Social Science Computer Review
28(3) 381-390

DOI: 10.1177/0894439309346398
http://sscr.sagepub.com


New Technology in Developing Countries: A Critique of the One-Laptop-Per-Child Program

Jeffrey James[1]

Abstract
The one-laptop-per-child (OLPC) project offers no rationale for its view that there should be no sharing in schools. It is certainly not because this view requires no defense. On the contrary, the author shows that the program causes so much to be invested in computers that other educational inputs are entirely neglected and in some cases this is also true of sectors other than education. The OLPC requires poor countries to use fewer students per computer than is recommended even in the developed countries. The author argues, by contrast, in favor of what is defined as a balanced pattern of sharing that reflects the level of per capita income in poor relative to rich countries. The higher is per capita income the less is the need to rely on sharing arrangements and conversely.

Keywords
sharing technology, low-cost computers, balanced expenditure

Proponents of the one-laptop-per-child (OLPC) program have made no serious attempt to justify the granting of a computer to each and every child in developing countries, though this is a cornerstone of the entire project. In this note, I use basic economic reasoning to show that meeting the goal of the OLPC proposal causes severe resource imbalances and negative welfare effects. I use per capita income differences between rich and poor countries to define a ''rational'' number of students per computer per country. Our finding is that the lower is the relative per capita income of a country, the less does it make sense to use the policy on nonsharing as advocated by the OLPC. It is not that there are no grounds for using more computers in the ''production'' of education. Indeed, the substitution of these low-cost laptops for other educational inputs is exactly what should occur (up to a point) on the grounds of efficiency. However, to benefit as many students as possible, these extra computers should be spread among as many students as is technically feasible. Before making this, case let me provide a brief history of the OLPC.

[1]Tilburg University, Netherlands.

Corresponding Author:
Jeffrey James, Tilburg University, 2 Warandelaan, Tilburg 5000 LE, Netherlands
E-mail: m.j.james@uvt.nl

History of the OLPC

The mission of the OLPC is to ensure that all school-aged children in the developing world are able to engage effectively with their own personal laptop, networked to the world so that they can openly learn and learn about learning (laptopfoundation.org/program/).

To this end, the OLPC was designed, mainly in the MIT Media Lab Cambridge, Massachusetts, to produce an ultra low-cost laptop with features designed for developing rather than developed countries (such as open-source software, low power, mesh networked devices, and ruggedness). An initial prototype was presented to the WSIS (World Summit on the Information Society) in 2004 and 2 years later full operations began. Although the target of the project has been to produce a $100 laptop, this has not yet been achieved (with the current price around $175).

Sales are made mainly to governments through a ''give one get one'' campaign allows private buyers in developed countries to donate 1 computer to a school in the developing world. This means that governments in the latter region do not have to rely solely on their own resources (see more on this below). Although the OLPC cannot claim to be the first well-known computer for developing countries (that honor belongs to the Indian ''Simputer''), it can certainly be said to have spawned a lot of interest and activity in this previously neglected market. Intel's ''Classmate'' for example is a serious competitor of the OLPC, as is ''NComputing'' a firm that is based on the idea that modern computers use only a fraction of their capacity (so that there is scope for simultaneous sharing by many users).

To its credit, the OLPC project's ''wiki'' has begun to provide deployment estimates per country (at www.laptop.org/go/deployments), but it is not always possible to discern the period over which the estimates relate. An article published in 2009 suggests that total deployment is now around 1 million laptops (Buderi, 2009).

Developed Country Products (and Standards) and Resource Imbalance in the Third World

Resource balance in a society or for an individual occurs when products and technologies are designed to fit in with average income levels, skills, infrastructure, and so on. To a large extent, R&D and new products are generated in and for the rich countries, which are thus likely to exhibit balanced patterns of resource allocation. The same is true by the way of those with relatively high-income levels, skills, and infrastructure in the developing countries. The problem therefore most likely occurs among the poor majority in those countries, whose preferences are dissimilar to the average of the rich countries (more on this below).

What then occurs is that the consumption of a good (from the developed countries) causes a major and usually negative reduction in resources spent in the same category or even entirely different product categories. Consumer durables for example are a somewhat notorious case in point. A well-known study of Brazil by Wells (1977) found that increased spending on goods such as televisions and refrigerators by low-income households led to an absolute deterioration in their nutritional and housing standards (Wells, 1977). A similarly negative effect on nutrition can be observed when Western processed food products are imported into and consumed by the poor in developing countries. Consider for example the data contained in Table 1.

Maize flour is the traditional staple and bread the more modern product. Weetabix and Weetaflakes are Western ''high-income'' breakfast cereals. The entries in the table show first that ''in terms of nutrient cost these Western-style products were clearly inappropriate to the needs of the mass of consumers'' and they also show ''the relative attractiveness of bread as a convenience staple'' (Kaplinsky, 1990, p. 72). The imbalance in consumption to which these data may give rise is

Table 1. Differential Between Unit Nutrient Costs for 100% Extraction Maize Flour and Locally Manufactured Breakfast Cereals

							Vitamins		
Product	Carbohydrates	Protein	Fat	Ash	Fiber	Calories	Thiamine	Riboflavin	Niacin
Weetabix/maize flour	18	19	45	55	22	21	9	3	4
Weetaflakes/maize flour	22	30	64	68	29	24	12	3	5
Bread/maize flour	4	4	4	17	na	4	2	1	1

Source: Kaplinsky (1990).

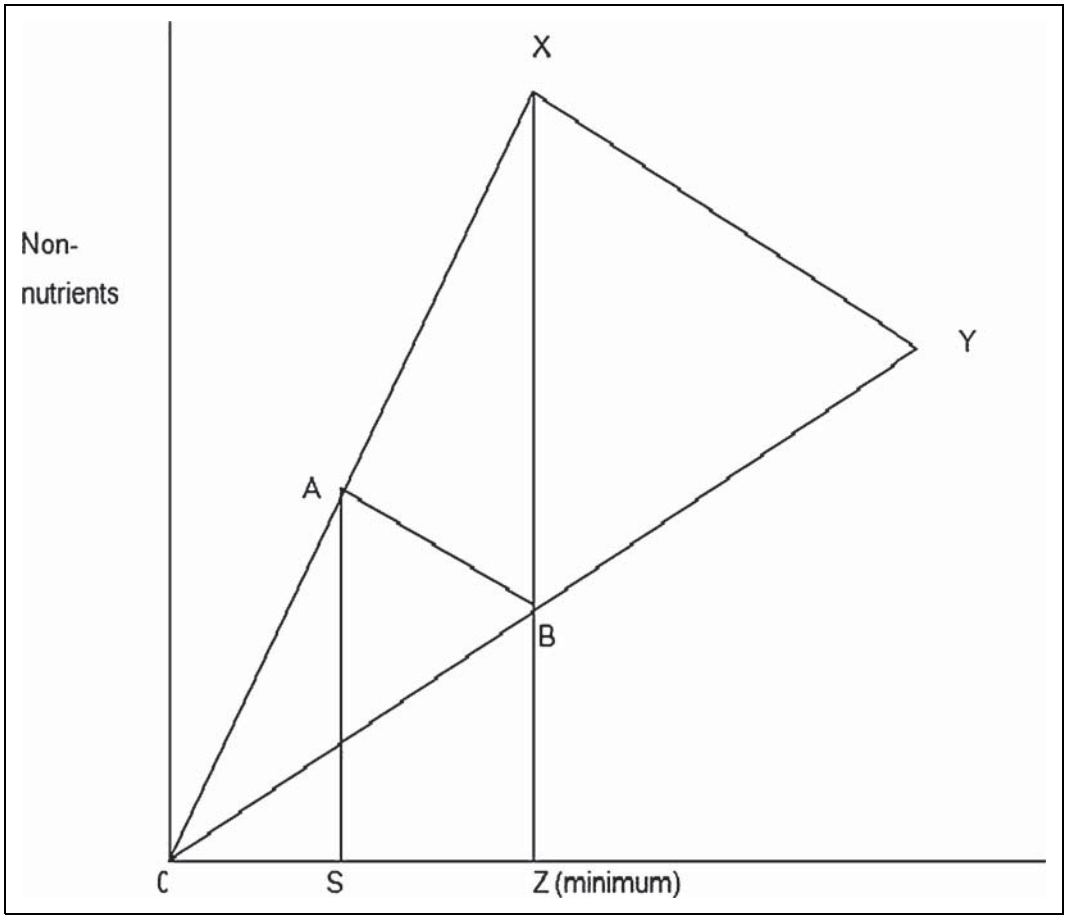

Figure 1. Western products and consumption imbalance in developing countries

perhaps most clearly expressed in Figure 1. (Bread, however, is seen to be a rather attractive alternative to maize flour, in that its unit nutrient costs are close to the latter product.)

Figure 1 portrays goods X and Y as bundles of the two characteristics, nutrients and nonnutrients. Good X is relatively intensive in the latter, and for good Y the opposite holds. Indeed, in a rough way one can conceive of good X as the Western food product and good Y as the local good (maize flour in Table 1). Assume now (purely arbitrarily) that with a given income one can purchase OA units of

the Western product and OB of the local good. In the latter case, I assume further that the minimum amount of nutrients OZ is attainable. If, however, the Western good is purchased by the poor in an amount equal to OA, there will be a sizeable nutrient deficit equal to SZ. This can be considered the manifestation of an imbalance in the consumer's spending pattern. With a more affluent consumer (in say the West), the minimum amount of nutrition can be attained (without distortion) by a higher purchase of the Western good to the level of OX. With a higher income, that is to say, the nonnutritional characteristics can be readily absorbed into the consumer's budget.

Why though would a poor individual engage in consumption that entails an imbalance of the type just described? In all likelihood, the main reason has to do with the advertising and marketing practices of multinational firms in the food processing (and other) sectors. These practices are closely related to globalization as Hawkes (2006) and others (James, 2000) have emphasized. As the former author puts it,

> The globalization of food marketing ... comprises three core components: the globalization of TFCs (Transnational Food Companies) and the foods they promote; the globalization of advertising/marketing agencies; and the globalization of communication technologies. Together, they have increased the power of marketing as an agent of dietary change. (Hawkes, 2006)

Hawkes (2006) also cites evidence to the effect that snack foods in Thailand are being driven by a focus on youngsters between 5 and 24 years old. What is more "a survey conducted in 2004 concluded that the major contributing factor to high-snack consumption among children was the influence of television commercials."

Governments too play a role in influencing the consumption of Western goods by those with relatively low incomes. They often take the point of view, for example, that local products fail to meet certain standards, standards that are invariably of Western origin. A good example is the field of housing where,

> it is common for public agencies to build houses or flats to standards which the majority cannot afford, nor can the country possibly subsidize them on a large scale. On top of this, it is not unusual for governments to prohibit private building of the type of housing the majority can afford and are satisfied with. (Stewart & James, 1982, p. 264)

Purchase of the housing with "too-high" standards involves a disproportionate expenditure on this item compared to other items in the household budget, that is, it leads to imbalances in consumption (or for concentration of public expenditure on housing to the exclusion of other social needs). However, having *no* standards is also undesirable. What are needed are "intermediate" standards between the two extremes.

OLPC and Resource Imbalance

I wish now to apply these concepts to the OLPC and in particular to the choice by governments of the XO (the name of the OLPC computer) for their schools in developing countries. Using initially data from numerous developing and one developing country, I wish to denote and compare three major possibilities. The first is where the objective of the exercise is to provide laptops in the same ratio as in developed countries. The second deals with the case advocated by the OLPC of giving each child his or her own laptop computer. The final option is to apportion laptops to developing country students in the same proportion as differences in per capita incomes of rich and poor countries (expressed as a ratio).

Let us first provide some estimates of the macro-economic imbalance that is associated with the OLPC proposal. There are for example calculations I have made for a poor African country,

Malawi. In particular, I assume that the total number of schoolchildren in that country was 3.3 million (in 2000); that the total cost of supplying OLPC computers to children was $57,750,000; an estimated educational budget of $101,094,000 (in 2003) and a ratio of cost to the budget of 5.7. This estimate is certainly not the only attempt to draw attention to the resource imbalance associated with the OLPC. An estimate for Nigeria comes to the conclusion for example that an OLPC purchase—that is, a laptop for each child—would amount to 75% of total government income. Moreover, the supply of laptops for each cohort of students and the replacement of worn-out computers is found to absorb 13% of government income per year (Vota, 2006).

If it is therefore easy enough to associate the OLPC program with acute resource imbalance at the national level, it is quite another thing to formulate a balanced level of expenditure that confirms to my previous arguments about appropriate technology. I propose that the number of students per laptop computer stands in roughly the same ratio as the difference in per capita incomes between the rich and poor country (the former by definition is taken as the frame of reference in this comparison). This proposal can in fact be viewed as the opposite extreme of the OLPC proposal. Let us then evaluate the numbers that emerge from this concept of balanced expenditure in a comparison of Kenya and the United Kingdom (representing an arbitrarily chosen developed country), bearing in mind that in the real world a minimum of say 30 students per laptop may sometimes be more realistic than higher amounts. The actual number will depend among other things on how the computer laboratory is organized and how often it is used by different groups in the school. One also has to recognize that Kenya is a relatively poor developing country and that comparisons between the United Kingdom and a more affluent country such as Peru may yield a very different result. And in fact the ratio of per capita income in Peru to OLPC computers should, as indicated below, be allocated to students in the ratio of 27:1 (following what I have earlier termed a balanced allocation of resources).

Note though that the purpose is to make the developed country a situation of five students per computer and not one where the OLPC situation prevails. The latter can be calculated by multiplying the per capita income of the United Kingdom in 2007 (equal to $42,740) by five (i.e., $213,700). Five, recall, is the number of computers per student in developed countries, as typified by the United Kingdom. To be more precise, the government agency in the United Kingdom that is responsible for technology and learning in schools puts the numbers at six students per computer in primary schools and three in secondary school (*The Guardian*, January 8, 2008). An OECD Report in 2002 estimates the numbers per computer as 5 for Australia and the United States, 6 for New Zealand and Norway, and for the other OECD countries more than 20 students share a single computer (OECD, 2002). As distinct from the actual numbers of students per computer, it is crucial to realize that the *recommended* level in the United States is 4 or 5 to 1 (U.S. Department of Education, *Internet Access in U.S. schools*, Fall 2000). It is crucial because of its implication that the OLPC is suggesting *a level of sharing that goes beyond what even the experts consider reasonable for the developed countries*. We can now calibrate the per capita income in Kenya in 2007 of $680 against the 1:1 case just calculated (i.e., $680 against $213,700). In particular, the ratio of the former to the latter level of gross national income (GNI) per capita is equal to 0.32% which, in the ratio of 100:32, gives the balanced amount of computer spending per child (in this case, 1 computer should be "shared" by 313 Kenyan students). In the United Kingdom by contrast, the comparable level of sharing is 1 to 5.

Countries with income levels between Kenya and the United Kingdom, therefore, should have estimates of balanced spending ranging from 313 to 5. I illustrate this point with a selected sample of countries from the low-middle income group as defined by the World Bank.

One of the most striking aspects of the table is that the vast majority of the countries could not possibly implement the "optimum" number of students per laptop-classroom size alone would disallow this. Only in the case of Peru is it possible even to debate the number indicated in the final

Table 3. Balanced Number of Students Per Computer (Selected Countries, 2007)

	Per Capita GNI (Atlas Method) in Current Dollars	Ratio of GNI Per Capita to OLPC	Number of Students Per One Laptop
OLPC	213,700	100%	1
United Kingdom	42,740	20%	5
Kenya	680	0.32%	312.5
Low-middle income countries			
Thailand	3,400	1.6%	62.5
Peru	7,958	3.7%	27
India	950	0.44%	227.3
Philippines	1,620	0.76%	131.6
China	2,360	1.1%	90.9
Colombia	3,120	1.45%	69
Dominican Republic	2,038	0.95%	105.3

Note: GNI = gross national income; OLPC = one laptop per child.
Source: World Bank, Key-statistics.

column of the table. What is also striking is that it takes a per capita income of five times the U.K. level to make the one-child policy economically sound or balanced (a level that no country in the world currently attains). Consider finally India's decision to reject the OLPC proposal in the light of the data for this country shown in Table 3. With a per capita income not much higher than low-income Kenya, an OLPC policy in India would be simply impractical, not to speak of economically unbalanced. The Indian decision to reject this policy seems well founded according to the data in Table 2. Urging developing countries to adopt developed-country standards is one thing, but persuading them to *exceed* these standards seems utterly perverse.

The previous paragraph should not however be taken to imply that there is *no* justification for adopting OLPC computers. One reason is that governments and nongovernmental organizations no longer have to bear the full costs of computers. For, beginning in 2007, the project introduced a "give one get one" campaign, whereby individuals in many developed countries can buy an XO laptop for their own use and one for a child in poor countries. Together they cost the purchaser $400. A second reason, which is also true of Intels's low-cost computer, "The Classmate" and other similar alternatives, is that a reduction in the price of computing relative to other factors of production induces an economically rational substitution of this for other inputs. Figure 2 illustrates the process.

$O'O'$ shows the input combinations that can be used to produce a given output (in this case education). The initial equilibrium occurs at point Q where the price ratio line $R'R'$ is tangent to the $O'O'$ curve. Now assume a fall in the price of computers relative to other inputs, causing a shift in the price ratio line to $K'K'$ and an increase in the number of computers relative to other inputs, that is, from OB to OT (the extent of the shift depends on the slope of the curve $O'O'$ and the change in the price of computers).

These potential efficiency gains may however be difficult to realize in practice, the reason being that computer use requires certain other complementary factors. The argument is made by James (2008). In Figure 3, for example skills are shown as constraining computer use and indeed below a certain minimum amount of this factor, further computer use yields no extra gains in output. Indeed in the area below the minimum of skills, (Op) output is zero. No amount of computers can increase output in this area. Note too that the increase in computers induced by efficiency considerations is constrained by the low *existing* levels of this form of information technology in many poor countries. If the use of an input is limited, that is to say, even a relatively large fall in its price will not induce a large absolute increase in its numbers.

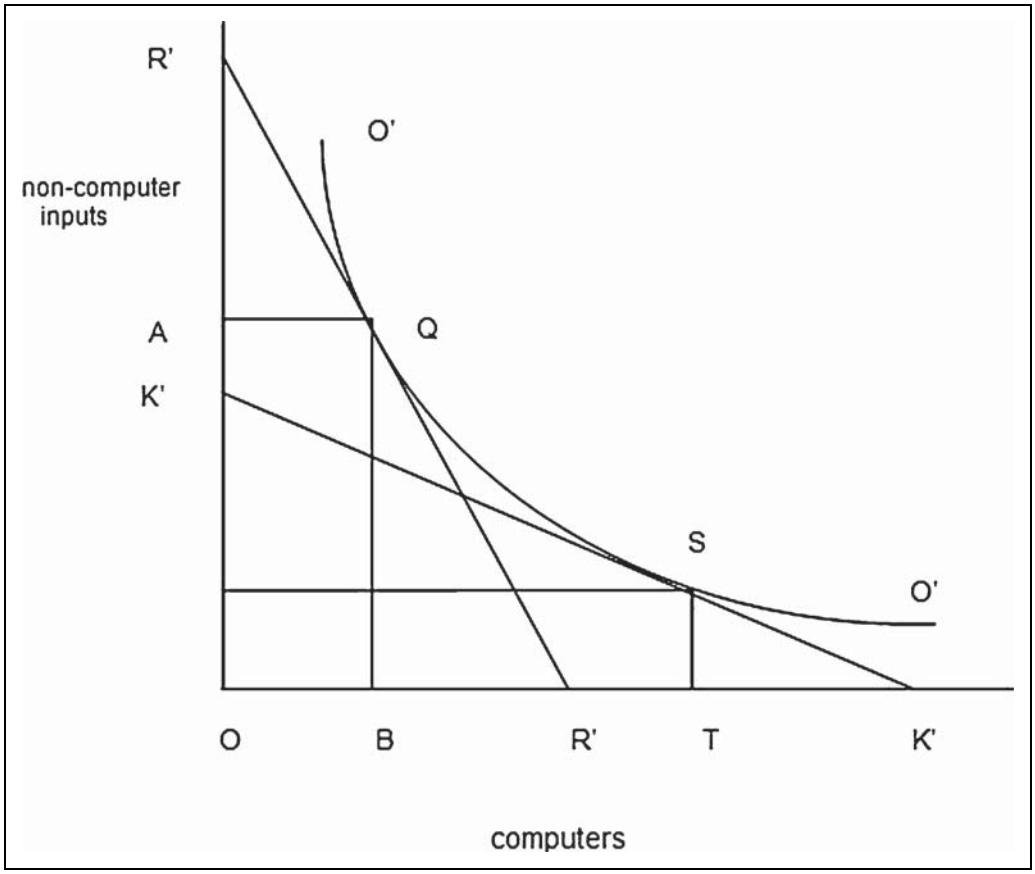

Figure 2. Substitution of computers for other inputs

The need for possible increases in teachers and skills is largely neglected by those associated with the OLPC project even though such increases could substantially increases the cost of the endeavor. They are neglected mainly because it is assumed that school-age children can ''teach themselves,'' an educational philosophy that is associated with Seymour Papert and others. But while it is reasonable to suppose that children will take over part of the role formerly played by teachers, it is hard to conceive of a ''teacherless world.'' After all, proponents of the OLPC have to confront the current education system in most developing countries where students are taught in a traditional way with teachers playing the central role.[1] This system cannot easily be abolished at least in the short run and probably beyond. I have unfortunately seen no evidence across countries with OLPC computers that might help answer these questions. Certainly, some developing countries such as Peru have found it necessary to train teachers in rural areas, where training involves not only increased familiarity with the OLPC computer but also operation and maintenance of the product (Talbot, 2008).

Conclusions and Policy Implications

For all the attention it has received in recent years, one might have thought that the idea of giving a laptop to each schoolchild in developing countries had been subject to intense scrutiny.

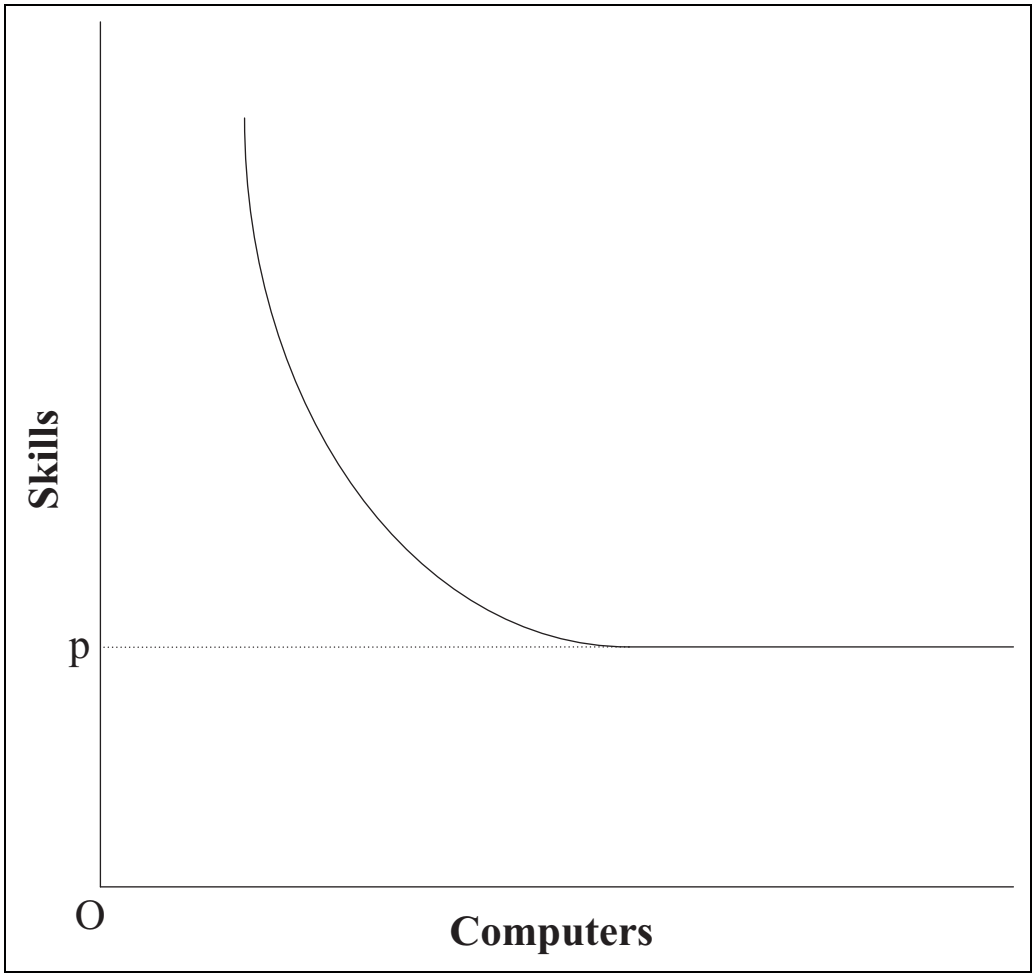

Figure 3. The skills constraint on computers

Unfortunately, it has not been seriously reviewed by either proponents of the idea or anyone else for that matter. The purpose of this note is hopefully to initiate a debate on the economics of the issue.

From an economic point of view, there are in fact two separate roles played by the OLPC program, roles that together determine its overall appropriateness. One is as a highly commendable low-cost computer designed specifically for schoolchildren in developing countries. The other is an attempt to exceed even developed country levels of sharing, an endeavor, which I show leads to serious resource imbalance especially in the poorest countries. Whereas for example my calculations show that a balanced number of students per laptop would be above 300 in Kenya, this number falls sharply in Peru, a much richer country. I am also able to distinguish between the costs of extending sharing to the developed country level and those due to an OLPC policy.

One of my conclusions is that with growing interest in technology sharing as a means of reaching the poor, proponents of the OLPC should seriously reconsider their position (no-sharing) on this issue, instead of focusing only on the costs and suitability of hardware and software. If this does not occur (and perhaps even if it does), governments have several other options. One is to purchase Intel's ''Classmate'' computer at a similarly low price and let it be shared by as many students as

is thought desirable. Alternatively, at what appears to be a still lower cost, there is a product based on sharing that has already been successful in various parts of the developing world. Produced by a company called ''NComputing,'' the idea is to divide up the resources of a computer in a way that permits up to 30 people to work together and independently on separate monitors. (See the interesting discussion in Greenberg, 2008.) Less well known are attempts to induce sharing of computers by providing each child with a mouse and cursor. The software entailed allows a single computer to connect with multiple mice, each of which belongs to an individual student (Pawar, Pal, & Toyama, 2006).

Finally, I would like to question the progress being made by the OLPC project toward its avowed goal of reducing global poverty. On the one hand, the vast majority of laptops from the project have gone to three relatively wealthy Latin American countries, while on the other, the allocation of health and education resources in these countries is notoriously unequal.

Notes

1. ''Learning by doing may be a radical approach not appreciated by local teachers used to teaching by rote (teaching to test). Indeed, OLPC seems to imply that teachers aren't central to the educational process and that the kids will learn by doing themselves'' (Nussbaum, 2008). The same author also notes that ''Intel has put real money into teacher training and digital curriculum development.''

Declaration of Conflicting Interests

The author declared no conflicts of interest with respect to the authorship and/or publication of this article.

Funding

The author received no financial support for the research and/or authorship of this article.

References

Buderi, R. (2009). OLPC 2.0: After layoffs, One Laptop Foundation reboots with new focus and big plans. Retrieved March 15, 2009, from http://www.xeconomy.com.boston/2009/01/29/olpc-20-after-layoffs-one-laptop/

Greenberg, A. (2008). One virtual PC per child, Forbes, 13 October. Retrieved February 7, 2009, from http://www.forbes.com/2008/10/10/ncomputing-olpc-india-tech-per-sonal-cx_ag_1031ncomputing.html

Hawkes, C. (2006). Uneven dietary development: linking the policies and processes of globalization with the nutrition transition, obesity and diet-related chronic diseases. *Globalization and Health*, *2*, 1-18.

James, J. (2000). *Consumption, globalization and development.* London: Macmillan.

James, J. (2008). Re-estimating the difficulty of closing the digital divide. *Journal of the American Society for Information Science and Technology*, *59*, 2024-2032.

Kaplinsky, R. (1990). *The economies of small.* London: Intermediate Technology Publications.

Nussbaum, B. (2008, September 28). Where are the teachers in the debate over OLPC? *Business Week*. Retrieved January 9, 2009, from http://www.businessweek.com/innovate/NussbaumOnDesign/archives/2007/09/where_are_the.html

OECD. (2002). *Education at a glance.* Paris: OECD Indicators.

Pawar, U., Pal, J., & Toyama, K. (2006). Multiple mice for computers in education in developing countries. IEEE/ACM International Conference on Information and Communication Technologies for Development, ICTD.

Stewart, F., & James, J. (1982). *The economics of new technology in developing countries.* London: Pinter.

Talbot, D. (March 27, 2008). Laptop training begins in Peru. *Technology Review, Editors Blogs*. Retrieved April 9, 2007, from http;www.technologyreview.com/blog/editors/22041

United Nations Development Programme. (2006). 5th Kenya Human Development Report.

Vota, W. (2006). OLPC in Nigeria by the Numbers. *One Laptop per Child News*, Retrieved October15, 2008, from http://www.olpcnews.com/countries/Nigeria/olpc_in_Nigeria_budget.html

Wells, J. (1977). The diffusion of durables in Brazil and its implications for recent controversies concerning Brazilian development. *Cambridge Journal of Economics*, *1*, 259-279.

Bios

Jeffrey James is professor of development economics at Tilburg University in The Netherlands. He has worked as a research fellow at Queen Elizabeth House, Oxford, and as assistant professor of economics at Boston University. He can be contacted at m.j.james@uvt.nl.