

The Digital Frontier: Policy Issues and Recommendations for Laptop Computers in Science Learning

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Abstract

Laptops belong to the new frontier of technology use in schools around the world and are finding their way into science classrooms. This paper considers policy issues and makes recommendations for laptop computer implementation in science learning. Although the analysis and findings apply directly to science education, policy recommendations also likely apply across disciplines and have a broader application. Enhanced access to handheld computers in tandem with complementary resources may help to break down socio-cultural barriers. Higher level use of laptops in elementary, middle and secondary grades is needed to maximize benefits to students. The unique advantage of anywhere, anytime use that laptops offer must be weighed against initial and long term costs to sustain quality. As educational leaders and policymakers develop plans for future school and community needs, they are encouraged to consider the role of laptops and the relationship to education goals. If leaders decide to invest in laptops, they must determine how the technology can best be incorporated in the curriculum and built into teacher preparation and continuous professional development programs.

1. Overview

Laptops and wireless networks are among the fastest growing technologies in schools and will increasingly become part of education politics and policy debates. The purpose of this paper is to revisit the data on laptop computer use in school science from a global perspective reported in Kumar (2004). Although the findings reflect science instruction, we argue that the policy implications are not confined to one subject area but rather are transferable across disciplines and have broad application. The analysis was based on three criteria: grade level; the InfoTech hierarchy of use (Owen, Calnin, & Lambert, 2002); and models of laptop use. Grade level analysis involved data sorted by elementary, middle, and secondary. The InfoTech hierarchy, according to Owen, et al. (2002), is a framework for how computer technology is used in teaching and learning. It is comprised of seven categories including: Support, for example database management and graphic

presentation; Link, for example email and videoconference; Resource, for example researching the Internet and accessing electronic databases; Tutorial, for example drill and practice; Curriculum Adjunct, for example subject specific data analysis and graphing; Curriculum Alternative, for example robotics; and Exploration and Control, for example simulations. (See Owen, et al. [1997] for more details on the InfoTech hierarchy.) Finally, there are three primary models of use—concentrated, dispersed, and class set—as well as a mixed usage model (Rockman, et al., 1997; Belanger, 2000), which will be described later in the paper.

2. Findings & Discussion

The analysis is limited because data are not available for all seven continents. The findings represent data from Asia, Africa, Australia, and North America, confining the discussion to these four continents. Also, the database did not uniformly provide information for the four continents about laptop use according to grade levels, elementary, middle and secondary, thus we do not have a complete picture of how laptops are used by grade level. The study is delimited to use of laptops in science classrooms by continent.

The data source for the analysis was published literature dealing with laptop computers in science in the Education Research Information Center (ERIC) and WilsonSelectPlus databases. Initial data search produced 82 pieces of literature which were screened for articles dealing with laptop computers in K-12 science resulting in a sample of 16 journal articles, conference presentations and reports from North America, Asia, and Africa. The sample was analyzed using the criteria the InfoTech hierarchy of use, models of laptop use, and grade level use mentioned elsewhere in this paper.

The four key findings that are explored in this paper and mined for policy implications follow. First, there is inequitable laptop use in science classrooms across four continents. Second, laptops enjoy greater use in the upper grades. Third, laptops are utilized largely for instructional

support purposes; however they are also frequently used for application of critical thinking skills. Fourth, the most common model of use is concentrated where each student has access to one laptop computer for school and home.

2.1 Inequity

There is inequity in laptop use in science classrooms. Only about 6% of the samples analyzed are from Asia and Africa each, and 13% from Australia while 75% are from North America (See Figure 1).

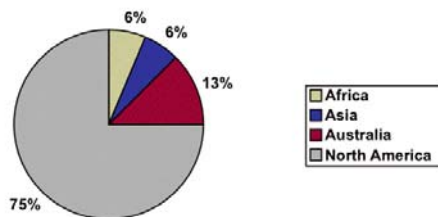


Figure 1. Analysis sample grouped by continent

The wide disparity in the availability of hand-held computers coupled with disparity in availability of personal computers for students around the world contributes to uneven opportunities for schools to teach learning skills and knowledge required in the 21st century. The unique versatility afforded by hand held computers means that the potential for aiding instruction goes beyond the typical school boundaries of space and time. A student assigned a laptop that may be taken home has a distinct advantage over individuals without after school computer access. The fast increasing numbers of cellular networks coupled with the growth of wireless connections worldwide, means that hand-held computers may also open doors to the Internet for people without previous access.

Although there is minimal evidence that laptop use increases standardized test scores, in a study of 10 schools in the US it was found that the one-to-one laptop learning programs facilitate 21st century learning skills, greater engagement through multi-media, more and better writing, deeper learning, and make it easier to integrate technology into instruction (Warschauer, 2006). This suggests that laptop use in classrooms has advantages for all students, including groups that have been marginalized.

When students have the appropriate technology, they can take advantage of the rapidly growing virtual learning opportunities. For example, students with laptops are equipped to utilize virtual science laboratories and may take online courses not available to them otherwise. The data indicate that laptops are being used in science instruction to facilitate virtual simulations and higher order skills (See Figure 3, Exploration and Control). This becomes especially significant in communities that cannot afford instruction in all subject areas, such as advanced level courses. Also, schools and policymakers are showing interest in electronic textbooks that may add to or eventually replace traditional texts. Laptops would help ensure that students have the option to utilize electronic textbooks, do homework, research the Internet, and communicate day or night, seven days a week.

2.2 Grade Level Use

In school science, secondary grades account for 88% of laptop computer use when compared to 13% each in elementary and middle grades to include three overlapping grade levels use (see Figure 2).

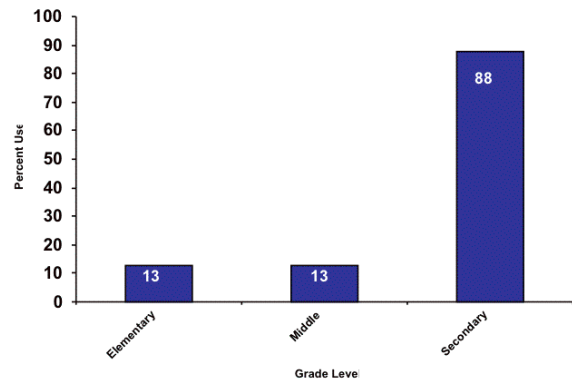


Figure 2. Grade level use

The proportions may be somewhat inaccurate, however, because of overlapping grade levels and because about 13% of the sample analyzed did not provide any information on grade level use. Even so, it is clear that lower grades have significantly less access to laptop computers.

It is not surprising to find greater implementation in the upper grades. Some policymakers may decide in times of limited resources to provide laptops first to older students who are getting ready to enter the workforce, and eventually expand the program to the younger population. There is also the belief that children in the lower elementary grades are not

ready for the responsibility required to take care of and manage the equipment, particularly if the school is using the concentrated model that allows the computers to follow the children home. Yet it has been found that the self-contained or homeroom arrangement typical in elementary settings is conducive to “qualitatively different learning experiences...where computers are made integral to the curriculum and used across a range of subjects” (Owen, Calnin & Lambert, 2002, p. 138). It may be worth the extra effort to provide laptops in the elementary grades and adjust use accordingly.

2.3 InfoTech Hierarchy of Use

The most common uses of laptops across the four continents are data management, problem solving, and Internet searches, representing the following three areas of the InfoTech Hierarchy: support (81%), exploration and control (69%), and resource (56%) (see Figure 3). Educators utilize laptops for multiple purposes ranging from simple spelling and grammar checking to application of sophisticated decision-making models, and this can occur within the same classroom, thus the figures for use exceed 100%.

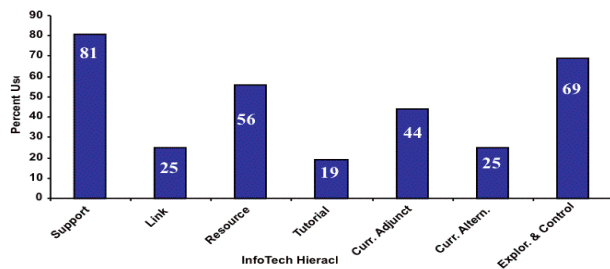


Figure 3. InfoTech Hierarchy of use

The support mode describes the use of hand-held computers “to enhance the presentation of work” and data management, including word processing, data bases and spreadsheets; the exploration and control category describes usage to “facilitate testing out solutions, decision-taking and problem-solving;” and the third category, resources, describes use of the laptop to access “information and other resources,” including the Internet (Owen, Calnin & Lambert, 2002). This finding tells us that for science instruction laptops are, similar to what we find with personal computers, used largely for instructional support purposes. They are also used a good deal of the time, however, for application of critical thinking skills. Laptop use as framed by the InfoTech Hierarchy demonstrates that

the full potential of the hand-help computer is far from realized.

2.4 Models of Laptop Use

Among the four models of use across the continents sampled, the concentrated model (56%) is the most common model where every student has access to one laptop computer for school and home (See Figure 4).

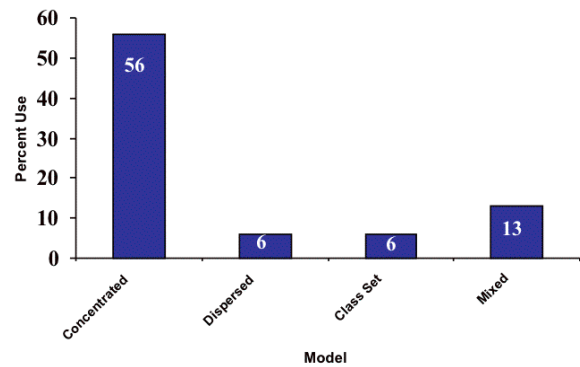


Figure 4. Models of laptop use

It comes as no surprise and for good reason that the most popular model is concentrated because this allows a student to take advantage of the equipment anytime, anywhere, the most unique feature of the hand-held computer. In contrast, a dispersed model (6% of sample) provides a limited number of laptops in classrooms (5-20) that are primarily for in-school use. The class set model (6% of sample) provides a set of laptops on mobile carts that are available for an entire class; the set of laptops can be shared with other classes. In the mixed model (13% of sample), laptops are used in some combination of the other models, for example a portion of the laptops may be used in concentrated fashion while others are reserved for class sets.

Budgetary constraints may prevail and force schools to choose the more restrictive models of use that do not yield full advantages. Yet the nature of the laptop allows for flexibility and the model of use could shift over time.

3. Policy Implications & Recommendations

What are the policy implications for the global use of laptops in science instruction? How might educational leaders and policymakers best approach the use of laptop computers in schools?

First, laptop computers must be considered in the context of equity or what Warschauer (2002) calls “technology for

social inclusion.” It is recommended that handheld computers become a larger part of the global effort to bring technology to people and places that have not yet had access or only limited access. This movement is clearly underway with major initiatives such as One Laptop Per Child which aims to provide inexpensive, wireless laptops to children in developing countries (see <http://www.laptop.org/>).

Schools that adopt the concentrated model and provide hand-held computers for students who do not have computers in their home can dramatically increase computer and Internet access, and help to ensure participation in the digital world. Even in settings where it is not feasible to provide a laptop computer to each student, if the laptops allow the school to expand access during the school day, there are academic advantages. In places where people are geographically dispersed, such as rural areas, there are distinct benefits for distance learning.

The videoconferencing capability of laptop computers further facilitates Internet communication and virtual learning. A note must be made, however, that teaching science via the Internet demands powerful computers capable of handling simulations, multimedia presentations, and adequate technical assistance for uninterrupted delivery (Kumar, 2001). This is a reminder that advanced hardware and connection speed, in addition to technical support, are important considerations for program planners. It is insufficient simply to provide the hardware without considering the full picture of what resources and systems are needed for quality application and sustained access.

It is also recommended that international, national, and regional databases expand tracking of computers in schools to maintain information about laptop use. It would be helpful to know what model of use is employed and by grade level, as well as how hand-held computers are being used to balance inequities. Policymakers would benefit from knowing if and how various models have contributed to student learning, as well as how this varies across grade levels, to assist with decisions regarding how to invest in technology. It would also be useful to look at how laptops are providing computer access to students who do not have computers in the home to determine if a laptop program would best serve a particular community.

A second policy implication is that the appropriate grade level for laptop use is elementary through secondary, with the understanding that students in the early primary grades may not be ready to manage their own computers. Laptops are currently more prevalent in the upper grades and this is an issue to be addressed over time. Given the development of new designs for hand-held devices, such as using a cell

telephone as a computer, they may become more easily manageable for students in the early grade levels.

It is recommended that there be direct involvement of parents and/or grandparents, siblings, and guardians, particularly at the elementary level, to assist with management and to encourage home use. Involvement of the family brings an added benefit of helping to bridge school and home, always a worthy goal. It also may assist in expanding computer access to older generations.

A third policy consideration, and most significant to educators, is how laptops will be utilized to improve teaching and learning. Handheld computers empower students with more control over their learning and teachers with their teaching (Milner, 2006), for example “handheld devices empower teachers with assessment data they can put to immediate use” (p. 31). The curriculum must be considered in conjunction with decisions to purchase classroom technology, and assessed after in place to see if and how goals are being met. Computers are a means to the kind of learning that we expect of our students today, such as critical thinking, problem solving and in-depth exploration (Kumar, 2005; Kumar, 2003b; Vye, Schwartz, Bransford, Barron, Zech, & the Vanderbilt CTGV, 1998). It is best to include teachers and curriculum developers in the decision-making to ensure technology is integrated with curriculum goals. The InfoTech Hierarchy of use provides a framework that could be helpful to teachers when planning their curriculum. The range of use is wide and has yet to be fully realized. Once it is decided that there will be a laptop initiative, program evaluation also needs to become part of the plan.

It is recommended that the preparation, professional development and support of teachers be included from the point of start up in policy and planning decisions. The support of teacher learning is critical to student skill development and learning, thus needs to be considered a cornerstone of the program. Often neglected (Cochran-Smith & Lytle, 2001, Darling-Hammond & Sykes, 1999), there exists a broad array of professional development models that can be utilized to meet the learning needs of teachers, including models that can lead to transformational learning (Drago-Severson, 2004). Also, ongoing technology support for software and hardware, including virus and security protection, is essential for best results and for sustaining programs, similar to what has been found with desktops. When equipment breaks down, requires updating to be compatible with new software, becomes incapacitated due to viruses, the laptops cannot yield the desired results and the investment is in jeopardy.

It is recommended that colleges of education and local governments explore ways to provide student-teachers with their own laptops and that laptop use be incorporated into the pre-service curriculum for education majors at all levels, elementary, middle and secondary. This sets the stage for infusing computer use into the curriculum. "The use of information technology in science teacher education is a major area of research and development" (Kumar, 2003a, p. 84). Research will need to be conducted to see if and how teacher use of laptop computers leads to higher order use of computers in teaching and learning in the classroom.

Fourth, a cost-benefit analysis of the various models of use should be conducted prior to start up to determine what best suits the schools and community. The most popular concentrated model of "anywhere, anytime" use provides distinct advantages over the more limited use models. If this does not match the budget or particular needs of a community, variations on the model of use can be explored. When the laptop is restricted to use by place and time, however, the full benefits of the hand-held computer are not being realized. Eggers, Snell, Wavra, and Moore (2005) presented an example from Sarasota County, New York where school districts have created opportunities to share technology that can reduce software and personnel cost, and make the project more feasible. With the increasing availability of wireless networks and reduced cost of hardware, it is more possible than ever to implement shared laptop computer access in economically disadvantaged schools.

Finally, policy considerations at the ground level are wide ranging and require attention. They include matters such as how to monitor students who are off task, how to monitor student access to inappropriate web sites, availability of software in diverse languages, the problem of identity theft whereby a student or parent's financial and other personal information could be abused by a computer hacker, how to cope with loss and damaged equipment, determining if laptop use is mandatory or voluntary, choosing to purchase or lease computers, and deciding what happens to the computers at the end of a school year. Long term financial planning at the local level is critical to success. If there is not a plan to administer and finance the program over time, the initial investment of large sums of money and other resources may be jeopardized.

4. Conclusion

As educational leaders and policymakers strive to enhance academic achievement and strengthen computer literacy, laptops are increasingly expected to enter policy debates and find their way into the hands of students across the globe. Often policymakers are left with no choice but to make decisions affecting education based on the face value of

research and development efforts that are not-so-well-informed and of limited scope, and based on opinions of politicians. We think the data is clear that laptop computers have the potential to improve classroom practices in science and other subject areas of instruction, but we do not see them as the route to reforming schools and raising test scores. They should not be touted as a panacea for school science reform yet they do offer benefits to learners and because of their unique design improve access to educational opportunities.

Laptops are convenient, sophisticated tools that have the potential for improving science learning provided educators know how to use them appropriately and the infrastructure to support use is in place. When educational leaders and policymakers consider the pros and cons of laptop use in schools, the decision must ultimately be based on how hand-held computers contribute to learning and further the community's education goals. Educators are encouraged to cultivate high-level curriculum applications and increase accessibility across socio-cultural barriers. Beyond the classroom, continuous access to computers at the work site and home is necessary in the global communications network. Laptop computers have a distinct advantage over desktops: they may be easily used anytime inside and outside the schoolhouse by students and families, and for communities that have been slow to connect, the digital inequity within and across nations diminishes.

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