addition, however modular the hardware may be, software update and maintenance require expert support. When it comes to software problems with the Linux-based Sugar system, we find the idea of primary school teachers and pupils doing the maintenance to be naïve. In the Sri Lankan OLPC initiative, a



**Figure 1:** *Who is to blame when a computer breaks down? Teachers discussing a solution with support staff at the Blackwood School in Sri Lanka. (Photo: Peter Mozelius).*

<sup>4</sup> OLPC Support wiki (2010), “Deployment Guide/Support”, Retrieved 22/11/2010 from: [http://wiki.laptop.org/go/Deployment\\_Guide/Support](http://wiki.laptop.org/go/Deployment_Guide/Support)

<sup>5</sup> OLPC Service Repairs wiki (2010), “Deployment Guide/Service Repairs”, Retrieved 22/11/2010 from: [http://wiki.laptop.org/go/Deployment\\_Guide/Service\\_Repairs](http://wiki.laptop.org/go/Deployment_Guide/Service_Repairs)

dedicated support group from the University of Colombo, School of Computing, assists the schools with more complex problems.

### 3.4 Content in Local Languages

UNESCO, for one, acknowledges that education in a child's native tongue is a "critical issue" [32:§41]. In our work with one-to-one computing initiatives we have experienced a dire need for e-learning objects in local languages. In Tanzania, we have found that there is little freely available e-learning material in Swahili. Similar, in Sri Lanka we have found that the importance of content in local languages cannot be overemphasized. Even in former British Colonies, where English may be the language in secondary and tertiary education, English-only learning content in the primary school does not work. In Uruguay we have found that belonging to a large language group—Spanish in this case—is extremely beneficial, because there is a large amount of material and resources available.

Nevertheless, a lot of learning material in Uruguay needs to be translated from English to Spanish, and a lot of material needs to be made from ground up in order to be useful in the Uruguayan context. The scalability of learning resources across countries in Latin America is, of course, easier and much more economic than in many Asian or African countries. Granted, even without learning material in local languages, one-to-one computing can support classroom teaching and may work as a catalyst for transformative changes in education, but the greater visions of one-to-one computing require availability of learning objects in local languages.

Unfortunately, various one-to-one computing initiatives—such as the "Education for All" initiative [3] as well as the OLPC initiative—are poorly prepared for actually producing learning material, especially in non-English languages. The OLPC initiative has undertaken a serious internationalization and localization effort to translate the XO interface strings, messages, and key web pages into a large number of languages. However, translation of learning material is an operation that is several magnitudes larger in size and effort. Translation of learning material requires the contribution of not only technical people but also local content experts: mathematics teachers, history teachers, religious teachers, and so forth.

There again, it might be unfair to demand that the technology-oriented stakeholders, such as the OLPC Foundation, should bear the responsibility for producing learning content, too. Learning material should be produced by subject matter experts, not by technology experts. A number of critics of OLPC initiatives in developing countries criticize the lack of learning material in local languages, yet they do not propose solutions for the problem. From our perspective, when planning a comprehensive one-to-one



Figure 2: Tamil Language Exercises on an XO Computer. (Photo: Peter Mozelius).

computing project in a developing country, there must always be a plan for acquiring or creating learning objects in the country's medium of instruction.

### 3.5 Contextual Understanding

Computing is always a means to an end; computers are tools for achieving some specific goals in some specific environment. Every context of computer use is unique, goals are always defined in each context of use, and the local conditions and resources vary between locations. Hence, in one-to-one computing projects too, it is imperative to understand the context of implementation. Local conditions relevant to one-to-one computing can be divided roughly into environmental conditions, socioeconomic conditions, and technological conditions.

*Environmental conditions* between countries differ a lot, and how infrastructure, facilities, and equipment have been selected and prepared for those conditions greatly affects the success of any ICT project [4, 13]. Solutions suitable for the cold, mountainous areas of Nepal differ from solutions suitable for the dusty, desert areas of Namibia or the humid, tropical areas of Indonesia. *Socioeconomic conditions* include institutional, educational, economic, cultural, political, and other similar kinds of conditions—each of which greatly affect the success of one-to-one computing projects. Countries differ in terms of, for example, bureaucracy, official procedures, fees, corruption, literacy rate, educational level, and political stability.

Also *technological conditions* differ somewhat between developing countries and industrialized countries. In developing countries, ungrounded assumptions about available equipment, level of infrastructure, or technological preconditions are dangerous. Technical issues concerning IT work in developing countries are discussed in much more detail elsewhere (e.g., [4, 13, 31]), and those issues include, for example, adequate facilities, stable power supply, and secure network infrastructure. In case these considerations are not at place, things tend to go wrong. Take, for example, the case of Galadima School in Nigeria [19], which demonstrates a combination of insufficient contextual knowledge about technology, lack of preventive maintenance, and plenty of bad luck.

### 3.6 Parental Agreement and Support

Parents' reactions when a one-to-one computing initiative is launched may vary from deep curiosity to strong aversion. Two common objections are the worry about children getting an access to computer games and the worry of pornographically material. One one-to-one computing example where students got their hands on explicit sexual material was the Nigerian pilot project<sup>6</sup>, which demonstrated the need to take the parents' fears seriously if one does not want the laptops to be considered a threat.

When it comes to computer games some parents consider them to be something that keeps their children away from schoolwork and from learning useful things. Even when it comes to educational games, many parents seem to have a skeptical attitude [24]. The most negative reactions have come from people involved in Steiner-Waldorf education and anthroposophical pedagogy, where technology in general is seen as something that is damaging the healthy mental development of children and adolescents [30]. And if parents earlier have forbidden their children from watching television, they might not be keen on letting the kids use the Internet [24].

In Asia the parents' responses have been more affirmative, like in Cambodia where "*parents love the laptops because they are the brightest light they have in their homes at*

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<sup>6</sup> "One Pornographic Image Per Nigerian Child", *OLPC News*, July 19, 2007. Retrieved November 23, 2010 from [http://www.olpcnews.com/countries/nigeria/pornographic\\_image\\_child.html](http://www.olpcnews.com/countries/nigeria/pornographic_image_child.html)

night” [1], and in Sri Lanka where some parents said that: “*this is the first new technology that we have got in a very long time and it has brought new energy to the Blackwood school*”. In those cultures where it is appropriate, we would recommend a parental e-inclusion strategy, where each child’s learning activities are extended with parent-child collaboration [24]. If the parents are invited to participate in the exploration of the laptop and the Internet access, the catalytic effect of one-to-one initiatives would be stronger and supervision would happen in a natural way.

### 3.7 Monitoring and Evaluation

Most one-to-one computing initiatives around the world seem to lack a systematic monitoring and evaluation framework. Without such a framework, consistent data collection and fine-tuned improvements as the project progresses will not be possible. Of particular interest to follow up and study are the “21st Century skills” [9]. Those skills consist of 1) Information, media, and technology skills: information literacy, media literacy and ICT literacy; 2) Learning and innovation skills: creativity and innovation skills, critical thinking, and problem solving; 3) communication and collaboration skills; 4) life and career skills: flexibility and adaptability, initiative and self-direction; 5) social and cross-cultural skills: productivity and accountability, leadership and responsibility. The impact of computers and digital media for learning the school core subjects and achieving curricular goals should also be evaluated—though impact assessment is notoriously difficult. Few studies have been published about the learning impact of one-to-one computing [2].

### 3.8 Administrative and Political Support

The proponents of one-to-one computing advocate a wide array of transformations in the educational system: for instance, students will become self-directed learners, education will become student-centered, teachers will turn into guides-on-the-side, and computers will turn into essential learning tools and sources for learning resources. Those changes, however, entail a systemic change, which means that there has to be strong political and administrative support for the one-to-one computing initiative.

The hard lessons of OLPC Foundation in Nigeria in 2007-2008 revealed a number of crucial issues concerning political support for OLPC projects<sup>7</sup>. Firstly, the fears about pornography turned out to be real, as the OLPC pilot project was tarnished by stories in the world media about how schoolchildren surfed porn on donated laptops<sup>8</sup>. Secondly, OLPC became a target of ungrounded lawsuit fishing by a local IT company Lagos Analysis Corp [7]. Thirdly, after elections, change of political regime led to Nigeria pull out of the previous government’s OLPC plan—while it probably did not help the situation that OLPC spokesperson implied that Nigeria’s governmental authorities are “small thinkers”<sup>9</sup>. Fourthly, other players in the field came in the same market with solutions running on Intel, Windows, and Mandriva Linux, and according to some allegations, not everyone played the game completely fairly<sup>10</sup>. According to the news, the Nigerian Minister of Education called the OLPC project in Nigeria a “white elephant” project and claimed that the government

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<sup>7</sup> “OLPC Nigeria One Year Later: Hard Lessons Learned”, *OLPC News*, July 2, 2008. Retrieved November 23, 2010 from [http://www.olpcnews.com/countries/nigeria/olpc\\_nigeria\\_one\\_year\\_later.html](http://www.olpcnews.com/countries/nigeria/olpc_nigeria_one_year_later.html)

<sup>8</sup> “Pupils Browse Porn on Donated Laptops”, *Reuters*, July 20, 2007. Retrieved November 23, 2010 from <http://www.reuters.com/article/idUSL1966647020070720>

<sup>9</sup> “Politics ‘Stifling \$100 Laptop’”, *BBC News*, November 27, 2007. Retrieved November 23, 2010 from <http://news.bbc.co.uk/2/hi/technology/7094695.stm>

<sup>10</sup> “An Open Letter to Steve Ballmer”, *François Bancilhon, The Official Mandriva Blog*, October 31, 2007. Retrieved November 23, 2010 from <http://blog.mandriva.com/2007/10/31/an-open-letter-to-steve-ballmer/> (Cached by Google).

had “discovered that the [OLPC] scheme is a conduit pipe to siphon public funds”<sup>11</sup>. There again, local politicians’ support for OLPC project at Ukombozi School in Tanzania led the regional government to ensure that the school will have electricity by the time the XO-1 computers arrive, and that the teachers will get basic computer training.

### 3.9 Sustainability

Sustainability has been a keyword in development projects for quite a while, though the term has somewhat suffered inflation due to its alleged vagueness, hypocrisy, and delusions of unachievable goals and the wrong agenda [12, 26]. As few people would really defend “non-sustainable development”, the word has become somewhat an empty phrase [20]. However, the concept of sustainability entails several important constituent branches, or “pillars”, of sustainability: environmental, social, and economic sustainability. These pillars of sustainability, along with the somewhat different idea of self-sustainability, are important for one-to-one computing projects, too.

First, in the context of one-to-one computing, the *social dimension* of sustainability can be considered to refer to the idea that by using computers, students’ access to socially and culturally important resources should increase, or that their social capital would increase—neither happening at the cost of anyone else. But there has been little empirical research on the modern myths that computers *per se* foster social justice, democracy, education, various kinds of empowerment, or various forms of equity. Second, in the same context, the *economic dimension* of sustainability can be considered to refer to the idea of a non-zero-sum game where one’s gain is not at another’s loss.

Third, in the context of one-to-one computing, *environmental sustainability* can be considered to refer to the principles of substituting non-renewable resources with renewable ones, and keeping waste generation below the capacity to take care of it [6]. However, we have been unable to find any mentioning of how children’s laptops are collected, reused, recycled, and disposed after their useful life-span. Without proper product life-cycle management and responsible disposal, twenty million children’s laptops can transform from an educational solution to an environmental problem.

However, most commonly sustainability in one-to-one computing projects refers to *self-sustainability*: to the idea that the project should be able to run independently after a certain period of time. That is: one-to-one computing education should continue running (and preferably developing) even after there are no more donations from outside and after there are no more foreign experts overseeing the project. In most countries where the educational system is government-funded and staff is locally educated, self-sustainability refers to independence from foreign funding and foreign experts.

## 4. Conclusions

Decades of research on technology-enhanced learning have shown that new technology alone is unable to bring about any radical improvement in learning outcomes [28]. In a developing country a large-scale one-to-one computing initiative is a vastly expensive project where lack of planning and organization could result in failure and a waste of money. As an educational initiative, one-to-one computing should definitely commit to curriculum development, content development, and teacher training. In that sense, we disagree with Negroponte’s standpoint, and we would include pedagogy, support models, and parental agreement in the crucial considerations that will make or break a one-to-one

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<sup>11</sup> “Nigeria’s Federal Government Shelves One Laptop Per Child Scheme”, *Balancing Act*, #408, Retrieved November 23, 2010 from <http://www.balancingact-africa.com/news/en/issue-no-408/computing/nigeria-s-federal-government-shelves-one-laptop-per-child-scheme>

computing initiative. And in a long-term perspective educational initiatives will scarcely be successful without a strategy for evaluation, administration, and sustainability.

The introduction of computers must always be combined with a pedagogical framework where e-activities are aligned with the school's syllabus. Otherwise computers risk, as the critics in a number of countries have pointed out, becoming toys that hinder teaching and learning instead of supporting it. Every educational context and every school needs a unique support model, and without such support model a one-to-one computing initiative will hardly succeed. Instead of the current support model—a wiki system for general advice—we recommend that every primary school involved in one-to-one computing should be affiliated with a university or similar organization, which provide specialized support staff for hardware and software problems.

Computers and computer systems need frequent maintenance and updating that requires expert knowledge that primary school teachers neither have nor are willing to train for. That being said, we encourage technical training of teachers who are involved in one-to-one computing initiatives. We have, in our projects, learned that increased involvement of teachers and parents leads to greater community acceptance of the project, greater trust between the stakeholders, and generally more fruitful environment for achieving positive learning outcomes.

Content development is a critical element of one-to-one computing initiatives, and it should be done by a team of subject matters experts, instructional designers, and language experts. Without carefully designed content and e-activities in local languages, technology-enhanced learning initiatives are doomed to fail. Just providing computers with a programming environment and expecting the pupils to learn how to program is bad pedagogy. But with well aligned instructional design, and with an activity-oriented pedagogy there could be a substantial impact on primary education in developing regions—given that due consideration is given to all other elements of the learning environment, too.

We would like to encourage broader and more open networks with local, regional, and international partners, who can contribute their different and complementary perspectives—society (users and decision makers), industry (technical providers), academia (research and evaluation)—in order to gain a better understanding of the effects of One-to-one computing in schools. For future research, we recommend that instead of only comparing common components of support models between countries, like this article does, it would be beneficial for the one-to-one computing movement to undertake a more detailed, systemic study of a model applied in one country or in a few schools. Since we think that a thoroughly planned and well-implemented support system is a sine qua non of successful one-to-one projects, a systematic in-depth research study of a well-working support model would be of great interest for practitioners in one-to-one computing projects.

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