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Commentary: It Is Not Only About the Computers: An Argument for Broadening the Conversation

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Abstract

In 2002 the members of the National Technology Leadership Initiative (NTLI) framed seven conclusions relating to handheld computers and ubiquitous computing in schools. While several of the conclusions are laudable efforts to increase research and professional development, the factual and conceptual bases for this document are seriously flawed. The NTLI members' failure to address market forces, teacher agency, and sociocultural influences on schools and instruction perpetuates harmful myths about educational computing and makes successful integration of handheld computers less likely. The author argues for a more realistic, holistic, and teacher-friendly approach.

The following is the final paragraph from a report on the 2001 meeting of the National Technology Leadership Initiative (NTLI) Retreat:

> During the course of their careers, teachers beginning to teach today will enter a future in which every child has a tablet-sized computer connected to a wireless network. The technological capacity for innovation will be available to future educators. The educational benefits of coming technological innovations will depend upon how we plan for this future. The collaborative efforts of the teacher educator associations representing the core content areas are designed to help ensure that those benefits are realized. (Bell, 2001)

The 2001 National Technology Leadership Retreat set the stage for the group's 2002 National Technology Leadership Summit, which focused on ubiquitous computing (UC) and its impact on schools, teachers, and students. (In education, UC is generally defined as an environment where each student has a wireless computing device; see, e.g., Bull, Bull, Garofalo, & Harris, 2002). Results of the 2002 summit included seven conclusions based on the deliberations of representatives from the Association for Science Teacher Education, the Association of Mathematics Teacher Educators, the College and University Faculty Assembly (CUFA) of the National Council for the Social Studies (NCSS), the National Council of Teachers of English, Conference on English Education, the Society for Information Technology and Teacher Education and the International Society for Technology in Education. (***Editors' note:*** See the Resources section at the end of this article for URLs to all Web sites mentioned.)

The CUFA representatives to the NTLI Summit (van Hover, Berson, Bolick, & Swan, 2004) set out those conclusions and explored their implications for social studies education. The conclusions developed by the Summit participants pertaining to UC were as follows:

1. Ubiquitous computing will be a widespread force in schools by the end of the decade or sooner.
2. Ubiquitous computing will be a disruptive cultural force with great potential for good or ill.
3. Educators at all levels have a responsibility to articulate constructive visions for ubiquitous computing.
4. Educators must be prepared to use ubiquitous computing to advance teaching and learning.
5. Educators must work with hardware and software developers to shape pedagogically sound educational tools and evaluate them before widespread implementation in schools.
6. Small-scale pilot initiatives need to be immediately undertaken to demonstrate feasibility across a demographically-representative range of schools before ubiquitous computing takes place on a larger scale.
7. Pilot initiatives should be evaluated to ascertain the effect of ubiquitous computing on teaching and learning, and these findings should be used to guide future educators. (van Hover et al., 2004, p. 107)

These seven conclusions raise significant issues for computing, both in education, generally, and in social studies, specifically. Among the most important and positive are the call for substantial research efforts into "the effect of ubiquitous computing on teaching and learning" (van Hover et al., 2004, p. 107), the importance of professional development efforts to help teachers visualize and implement innovative pedagogical practices using computers' unique capabilities, and the recognition of significant impacts of computing on students and schools.

The benefits of the formula set out in these conclusions are already being felt. In addition to a marked increase in literature showing examples of handheld use in classrooms (Johnston, 2003; van 't Hooft & Kelly, 2004; Zurita & Nussbaum, 2004), research reports examining handheld computer use in teacher education (Wangemann, Lewis, & Squires, 2003) and in professional development (Johnston, 2003) have recently been published. These types of efforts to increase the knowledge base on which to make decisions about educational uses of handheld computing must be encouraged and continued.

Unfortunately, positive suggestions enumerated in the Summit's conclusions are overshadowed by fundamental problems in both conception and articulation. Although such problems might be passed over as insignificant, two factors suggest that the issues in the conclusions should be the subjects of continuing conversation. First, these conclusions were written and promoted by several of the most influential groups of teacher-educators in the United States. Second, there are several errors of commission and omission reflected in the conclusions that are present in much of the literature dealing with the integration of computing technologies into education.

Focus on Technology, Not Education

The most significant flaw in the conclusions is a logical outgrowth of the group that created them. The National *Technology* Leadership Initiative is a collaboration of teacher education faculty and the U.S. Department of Education that was created in an effort to address the Department's conclusion "that preparing technology-proficient educators to meet the needs of 21st-century learning is a critical educational challenge facing the nation" (Bell, 2001, p. 517). This mission puts technology, and specifically computers, at the forefront and contributes to a mindset that posits computers as the main factor in educational improvement.

I am not dismissing computers' role in educational settings, nor the considerable educational benefits of improved computer use. My point is, rather, that thinking of education in terms of computers redirects energy and resources away from larger problems in education. In other words, this approach puts the cart before the horse. The clearest evidence of this mindset is the conclusion proposing that, "pilot initiatives need to be immediately undertaken to *demonstrate* feasibility" (van Hover et al., 2004, p. 107) of UC. A group with less faith in technology and more focus on education would instead advocate a research program to *investigate* the possible costs and benefits of UC. Rather than assessing the status of the technology field to see where education fits in, we should be assessing the status of education to see where computers fit it (see, e.g., Saye & Brush, 2004).

Moore's Law Misapplied

A further example of where foregrounding technology affects the Summit's conclusions is in the "factual" argument set out as the basis for the first conclusion. This conclusion states, "Ubiquitous computing will be a widespread force in schools by the end of the decade or sooner" (van Hover et al., 2004, p. 107). Educational computing advocates have made similar claims repeatedly (see, e.g., Bork, 1980, 2003). In this case, the rationale for the claim rests on the highly questionable assumption that future reductions in the costs of wireless handheld computers will eliminate access concerns and turn the dream of ubiquitous computing into reality.

In their 2001 meeting the Summit participants' focus on technology led them to rely on the assertion in Moore's Law that there will be a 50% decline in the cost of computing every 18-24 months (Moore, 1965) to suggest that "in practical terms ... a handheld computer that costs $300 today [2001] will be $150 in 18 months and $75 in three years" (Bell, 2001) [and by extension $18.75 in 2007]. Van Hover et al. (2004) used this same logic and, in fact, the same set of numbers in their article, and argued that this price reduction will "certainly allow school systems to afford one wireless portable computing device per student by the end of the decade" (p. 108).

There are two significant problems with this argument. First, Moore's Law deals with the ability to fit increasing numbers of transistors on a single circuit. In other words, to increase the number of calculations a given circuit can perform at a "minimum cost per component” (Moore, 1965). This allows the inclusion of more computing power into hardware and thus allows more complex calculations to occur without increasing costs. Although the cost of making a particular component, thus, may drop linearly and as radically as predicted, it is entirely less clear that computer prices will follow.

For example, PCWorld’s best buy in the “advanced PDA [Personal Digital Assistant]” category in April 2002 was the Casio Cassiopeia E-200, which retailed for $545 (Thornton & Aquino, 2002). The most recent PCWorld.com PDA ranking (September 2005) lists models as best buys based on their operating system. The best buy Windows system PDA was the Dell Axim X50v ($499). The best buy Palm OS system PDA was Palm Tungsten T5 ($399; Rebbapragada, 2005).

Thus, while prices have come down, the reductions are not nearly as drastic as Summit’s participants projected. Also, a search for the Casio Cassiopeia E-200 revealed that this PDA is now unavailable from retailers. The only place where it could be purchased was on Ebay. There are other, similar examples that suggest that the technical implications of Moore’s Law cannot be transferred directly into the marketplace.

In addition, anyone who has tried to purchase new software for a computer with a 486 processing chip understands that manufacturers take advantage of increasing computing capacity by writing programs that require more computing power. Even if the current version of (for example) Microsoft Excel is sufficient for many social studies-specific applications, the likelihood that a Pentium III grade processor *and* a compatible version of Excel will be available for schools to purchase in 2010 is extremely low. A much more likely scenario is that increasingly powerful machines and computing-intensive software will be the only options on the market. These machines may calculate at a fraction of the price of current hardware, but are unlikely to be available at less than 1/10 of current prices.

In addition, the price of technical support for the thousands of individual computers involved in ubiquitous computing will certainly be a multiple, rather than a fraction, of school’s current technical support budgets. For example, the Henrico County, Virginia, School District provides wireless laptop computers for all secondary students. The 2004-2005 expenditures to continue this program, including technical support and teacher professional development (the initial outlay for hardware was completed in prior years) was $14.6 million (Henrico County VA Public Schools, 2006).

A similar size school district without the emphasis on technology, the Buffalo City School District, does not have a separate budget category for technology (Buffalo Public Schools, n.d.). Combining the 2004-2005 budget categories for Staff Development (p. 133), District Information Technology Services (p. 256), and Computer Assisted Instruction (p. 257) shows a total expenditure of under $4.4 million.

A look at the current state of educational finances also suggests a very different future. Many school districts, particularly large, urban districts, are faced with significant budgetary shortfalls. For example, the Cincinnati, Ohio, Public School District was $21.7 million over budget in the 2003-2004 school year and projects a $48 million budget deficit in 2007 (Mrozowski, 2004).

In addition, both the Cincinnati and Buffalo school systems are using buildings that were constructed in the 19th century (Cincinnati Public Schools, 2004; Louis P. Ciminelli Construction Companies, 2004). Even using the overly optimistic cost prediction from the Summit (van Hover et al., 2004), it is difficult to see how districts like these will be able to afford the expenditure necessary to provide each of their students with access to a handheld. Even if only secondary students are included, Buffalo would have to spend $1.4 million to purchase the hardware for its 19,000+ grade 7 -12 students, plus the additional money necessary for teacher professional development and technical support. If all students were involved in this initiative, it would require over $3.1 million for hardware alone. A more realistic cost estimate of $300 per handheld multiplies the costs fourfold (see Table 1).

Table 1
Estimated Costs to Supply Handhelds to Buffalo Public Schools[a]

No. of grade 7 -12 students	19,389
Cost of hardware @ $75	$1,454,175
Cost of hardware @ $300	$5,816,700
Total students	41,625
Cost of hardware @ $75	$3,121,875
Cost of hardware @ $300	$12,487,500

[a]Data based on New York State Education Department (2005).

Policymakers in these and other similar districts must make difficult choices, and if given the choice of reducing class sizes by hiring teachers or spending funds for wireless handheld computers, it is a reasonable assumption that many, if not most, will choose to hire teachers. This is especially true if they ask teachers for input on the decision. Most public school teachers would opt for a class of 25 students rather than one with 40 students who each have access to a handheld. Thus, the reliance on Moore's Law, which is a result of an emphasis on technology, leads to conclusions that are not supported by available evidence and do not take context into account. This is also true of the predictions the Summit reached about the results of greater student access to handheld computers.

Cause and Effect Assumptions

The Summit participants implied a causal sequence from computer affordability to classroom use to instructional transformation that does not match the historical record. In doing so, they pointed to an educational future determined by the affordances of the tools rather than one influenced by the beliefs and desires of teachers or even the educational needs of students. This implication is clear, as the only explanations provided for the fact that "technology has not transformed schools to the extent that many reformers believe it has the potential to" (van Hover et al., 2004, p. 109) are lack of access and teacher training. In other words, the Summit participants seemed to believe that providing hardware and training will cause pedagogical transformation.

This causative sequence ignores significant factors that affect teachers' practice in schools, such as teachers' and students' beliefs about learning and schooling, political and social forces, and institutional constraints (Cornbleth, 2001; Cuban, 2001; Segall, 2003; Windschitl & Sahl, 2002) while placing computer technology as the critical factor in pedagogical reform.

But What if Ubiquitous Computing Is Widespread?

The problems with this narrow view of cause and effect and the prioritization of technology lead to serious doubt as to whether UC will ever be the significant educational force envisioned by the members of NTLI. At the same time, it is increasingly likely that *some* school districts in *some* areas of the country will have sufficient funds and motivation to experiment with handheld computers. As van Hover et al. (2004) noted, this is happening on a limited basis already (van 't Hooft & Kelly, 2004). Given this possibility, further examination of the other Summit conclusions is warranted.

The second conclusion stated that "ubiquitous computing will be a disruptive force with great potential for good or ill" (van Hover et al., 2004, p. 107). A reading of the history of technology use in education suggests that this is unlikely. Two more likely results are that "ubiquitous computing will not be a disruptive force at all" or that "ubiquitous computing will be a disruptive force for good *and* ill."

Ubiquitous Computing Will Not Be a Disruptive Force at All

Cuban's work (1985, 1993, 1995, 2001) provides strong support for a view that teachers' role as classroom gatekeepers gives them much more agency than the Summit's conclusions provide. The role of teachers in mediating advocates' support for educational film, radio, television, and desktop computers provides considerable evidence that promoters' assertions of educational transformation consistently overstate the impact of technological innovations on classroom practice.

Advocates for each of these innovations made similar claims as those in the Summit's conclusions. Teachers' judgments about the innovations and the ability of teachers to control the use of technology in their classrooms were significant factors in the failure of these technologies to transform teaching and learning. There is no empirical or theoretical evidence provided that supports a view that wireless handheld computers are sufficiently different from prior innovations to suggest such a fundamentally different result.

Many teachers do not see sufficient benefit accruing from computer use to offset the costs. For teachers, the most significant costs are not financial but practical (Cuban, 2001). Among their concerns are that teaching students to use content-specific software applications takes time from other pursuits; student access to the Internet creates difficult classroom management issues, not the least of which is the exponential increase in cheating techniques available using wireless communication devices; and schools generally provide substandard technical support systems, which provide teachers little confidence that the machinery will work properly on a consistent basis. There is little evidence to date that handheld computers will succeed where other educational technologies have not.

Ubiquitous Computing Will Be a Disruptive Force for Good *and* Ill

If one is willing to accept the premise that ubiquitous computing will have a significant impact, then the second statement comes into play. All technology comes with costs as well as benefits. As Clarence Darrow asserted during the Scopes Trial,

> Every changed idea in the world has had its consequences. Every new religious doctrine has created its victims. Every new philosophy has caused suffering and death. Every new machine has carved up men while it served the world. No railroad can be built without

> the destruction of human life. ... No great movement that does not bear its toll of life and death; no great ideal but does good and harm, and we cannot stop because it may do harm. (quoted in Scopes, 1997, p. 182)

It is incumbent on educators to recognize and evaluate the consequences of new technologies, even when those consequences may be negative. That is not to suggest that technological advances not be utilized in schooling. On the contrary, new technologies will only reach their fullest potential for improving education when those in the profession are in position to not only take advantage of the positive potentials but also to recognize and minimize potential negative consequences. It is in omitting attention to negative consequences that the Summit participants do a disservice to technology integration.

Consequences

Consequences of UC are likely to include some of the benefits foreseen by the Summit participants. The Summit's conclusions, however, while acknowledging the necessity of research and input from educators in determining appropriate educational applications, do not recognize the inevitability of unintended and negative consequences; nor does there appear to be an effort on the part of this group to examine the current sociocultural consequences of wireless and handheld technologies to attempt to predict such consequences.

Researchers and commentators suggest that those who rely on digital communications devices rather than face-to-face interactions need specific instruction on decision-making in an environment that may be designed "to manipulate their actions or beliefs" (Berson & Berson, 2004, p. 5), may have difficulty forming the interpersonal skills necessary to function in the adult world (Staples, 2004), may view intellectual property rights in unconventional ways (Laird, 2001), and may not have sufficient experience with necessary human interactions involving physical space and community (Streibel, 1998).

A theory with more immediate global implications suggests that the instant communications capabilities of modern technologies provides stimuli that "takes anger to a higher level" (Ignatius, 2006, p. A15), and "provides an environment in which enraged people can gather at cause-centered Web sites and make themselves even angrier. The technology ... 'eliminates the opportunity for filtering or rage-dissipating communications to intrude'" (C.M. McLean, quoted in Ignatius, 2006, p. A15). These consequences are not common to all technology users, nor are they universally accepted as inevitable results of technology use. There is sufficient evidence to suggest these as foreseeable consequences, however, but little suggestion in the Conclusions that consequences beyond purely pedagogical ones should be included in discussions of the value of and uses for computers in education. Yet, should they develop as consequences of UC, there can be little argument that such consequences would have significant impacts on students, schools, and communities.

Equal Access

In addition to not acknowledging possible negative consequences, the Summit participants also overstated the extent of positive consequences of UC. While computers certainly can provide improved access to resources and broader cultural connections, the financial data presented earlier in this paper provide considerable evidence that the benefits of technology will not be distributed equitably. As Anderson and Becker (2001) concluded from their nationwide Teaching, Learning, and Computing study,

> The costs of technology implementation are not equal in different types of schools. Low-income school districts are likely to require greater expenditures due to having older facilities and higher security problems. In addition schools serving communities with poverty and high mobility may not be able to develop "exceptional financing methods" such as corporate donations and parent fund-raising activities. Moreover, the schools with the greatest need are the ones whose students are also least likely to have access to computers and the Internet at home. (p. 3)

The assertion that UC will help eliminate the digital divide by “equalizing educational opportunities, allowing students, regardless of socioeconomic background, to utilize the myriad of sources available on the Net” (van Hover et al., 2004, p. 108) thus seems unsupportable.

Beyond access, however, is the issue of how the hardware is used. A major element of the Summit’s conclusions is advocacy for research into appropriate uses and professional development. The school districts, such as Buffalo and Cincinnati, which can least afford the hardware, are also least able to provide sufficient technical support and professional development funds to encourage innovative uses of the technology.

If as Diem (2000) asserted, "The promise of technology is not so much in its cutting-edge advances as in its innovative and imaginative applications” (p. 494), then students in those districts will be increasingly *dis*advantaged as computers play a more significant role in education nationwide. "It is...naive to expect the provision of computers to reduce educational differences among children in any simple or automatic way. On the contrary, computers may, at least initially, exacerbate existing educational differences between social classes" (Attewell, 2001, p. 257).

The Summit attendees suggested that technology is a key component of educational inequality, or at least that increased access can mitigate such inequalities. As Light (2001) noted, however,

> it is comforting to imagine that the diffusion and use of a particular technology will remedy complex social problems. Hopes for a more equal future society are one of the most popular fantasies fastened onto new technologies. Yet fastening such hopes onto computers and the Internet evades the complex causes of inequality and instead focuses on treating one of its symptoms, unequal access to technology, with the assumption that closing one gap will close the others. (p. 716)

Ubiquitous computing may provide improved educational opportunities for some students, but any expectation that such improvements will provide fundamental movement toward equity will prove unfounded unless considerable attention is also given to underlying causes of inequality.

Potential Benefits from the Conclusions

As mentioned in conclusions 6 and 7, the educational community must take a leadership role in understanding and harnessing UC. Pilot projects investigating the potential of UC are necessary precursors to making effective use of handheld computers in classrooms. Texas Instruments and CUFA combined their efforts in one such project where teacher education faculty implemented three small-scale studies of the impact of using handheld computers in preservice education courses (Crowe & van 't Hooft, 2006; Williams, 2004; Wilson, Riley, & Stern, 2004).

These studies are necessary and important. If the educational community truly seeks to maximize the benefits and minimize the negative consequences of UC, then the suggestion in the conclusions that projects "should be evaluated to ascertain the effect of ubiquitous computing on teaching and learning" (van Hover et al. , 2004, p. 107) must be interpreted in the broadest possible way so that historical and contextual factors become part of the conversation about the educational uses of handheld computers.

Conclusion

The NTLI Summit's seven conclusions raise significant issues and appropriately suggest that work begin to prepare educators to make the best possible pedagogical use of handheld computers. However, there are significant shortcomings in the conclusions. They place primary emphasis on technology, rather than education, which leads to a skewed view of the likelihood of UC becoming universal, the impact of UC on the Digital Divide, and the role of UC in transforming pedagogy in schools. The history of educational technology adoption and an examination of a wider array of influences suggest that the assumptions underlying the Summit's conclusions are too optimistic. In addition, the Summit does not acknowledge the wide-ranging implications of UC and implies that the only consequences requiring investigation are those directly related to pedagogy. A broader look at predictable sociocultural changes resulting from UC makes it clear that this, also, is too narrow a focus on which to base decisions as to the advisability of implementing UC. The costs of UC are much greater than just the financial expenditure for hardware, and the NTLI, by ignoring those costs, shortchanges educators who are looking for leadership and are open to innovation in their efforts to improve schooling.

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Resources

Association of Mathematics Teacher Educators - http://www.cbmsweb.org/Members/amte.htm

Association for Science Teacher Education - http://aste.chem.pitt.edu/

College and University Faculty Assembly - http://www.ncsscufa.org/

Conference on English Education - http://www.ncte.org/groups/cee

National Council for the Social Studies - http://www.ncss.org/

National Council of Teachers of English - http://www.ncte.o rg/

PC World.com PDA ranking (September 2005) - http://www.pcworld.com/reviews/article/0,aid,121785,00.asp

Society for Information Technology and Teacher Education - http://site.aace.org/

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