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THE EQUITY THREAT OF PROMISING INNOVATIONS: PIONEERING INTERNET-CONNECTED SCHOOLS*

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ABSTRACT

This article examines the distribution of student Internet use across 152 schools in the National School Network (NSN), schools that were among the first to provide high-speed direct Internet access simultaneously for many locally networked computers. Apart from identifying the socio-demographic character of these schools, the article shows the extent to which Internet use varies by school socio-demographics, and, within school, by prior achievement levels of students. Although membership in the NSN disproportionately includes schools in high-SES communities, it was found that, among NSN schools, social class is not related to extent of use. On the other hand, within schools, Internet use favors high-ability classes, particularly in demographically heterogeneous schools.

RATIONALE

In education, innovations designed to improve students' accomplishments often have the unintended consequence of increasing inequality by improving the accomplishments of more advantaged students without helping, or even doing harm, to disadvantaged students. This undesirable outcome seems likely given the social distribution of conditions that often are required for successful implementation of new approaches to teaching.

For example, advocacy and support from a vocal community constituency is helpful to get a high-risk, high-cost innovation underway. High-education/high income communities may be more likely to successfully advocate for such

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innovations than are communities worried about the costs of public schooling or concerned about students not meeting basic reading and arithmetic literacy goals. Thus, without mobilization of external influence, moderate- and low-SES communities may be excluded from participation in promising innovative practices.

Research demonstrates that "the more factors supporting implementation, the more change in practice will be accomplished" [1, p. 67]. Reform goals themselves do not drive the innovation process [2]. Instead, varying beliefs [3], organizational conditions [4], and a variety of contextual factors [5] may influence the implementation of reform innovations. Thus, there may be especially difficult challenges facing poor, urban, and rural schools where conditions may be lacking, or where the demands for resources are seen as greater in other areas.

For schools with large numbers of ethnic minorities, there may be questions of competing priorities with limited resources. For example, Becker found that schools with largely Hispanic populations may be forced to expend needed resources on second language acquisition, therefore limiting resources available for other purposes [6].

Socioeconomic Status

One reason for concern is that implementation of new practices is costly, and may therefore be expected to occur more frequently in wealthier communities. As Rogers reports, "When a system's structure is already very unequal, it is likely that when an innovation is introduced (especially if it is a relatively high-cost innovation), the consequences will lead to even greater inequality" [7, p. 436].

Looking at technological innovation in schools, the premise of many technology-based school reform efforts seems to be that teachers and curricula have failed to keep up with the needs of our more global, technologically advanced world, but that with a little help, things will soon get better.

> The assumption seems to be that somehow this will compensate for decades of economic neglect, that almost magically the problems of achievement, of unemployment, of international economic competitiveness, of the disintegration of our inner cities and our farming communities and so on will largely disappear [8, p. 41].

There may be a discrepancy between the vision of reformers and teachers' beliefs about the use of technology in schools [3]. Across socioeconomic classes, schools and teachers may operate under different assumptions as expected skills and future workplace expectations vary. In working class schools there may, in fact, be an emphasis on punctuality, neatness, obedience, and structure because these are the attributes conducive to subordinate labor [9-12]. On the other hand, creativity, independence, and higher level thinking skills are taught in upper middle class and elite schools to prepare students for their future roles in the workplace. Therefore, expectations concerning students and their futures is another potential source of inequality. The same patterns may exist within schools, across classes populated by students with different socioeconomic backgrounds.

Student Ability

Second, many innovations require that students have broadly relevant and often tacit understandings and skills beforehand, such as the ability to do academic work independently from direct adult supervision. Students who have been successful in school and who feel at home and cared for in the school environment may be trusted more by school practitioners, may in fact act more responsibly, and may be better able to carry out relatively unstructured tasks characteristic of many innovative educational approaches. Thus, without substantial effort to target younger students, lower-track classes, or non-college-prep courses, opportunities may be directed much more towards more successful students and their classes.

Teacher Differences

Third, innovations in teaching often require that teachers learn to re-think their craft, their basic pedagogical teaching approach, and their goals for students. Teachers who are prone to reflect intellectually upon their job themselves may have been disproportionately recruited to teach in more educated communities and assigned to teach classes of more highly performing students. Thus, the unrepresentative sample of classes engaging in new forms of teaching and learning may itself increase differential accomplishments among students, merely as a result of the atypical location of the innovating teachers within the social structure of American schools and school systems.

Those arguments are, of course, merely hypotheses. It is important to determine whether these fears are well-founded. Our purpose is not to derail innovation where good theory suggests it will have probable important long-term benefits, but by recognizing a "natural" tendency toward inequity, it will enable that tendency to be countered by conscious planning and distribution of effort.

LITERATURE REVIEW

Equity and Technology Use

Research about group inequalities in technology access and use initially found sharp differences by student and class "ability-levels," even more than inequalities by social-class or ethnicity. In the earliest years of school computer use, it was clear that the greatest use of computers was by the highest-ability students in the school [13, 14]. Moreover, the lower-ability and middle-ability classes used computers primarily for drill-and-practice and tutorial computer-assisted instruction, while the upper 10 percent of classes used computers for a more diverse array of learning activities including computer programming [14, p. 306]. Additionally, teacher involvement with computers differed by the ability level of the classes using computers. For example, nearly one-half of the teachers of high ability classes owned a home computer in 1985 compared to under one-third of other computer-using teachers [14, p. 307].

After those early years, group differences in computer access and use have been diminishing. By 1989, a national study identifying the 5 percent of "exemplary" computer-using teachers who taught using computers in diverse, frequent, and often constructivist ways found that these teachers were no more likely to be found teaching higher-ability or average-ability classes in their school than they were teaching lower-ability classes. In fact, the statistical pattern was slightly in the opposite direction [15].

By 1992, an examination of national data (combining between-school differences in computer use and within-school differences) found that only in high school were the 30 percent of students nationally with the lowest grades less likely to be using computers than other students, and that the top-quarter of students by grade average were not significantly more likely to be using computers than other students at any of the three grade levels studied (5, 8, and 11) [15, Table 6.4]. Moreover, patterns of computer use (e.g., as between traditional skill-based activities versus higher-order activities such as word processing, programming, spreadsheet use, and using computers as part of laboratory experiments) also did not differ very noticeably among students with high, average, and low grades [15, Table 6.5].

In many ways, students' access to the Internet in schools today is roughly where student access to school computers was perhaps twelve years ago. Most schools now have at least one Internet connection in an instructional room [16], although the modem-based connections that are most common permit just a handful of simultaneous student users in a school, just as the typical school in 1985 had only a handful of computers (the typical school that year had only 8 computers) [14]. In 1996, about 20 percent of all teachers reported using the Internet or other "advanced telecommunications" in some way in their teaching [17, Table 5], whereas in 1985, 24 percent of teachers were said to have used computers "regularly" during the school year [14, Table 3]. If seen as a comparable innovation at a comparable point in its history, it would not be surprising, then, if inequalities in Internet use within a school or across different socio-economic communities resemble inequalities found over a decade ago in terms of computer use.

The Internet as an Innovation

Immature technologically-imbedded innovations, such as pioneering uses of the Internet that emphasize collaborative interscholastic project-based learning and worldwide publishing of student work, have precisely those characteristics that seem likely to produce increasing inequalities in opportunities for student accomplishment, particularly those associated with community socioeconomic status and individual student prior academic achievement. Constructivist Internet-based curricular innovations are high-risk and high-cost relative to more conventional instruction; they require substantial student initiative and independence; and they require from teachers substantial technical expertise, pedagogical reflection and reconceptualization, and intellectual flexibility.

There are a number of reasons to think that Internet use is not distributed equally across communities in this country. While access to the Internet in schools is growing rapidly, it is still problematic that schools in rural and poor areas, small schools, and elementary schools are less likely to be connected or to have plans in place [18]. As indicated previously, one reason may be that Internet-related technologies may favor adoption by wealthier communities as a result of being costly to adopt and requiring large capital investments [7, p. 270].

One can also speculate about reasons why more advanced students, even within the same school, are more likely to be offered opportunities to use Internet—successful students may be offered time on the Internet as a reward, their teachers may be less concerned about the "basics," these students may be better prepared because of experiences with computers in the home, and the risk of unsuccessful experimentation may be perceived as less significant with those students who are already performing at successful levels.

Finally, the teachers who teach successful students may be predisposed to experimentation and innovation, while those who are accustomed to working with lower performing students may, for whatever reason (their own bias or external pressures), be inclined to pursue traditional methods, including those geared toward increasing test scores.

As stated above, simply wiring schools is not enough. All too often, efforts have focused "on installing technology in instructional settings rather than on the effects of technology" [2, p. 1110]. For this study, not only are we concerned about equity of *access* across schools and communities, but we are also concerned with how teachers make *use* of this access with students of different abilities.

THE RESEARCH QUESTIONS

This study examines several questions concerning the relationship of innovative teacher-student technology use to 1) the status and ethnicity of school populations; 2) differences between teachers in the student groupings they teach; and, 3) differences between students (or classes of students) taught by the same teacher.

Question #1: Is Internet-related innovation related to school SES/ethnicity differences?

Question #2: Are teachers who teach lower-ability students less likely to be strong or expert Internet-users of the Internet compared to teachers who have higher-ability students?

Question #3: To what extent do teachers with mixed-ability level groupings during the school day (e.g., an honors class and a remedial class) treat their lower ability classes differently from how they treat their higher-ability classes in terms of their use of the Internet? Will we find that teachers use the Internet differently or not as much with their lower-ability students as with their higher-ability students?

DATA SOURCE

The National School Network (NSN)

This article provides information about the social location of innovation in schools from a national study of innovating elementary, middle, and high schools that belong to the National School Network (NSN).[1] The NSN is a collaboration involving more than 300 schools and more than 100 separate projects and organizations attempting to spearhead teaching reforms in schools having high-speed local-area-network-based connections to the worldwide Internet. The NSN model for seeding instructional reform through computer-based telecommunications involves a loose collaboration among a diverse set of intermediary institutions committed to instructional reform and active on a local, regional, or national scale in implementing some aspect of constructivist reforms in a modest number of specific school sites. Those intermediary institutions include school districts and intermediary and state agencies investing relatively heavily in telecommunications infrastructure and staff development (e.g., Boulder Valley CO, Juneau AK, O-C-M Counties NY, Battleground SD WA, and Orange County FL); curriculum development projects from universities (e.g., the CoVis project from Northwestern), science museums (e.g, the Science Learning Network), school collaboratives (e.g, the Maryland Virtual High School project), and other content-knowledgeable organizations (e.g., the Co-NECT Schools New American Schools restructuring project); private firms piloting programs in schools (e.g., Pacific Bell); local community school support organizations (e.g., in Lexington MA, the Lexington Educational Network); and pioneering individual schools with strong site leadership in educational reform and technology (e.g., Rosa Parks School in Cambridge, MA, Ralph Bunch School in NYC, and Mt. Baker HS in Washington state).

Data Collection Method

In January, 1997, survey booklets were mailed to 248 schools selected to represent the 300+ schools of the NSN. (The total number was limited by fiscal resources; limits were placed on the number of schools selected from any single

[1] For more information about the project, see the NSN homepage—http://nsn.bbn.com.

NSN member project or organization.) Separate booklets were identified for the School-Level Network Coordinator (a 13-page booklet with 47 questions, most with multiple sub-questions), a five-page "Technical Supplement," and a four-page "Administrator Supplement." In addition, a "Teachers Sampling Form" was mailed, requesting the rostering of two groups of teachers—the ten most active Internet-users and ten other teachers, the latter listed alphabetically by last name, beginning with a randomly selected letter of the alphabet.

Once the Teachers Sampling Forms were returned, samples of three school-designated Internet-users and two other teachers were selected at each participating school. Internet users were selected with probabilities related to how often they used the Internet themselves and with their students, and remaining teachers were sampled with probabilities related to how often they used computers in general. Survey booklets were mailed to an NSN-designated contact person for distribution to the teachers. The booklet for the Internet-using teachers had thirteen pages containing fifty-four questions, while the booklet for the other teachers was a little over four pages in length, with fifteen questions.[2]

A professional survey organization at a university campus was contracted to do the data collection, follow-up, receipt, and data entry. Multiple mailings, follow-up phone-call reminders, and a promised gift incentive for Internet-using teachers and schools returning all booklets were implemented in the data collection design.

This report is based largely on 438 teacher surveys from 152 schools, 62 percent of the teacher surveys mailed (61% of the Internet-users and 63% of the other teachers). In addition, between-school differences are examined using data from the 125 returned Network Coordinator surveys as well as school demographic data on nearly all of the 248 NSN schools from Quality Education Data, a Denver market research firm. The Technical and Administrative supplementary surveys are not used in the analysis for this article.

RESULTS

Which Students Have Access to the Resources of the National School Network?

Created as a "testbed" to invent tools and exploit the resources of a worldwide, high-speed, pervasive digital communications network, the National School Network could not be expected to enlist as participants a fully representative sample of American schools. Merely the requirement that the schools be well-along in the process of building a digital infrastructure connecting many classrooms and computers to the outside world means that the schools, and perhaps

[2] The various survey instruments and selected findings are available online—http://nsn.bbn.com/nsn_learnings/survey.html

their students, are "different" in some way. Nevertheless, from the outset, the NSN leadership had a goal of creating a network that, insofar as possible, reflected the great diversity of social class, ethnicity, and academic ability that constitutes the American school population. In the first part of our analysis, we examine the extent that the hoped for diversity was accomplished.

Perhaps the outstanding characteristic of NSN schools is their affiliation with organizations whose mission includes substantial interest in and attention to educational reform. NSN schools, for example, are two to three times as likely as other schools to be involved in business partnerships or mentoring programs, four times as likely to have adopted outcomes-based education or school restructuring, and five times as likely to be a curricular magnet school.[3] Schools that take on such programs and make the external affiliations required to carry out reform plans are often led by administrators and staffed by teachers who, as a whole, are exemplars of their profession.

Along with the NSN's requirements for desktop networking infrastructure, this press toward innovation may also have contributed to a demographic mix of students that differs in some ways from the country's as a whole. Innovating schools, for example, are more frequently found in metropolitan areas; therefore it is not surprising that more NSN schools are located in urban areas than is the case nationally (30% vs. 20%) and in suburbs (31% vs. 18%), and fewer NSN schools are in rural areas (11% vs. 33%).[4]

"Progressive" or constructivist educational reform may also be primarily advocated in upper-middle class communities rather than in more "practically-minded" working-class communities. On a zipcode-based measure of socioeconomic status (SES) that incorporates data on the education, income, and occupation data of all residents in the school's zipcode (not just enrolled students), 30 percent of NSN schools are in the highest SES category compared to only 9 percent of U.S. schools, and only 29 percent are in the "average" or "below average" categories compared to 58 percent nationwide. Consistent with this, NSN schools serve fewer students from poverty-level families than schools do on average. For example, the average NSN public school has 18 percent of its students eligible for Chapter I funding compared to 28 percent for the United States overall.

On the other hand, the racial distribution at NSN schools is hardly different at all from those at other U.S. schools. In particular, the mean percentage of minority students at 225 NSN public schools for which we have data is 21.5 percent, which

[3] This conclusion comes from an analysis of reported participation in innovative programs in the QED data set. The percentages of schools in business partnerships are 11 percent of NSN schools vs. 5 percent of other schools; for mentoring, 8 percent vs. 3 percent; outcomes-based education, 6.6 percent vs. 1.4 percent; school restructuring, 7.1 percent vs. 1.8 percent; and magnet schools, 7.5 percent vs. 1.4 percent.

[4] These statistics as well come from the QED database of public schools; and in particular, their "lifestyle" typology.

is in fact about 2 percentage points *higher* than across the United States. NSN schools serve nearly exactly the same proportion of black and Latino students as other schools do and about twice as many students of Asian heritage (which accounts entirely for the 2 percentage point higher minority percentage mentioned above).

NSN schools are also somewhat more advanced in terms of computer technology than American schools as a whole. NSN schools have more potential in this area in that they have nearly 25 percent more discretionary expenditure dollars per pupil than the average public school (defined in terms of district-level budgets for non-salary items), $516 vs. $417. In terms of numbers of computers relative to the number of students enrolled, NSN *high schools* have only 5 percent more computers per capita than other U.S. high schools, but NSN elementary and middle schools have roughly 50 percent more.[5] The predominant type of computer in NSN schools is more likely to be a newer computer—a Macintosh or Windows-capable computer. And, not surprisingly, many more computers in NSN schools are networked than elsewhere.[6]

Equity Among the National School Network Schools

Although the NSN schools all have a minimal level of hardware connectivity, the schools differ among themselves tremendously in how far they have progressed in bringing Internet-based learning to their teachers and students. Some NSN schools have programs involving many teachers and many students. In others, only one or two teachers and a handful of students are involved. The World Wide Web in some schools is simply a means of acquiring encyclopedic information from digital sources, while in other NSN schools teachers and students are producers and publishers to their community and the outside world. The question we address in this section is whether students in the particularly accomplished NSN schools are disproportionately upper-middle-class white students or whether the NSN's most successful institutions serve poor and minority students as frequently as do the schools that have made the least progress so far in achieving Internet-based teaching and learning goals.

Our basic finding regarding this question is that poor and minority students are not at all at a disadvantage in NSN schools, except in the area of external community support for telecommunications activities. In fact, in some ways the

[5] The measure used here was computers per thirty students enrolled. The means for high schools were 4.44 (NSN) vs. 4.17; for middle schools, 4.86 vs. 3.32; and for elementary schools, 4.38 vs. 2.85.

[6] The QED data on networked computers, while quite out-of-date, nevertheless is useful for comparative data in this regard. Based on QED data, NSN elementary schools averaged twenty-three networked computers compared to only five for the United States overall. Among high schools, the means are 50 vs. 12, although part of that difference is due to the fact that NSN high schools are about twice as large as average, probably because of their somewhat disproportionately high incidence in larger metropolitan areas.

Network schools enrolling less advantaged students have been even more successful than others in developing their telecommunications instructional program. These conclusions derive from examining the statistical patterns among three measures of economic disadvantage and racial diversity, three other demographic factors, and ten aspects of the school's program for implementing Internet-based instruction.

The diversity measures included community social class, including residents outside the school; the percentage of students eligible for Chapter I (now Title I) government subsidies; and the percentage of students who are from historically disadvantaged racial minorities, primarily blacks and Latinos. The other demographic factors were school grade level, school size, and metropolitan/non-metropolitan location. The outcomes measured included the extent of teacher and student use of electronic mail; their involvement in ten types of network-based learning projects[7] (measured both in terms of breadth—the number of types of activities occurring—and scale—the percent of teachers involved); use of the World Wide Web for publishing student work; the amount of leadership and investments in staff development for network-based teaching; support for school networking from local and state agencies, officials, and businesses; and teacher involvement in planning and interpersonal communications related to the school's network-based learning program.[8] Data were analyzed bivariately, and then through multiple regression, holding constant school level, student enrollment, and metropolitan vs. non-metro location.

For most of the outcome measures of Internet use and involvement, there were no statistically significant or sizable correlations with the percentage of students from poor families, the percentage from historically disadvantaged ethnic groups, or the rating of the community as "high," "high-average" or "low-to-average" socio-economically. (See Appendix A, Table A-1.) This absence of substantial difference was not the result of inadequately sensitive instrumentation. The other three demographic variables—school grade span and school size in particular—were much more often correlated with network outcome variables than the socio-demographic variables. The absence of correlations here suggests that it is possible to construct and implement network-based teaching and learning reforms in ethnically and socio-economically diverse schools and communities, perhaps as easily as in more privileged schools.

[7] These included class e-mail exchanges with other schools, collaborative writing and science projects with other schools, participation in live events via computer, publishing class or individual projects on the Web, participation in Web-based contests, telementoring by adults, and several other categories.

[8] The demographic variables were obtained from the data files of Quality Education Data (QED), and from information supplied by the NSN schools directly. QED background data were used when obtained with more precision that way, and when not otherwise available. The networking outcome measures came from the survey booklets completed by NSN school networking coordinators.

In two respects, the NSN schools in more diverse and disadvantaged school and community settings looked even better than other NSN schools. First, in terms of the number of different types of network learning activities in which teachers participated, schools in low-middle SES communities averaged 5.4 types of activities per school compared to 3.7 types for higher SES schools ($p < .001$). Similar results were obtained comparing schools high and low in Chapter I enrollments and comparing more and less ethnically diverse student bodies. Controlling on school level, enrollment, and population density (metro vs. non-metro), these socio-demographic variables still had a strong relationship with breadth of the variety of network learning activities used, explaining 11 percent of the variance in addition to that explained by the control variables.

Second, a Web Publishing Index constructed from indicators of both student and teacher involvement in creating pages for the World Wide Web suggested higher participation rates in schools with more Chapter I students and in low-to-middle SES communities (both, $p < .05$). However, when controlling on school level, size, and density, the combined effect of the socio-demographic variables was only half as large as in the previous example, accounting for 6 percent of variance.

The only relationship to emerge in this analysis that links disadvantage with *less favorable* outcomes for computer networking concerned our index of external support for school telecommunications activities. This index combined information about support to the school from the PTA, the teachers' organization, a district-wide task-force, local media, community referenda, local officials, the local school board, the state education agency, and district administration. NSN schools in socioeconomically well-off communities and having relatively few Chapter I students had more reports of this kind of external support than did low- or middle-income communities or schools with many Chapter I students. (Effect sizes for these relationships were .38 and .67, respectively.) Combined with the previous findings showing substantial network-learning and Web-publishing involvement by teachers and students in poorer and more racially diverse schools, this suggests that socially heterogeneous schools in the National School Network were being successful in spite of a less favorable political economy surrounding the school's networking efforts.

Thus, overall, NSN schools that serve lower socioeconomic and historically disadvantaged groups are doing as well in innovating instructionally useful Internet- and network-based learning experiences for their student bodies as are NSN schools serving more advantaged populations. In the next section, we examine the question of equity *within* NSN schools—that is, does privilege rear itself within a heterogeneous student body so that students who are academically more successful are the ones who are given the opportunity to use the Internet and are challenged more academically by it?

Differences between Individual Classes at NSN Schools

Three sorts of analyses follow: First, we examine the differences in student "ability" levels between classes that use the Internet and those that do not. Second, we look at differences among a given teacher's classes in terms of that class' likelihood of using the Internet—i.e., do Internet-using teachers tend to use this resource only with their "better" classes? And third, we compare "strong" Internet-using teachers with other Internet-using teachers *at their own schools* in terms of subject-matter responsibilities and the ability levels of students they teach. By "strong," we mean Internet-using teachers who have substantial technical skill, Internet experience, who use these resources in a major way with many students, and who employ the Internet for project-based teaching that reflects the curricular reform goals of the National School Network.

Although the primary focus of our within-school analysis is on differences in student "ability" levels (because no information was gathered about socio-economic or racial characteristics of each teachers' students), where sample sizes permit, results are desegregated in order to examine schools that are socio-economically diverse separately from those that are homogeneously advantaged. We use the term "ability levels" rather than "achievement levels" to represent the construct of expected student accomplishment in order to express this idea as an "input variable" rather than an output, as the term "student achievement" is most often considered. In fact, the construct is probably best represented by the term "prior achievement."

The analysis is based on 438 returned survey booklets (roughly 60% of the teachers sampled), including 270 sampled from the 10 most active Internet-using teachers in their school and 168 sampled from the remaining teachers at their school. The analysis uses unweighted data, however, and so may be best thought of as a convenience sample of teachers connected with NSN schools, substantially biased toward those who are predisposed toward computer and Internet use. About 60 percent of the teachers have taught for more than ten years. About two-thirds have used computers personally for more than five years, but only 27 percent report having used computers with students for that long. Typically, they have taught using computers for about three to four years. They have used modems, on average for about two years, but nearly one-half of the teachers have been using telecommunications with students for only "a bit" of time.

Each of the 438 teachers reported teaching between one and six different classes of students, although for the purpose of this study, teachers of self-contained classes were instructed to count each major subject they taught students as a separate "class." The analysis examines differences in the extent of Internet use separately for elementary grade, middle grade, and high school grade classes.

Teachers were asked, for each class they taught, for the "achievement or ability level of the students in that class relative to students in general at that grade level." They were instructed to "circle ALL 'abilities' that apply to at least several students" in that particular class. Five categories were provided: "very high" (5), "above average" (4), "average" (3), "below average" (2), and "very low" (1). For each class, an average ability level was constructed by averaging the levels circled by the teacher. In other words, if a teacher indicated a specific class was composed of "average" and "above average" students, that class was scored as ability level 3.5. For the teacher-level analysis, an average class ability level was computed by averaging the ability levels of all the classes taught by that teacher. Altogether, we have data on 1,731 different classes taught by these teachers, of which 1,542 (89%) had class ability levels reported.[9]

Table 1 shows teacher-reported student Internet use for elementary, middle, and high school classes and overall.[10] Each sub-table shows Internet use reported for three sets of classes—those where typical ability levels were "below average," "average," and "above average." At all three grade level groupings, classes with "above average" students were more likely to use the Internet (5 or more times) than other classes did. For example, students in 27 percent of "above-average" elementary classes were said to have used the Internet five or more times for that class, compared to 17 percent of "average" elementary classes. At elementary and middle levels, "below-average" classes were less likely to have had any class-related Internet use at all. The ability-level differences appear to be greatest at the middle grades, and smallest at the high school level.

Still, the amount of difference favoring the above-average classes was not that striking. In a multiple regression analysis predicting class-level Internet use (treated as a 4-step interval-level variable), both metropolitan location (vs. small-town/rural) and community socioeconomic status (negatively, thus favoring the low-to-average SES communities over the high SES locations) had higher beta-coefficients (.11 and –.08, respectively) than did class ability level (.05), although all three were statistically significant. Roughly the same results were obtained with the dichotomous dependent variable referring to frequent (5 times or more) use of the Internet.[11]

Internet use was much greater for some subjects than others—in particular, "computer and media" classes, social studies classes, and science classes. For example, across all grade levels, students in 38 percent of the computer or media

[9] Classes with scores from 1 through 2.5 were grouped as "below-average"; above 2.5 through 3.5, as "average"; and higher than that as "above average." Eighteen percent of the classes were self-designated as below-average, 54 percent as average, and 28 percent as above-average, in terms of mean student achievement or ability.

[10] More accurately, the grade level groups are not for that particular class but for the teacher's average class assignments. Teacher's average grade level taught was used rather than school grade span because a substantial number of teachers taught middle-grades at schools that are nominally high schools.

[11] Here, the beta-coefficients for the three predictors were SES (–.11), metropolitan location (.10), and ability level (.06). Logistic regression produced the same ordering and statistical significance levels.

Table 1. Frequency of Internet Use for Each Class Taught by Grade Level and (Teacher-Reported) Class Ability Levels

Grade Level and Class Ability	No Use (%)	Use by Some Students (%)	Use by ALL Students: 1-4 Times (%)	Use by ALL Students: 5 or More Times (%)	No. of Classes (*N*)
Elementary Grades					
Below Average	32	26	19	23	(57)
Average	25	37	21	17	(218)
Above Average	22	44	8	27	(92)
All Elementary	25	37	17	20	(367)
Middle Grades					
Below Average	29	30	23	19	(149)
Average	17	45	20	19	(343)
Above Average	16	13	24	28	(177)
All Middle	19	38	22	21	(669)
High School Grades					
Below Average	25	36	22	17	(81)
Average	27	40	20	13	(233)
Above Average	27	33	19	21	(164)
All High School	26	37	20	17	(478)
ALL Grades					
Below Average	28	32	21	19	(294)
Average	22	41	20	16	(812)
Above Average	21	36	19	25	(436)
Total All Schools	23	38	20	19	(1542)

classes used the Internet five or more times compared to 26 percent of science classes, and only 15 percent of English and 14 percent of math classes. Grouping these subject-matter classes by student ability, we find that Internet use was higher for above-average computer, science, and social studies classes than for average classes, but there was no difference in use by class ability for other subjects (see Table 2.) For example, students in 34 percent of above-average science and social studies classes used the Internet five or more times compared to only 19 percent of average-ability classes in those subjects.[12] However, there were virtually no

[12]Note, however, that below-average science/social studies classes also reported more Internet use than average ability classes in those subjects, 27 percent vs. 19 percent, although students in fewer of those below-average ability classes used the Internet to any extent.

Table 2. Frequency of Internet Use for Each Class Taught by Class Subject and (Teacher-Reported) Class Ability Levels

Class Subject and Ability Levels	No Use (%)	Use by Some Students (%)	Use by ALL Students: 1-4 Times (%)	Use by ALL Students: 5 or More Times (%)	No. of Classes (*N*)
Computers/Media Classes					
Below Average	21	29	21	29	(24)
Average	18	38	10	35	(84)
Above Average	9	28	15	48	(65)
All Computer/Media	15	33	13	39	(173)
Science/Social Studies					
Below Average	19	25	29	27	(85)
Average	10	45	27	19	(228)
Above Average	15	28	23	34	(109)
All Science and Social Studies	13	37	26	24	(422)
Other Classes					
Below Average	34	34	18	14	(169)
Average	28	41	19	12	(457)
Above Average	25	42	19	14	(235)
All Other Classes	28	40	19	13	(861)

differences for other academic subjects—see the 3rd panel in Table 2. Thus, ability-group differences in Internet use emerge only in subjects for which the Internet frequently plays a significant role. In results not shown here, both linear and logistic multiple regression analysis confirmed the finding of a significant student ability effect for frequency of Internet use in computer/media classes, when controlling on school socioeconomic factors (beta = .16), but the regression analysis did not confirm the crosstabular results for science/social studies classes.

Differences between Classes of the Same Teacher

About two-fifths of the teachers participating in the survey either taught a single class or taught different classes that they judged to be composed of students of roughly equal abilities. But the remaining teachers made some distinctions in ability levels between the different classes they taught. For about 30 percent of the sample, the differences were substantial—that is, roughly the difference between a class primarily composed of "average" students and one composed equally of "above-average" and "very high" students. For those teachers who reported some difference in ability levels between classes, we analyzed whether they also reported differences in how much they used the Internet between their class highest in ability and their class lowest in ability.

Most of these data come from the middle and high school teachers, because most elementary teachers reported similar abilities in their different "classes," which were primarily composed of the same students anyway. Nearly one-half of the secondary teachers who reported having classes of different abilities reported roughly similar levels of Internet use between higher and lower ability classes. But of the remainder—that is, secondary teachers who did report differences in Internet use between classes differing in student ability—in more than three-fourths of the cases, it was the higher-ability classes that received more opportunity. And the greater the amount of difference in reported ability between the "top" and "bottom" classes of a teacher, the more the top class was favored (see Table 3).

It is particularly the case that high ability classes are favored with Internet use when two conditions occur in conjunction: substantial ability differences among the classes taught by the same teacher (as defined above) plus the presence of substantial socioeconomic or racial differences in the school population. When neither or only one of those two factors is present, roughly one-third of the teachers favored their higher ability classes, but when both are present, more than one-half of the teachers did so. Moreover, under those conditions, the lower-ability classes were *almost never* favored with more Internet use. The same results obtained for all three measures of diversity used in the school-level analyses—community socioeconomic status, presence of 25 percent or more students eligible for Chapter I funding, and presence of 25 percent or more students from African-American or Latino backgrounds. Table 4 combines these different indicators into a simple dichotomy—low vs. high diversity/disadvantage—and summarizes the relationships among ability differences across classes of the same teacher, school socio-economic diversity, and amount of Internet use.[13]

[13]A linear multiple regression analysis over the same group of 221 teachers finds 3 predictor variables—teachers' average grade level taught, school socio-economic diversity index, and ability differences between highest and lowest ability class—to be roughly equally predictive of the amount of difference in Internet use favoring the teacher's highest ability class over the lowest ability class. Each beta coefficient is between .09 and .10. None of the three are statistically significant, however, at this sample size. When an interaction term is incorporated into the equation (diversity x ability differences), the interaction term becomes dominant, with a beta coefficient of .26 ($p < .15$), which is still, however, not statistically significant.

Table 3. Differential Internet Use between Highest and Lowest Ability Classes Reported by Secondary Teachers Who Taught Classes Differing in Ability, by Magnitude of the Ability Difference

	Which Class Uses Internet More?			
Magnitude of Ability Differences between Classes?	Low Ability Class (%)	No Difference (%)	High Ability Class (%)	No. of Teachers (*N*)
Modest Ability Differences	14	52	35	(95)
Substantial	10	46	44	(98)
All Secondary with Classes of Different Abilities	12	49	39	(193)

Table 4. Differential Internet Use between Highest and Lowest Ability Classes of Teachers Who Taught Classes Differing in Ability, by SES/Racial Diversity (and by Size of the Ability Differences)

	Which Class Uses Internet More?			
Magnitude of Ability Differences between Classes?	Low Ability Class (%)	No Difference (%)	High Ability Class (%)	No. of Teachers (*N*)
Homogeneously High SES or White				
Modest Ability Differences	12	59	29	(61)
Substantial	17	50	33	(54)
Total, Homogeneously High SES/White Schools	14	55	31	(115)
Middle SES and Racially Diverse				
Modest Ability Differences	17	49	34	(53)
Substantial	4	41	55	(53)
Total, Middle SES and Racially Diverse Schools	11	45	44	(106)

Differences between Strong Internet Users and Other Users at the Same Schools

As we pointed out at the start of this article, "Internet use" is a concept with many meanings—a teacher might use the Internet to find teaching resources, but not really involve his or her students, or students might occasionally search the Web for information for a report, whereas other teachers may regularly incorporate a wide range of Internet activities into their teaching including students publishing on the Web, collaborating with other school sites, and participating in live events over the Internet. To identify "strong" Internet-using teachers, we combined information from seventeen questions in the teacher survey booklet (comprising 63 different response items):

- HOWLONGT: How many years a teacher has used telecommunications (a modem or the Internet) for professional or recreational purposes.
- HOWLONGS: How many years a teachers has used telecommunications with students.
- DIRECTUS: Whether the teacher directs student Internet use or, instead, another teacher does it for his/her students, or students do this on their own.
- MAXUSE: The maximum use a teacher made of the Internet in his/her classes, on a scale from 1 to 4, where 1 represented no use; 2, voluntary student use; 3, occasional use by all students; and 4, use by all students on at least five occasions.
- AVGUSE: The average use a teacher made of the Internet across all his/her classes.
- NNETPROJ: The number of discrete types of network learning activities the teacher has had students participate in during the year (from a list of 17 types including working with scientists, tutoring students by e-mail, doing Web searches, etc.).
- NCOLLABP: The number of semesters that the teacher has had classes do collaborative telecommunications learning activities, such as collaborative projects with other schools.
- PCTSUSE: The proportion of his/her students that the teacher has involved in these kinds of network learning activities.
- EXTRCURX: The number of students, if any, the teacher worked with on Internet-related activities *besides* the students in the teacher's own classes.
- REQDUSE: The frequency with which the teacher *requires* students to use the Internet.
- ESSENTL: The extent that the teacher regards the Internet as essential (vs. supplemental) for his/her own teaching practice and for professional development.

- USE4PREP: How frequently the teacher accesses the Internet while doing class preparation work during the school day.
- SELFUSE: How frequently the teacher engages in six other Internet-related activities, such as posting a message to a newsgroup or creating or editing a World Wide Web page for their class or school.
- FUNCTION: How many of five functions for using the Internet (e.g., professional collegiality—sharing new ideas, discussing teaching) occupies the teacher for at least an hour per week.
- OWNSKILL: The teacher's self-rated skills related to Internet use (a set of 13 specific skills).
- OWNPREP: The teacher's judgment about their own current possession of five broad Internet-related competencies, including, for example, "awareness of what the Internet can do."

A factor analysis of these variables across 254 survey respondents (those rostered as the school's most active Internet-using teachers) led to an identification of three dimensions of teacher Internet involvement, which we labeled "Internet Expertise," "Broad Student Participation," and "Use of Network Projects." Table 5 summarizes the factor analysis results.[14] The sum of each teacher's factor scores on these three dimensions became our measure of strong Internet practice. For the following analysis, teachers averaging 0.5 standard deviations above the mean for the sampled "most active" Internet-using teachers on the three dimensions of involvement were designated as strong users. Forty-nine teachers met this criterion, or roughly 20 percent of the school-designated most active Internet-using teachers. The forty-nine teachers came from forty-three different NSN schools. Only five of the forty-nine, however, were high school teachers; the rest came roughly equally from middle grade and elementary grade teachers.

We wanted to compare these strong Internet users to other school-designated active Internet-using teachers who *taught at the same school* (and who completed a survey booklet). In thirty schools (with a total of 32 identified "strong" teachers), we had information on at least one other Internet-using teacher (a total of 41 such teachers in all). Thus, for this final analysis, data was examined for these seventy-three teachers only (32 "strong" Internet users and 41 other users at the same schools).

We addressed two specific questions about the differences between the strong Internet users and the other teachers. At the secondary level, did the two groups teach different subjects? And, at either the elementary or secondary level, did they

[14]The factor analysis employed principal axis extraction, mean substitution for missing values, Kaiser normalization, a minimum Eigenvalue of 1.3, quartimax rotation, and a regression approach to computing factor scores.

Table 5. Factor Analysis of Internet-Using Teachers' Extent of Use

Variable*	Communality	Factor 1 Teacher Internet Expertise	Factor 2 Broad Student Involvement	Factor 3 Use of Network Learning Projects
AVGUSE	.68	.25	**.83**	.05
EXTRCURX	.10	.23	.07	–.04
MAXUSE	.63	.25	**.72**	–.01
NCOLLABP	.58	**.44**	.20	**.67**
NNETPROJ	.56	.37	.33	**.61**
REQDUSE	.35	.37	**.48**	.00
ESSENTLP	.51	**.53**	.29	–.18
USE4PREP	.39	**.60**	.18	.01
OWNSKILL	.61	**.79**	–.14	.01
OWNPREP	.54	**.69**	.08	.05
SELFUSE	.64	**.81**	–.01	.12
FUNCTION	.47	**.65**	.22	.03
HOWLONGT	.50	**.51**	–.17	.14
HOWLONGS	.50	**.45**	–.02	.28
DIRECTUS	.26	.30	.34	.07
ESSENTLT	.51	**.53**	.34	–.15
PCTSUSE	.30	.09	**.48**	.12

Factor	Eigenvalue	Pct. of Variance	Cumulative Pct. Explained
1	5.61898	33.1	33.1
2	2.06078	12.1	45.2
3	1.34033	7.9	53.1

*See text for variable definitions.

teach students of different average ability? Results with these small numbers of teachers can at best be suggestive rather than conclusive, even for the set of schools under study.

At the secondary level, science teachers were much more likely to be "strong" Internet users (80%) than were secondary teachers of other subjects (35%) ($p < .05$). No other subject specialization came close to statistical significance.

Also, at the secondary level, the strong users taught somewhat higher-ability students (effect size = 0.2 standard deviations), but given the small *N*, this difference was not even close to being statistically significant. No difference in reported student abilities was identifiable at the elementary level.

Finally, when we looked at the original factor scores (i.e., teacher's self-reported Internet expertise; the breadth of their involvement of students in Internet-based learning, and the extent of their use of network learning projects), for the forty-one secondary teachers in this analysis there were small positive correlations between average student ability and each of these dimensions of teacher Internet involvement ($r = .17, .13$, and $.10$). But none of these correlations were statistically significant, nor was the correlation between student ability and the sum of the factor scores ($r = .18$). Thus, this final analysis is inconclusive on the question posed concerning whether the most expert and active Internet-using teachers teach higher-ability students. There may be a small relationship, but the evidence is insufficient for a reliable conclusion.

DISCUSSION AND IMPLICATIONS

Summary of Findings

Our survey-based research into the distribution of Internet use and expertise among the schools of the National School Network has yielded several findings:

First, although the innovating schools of the NSN understandably are located in higher socioeconomic locations than a cross-section of American schools would produce, there is still substantial geographic, racial, social class, and student ability variations across the schools belonging to this loose confederation of curriculum development and reform projects. In addition, the racial balance at NSN schools matches that of American schools as a whole very well.

Second, among the NSN schools, those that serve more historically disadvantaged populations (by race, student poverty level, and community social class) provide at least as active and rich a program of Internet-related instructional activity as the NSN schools serving more advantaged students. In fact, student involvement in network learning projects such as working with scientists, collaborative writing activities, and Web publishing is greater in lower-to-middle-income communities than in the more well-off communities. The only area where the poorer schools are at a disadvantage relative to the other NSN schools is in the area of external political support for school networking from community, district, and state agencies. Those schools in particular depend upon the attention given them by their National School Network affiliates, the national or regional Internet- and curriculum-development projects that have taken them under their wing.

Third, within NSN schools, particularly among middle-grade schools, classes of above-average ability students make somewhat more regular and systematic use of the Internet than average ability classes or below-average classes. This was particularly true for classes in computer or media studies, even when controlling on socioeconomic factors, and may be true for other subjects, like science and social studies, where Internet use is greater than average. It was not true, though, for other subjects, which, however, are less likely to use the Internet than the three subjects named.

Fourth, at the secondary level, among teachers who reported they taught classes of different ability levels—that is, in which typical student abilities varied from class to class—a substantial minority of Internet-using teachers (roughly 40%) said they used the Internet more with their highest ability class, and that percentage was three times as large as the percentage who reported greater Internet use by their least able class. Moreover, where there was a *substantial* ability difference between classes *combined with* substantial ethnic or social class diversity in the school or community, the higher ability class was much more often favored with greater Internet use.

Finally, looking at different Internet-using teachers within the same schools, there was some indication that, at least at the middle school level, the strongest Internet users—those with the greatest knowledge and experience concerning the Internet, who systematically involved the most students in Internet activity, and who employed innovative curricular projects involving the Internet—also taught students of somewhat higher ability than the other Internet users. Secondary science teachers were disproportionately in this strong-user category as well. However, the small number of individual teachers able to be included in this last analysis limits the reliability of these conclusions.

The Vision for Equitable Internet Use

The vision that telecommunications can be a democratizing force has been advanced by federal interventions that have focused on reducing the discrepancy between higher and lower SES schools. The National School Network was funded by one of several federal agency programs (the Networking Infrastructure for Education (NIE) program in the National Science Foundation) that have made a special effort to bring innovative uses of new technologies to a broad cross-section of schools and students, particularly targeting disadvantaged student populations.

The federal commitment to provide educational opportunities via the Internet has been stated via presidential announcement—"In our schools, every classroom in America must be connected to the information superhighway with computers and good software and well-trained teachers" [19]—and in the U.S. Department of Education's statement of priorities: Priority Six: Every Classroom will be Connected to the Internet by the Year 2000 and All Students will be Technologically Literate" [20].

It is important to note that a democratic vision for school-based uses of digital technologies does not stop at the schoolhouse door—that equity is a matter of distributing appropriate opportunities among different student groups within a school as well as between them. As we suggested earlier, it is plausible that practical and curricular reasons, as well as the question of which students in a school take classes from the most technically expert Internet-using teachers, may result in a pattern of Internet access that favors more advantaged and higher achieving students within a school. However, there is a difference between rational reasons for differentially distributing educational opportunities and unplanned "convenience" reasons for doing so. Being true to a vision of equity involves careful attention to discriminating between those types of reasons.

Pioneering Internet-Using Schools and Equity of Access

The National School Network has accomplished the distribution of its services, tools, and community-building activities across schools varying in geography, social class, and, in particular, racial composition. Nevertheless, the opportunity to implement innovative Internet-based teaching and learning programs is limited by the fact that schools in high socioeconomic communities tend to participate more widely in innovative curriculum development projects and have the necessary support from community, district, and state entities to capitalize the needed investment in infrastructure and personnel support. In spite of these factors, where the National School Network has established itself in poor-to-average income communities and serving racially and socioeconomically diverse students, implementation has been at least as successful as in other NSN schools.

Inside some NSN school buildings, particularly those at the middle-school level and where "tracking" or between-class ability-grouping partly resegregates diverse student populations into different instructional groups, there appears to be an uneven distribution of opportunity to participate in Internet-based learning. Computer literacy classes, in particular, need to attend to issues of equity of access. And at the middle-school level, the most technically knowledgeable and reform-innovating teachers—science teachers in particular—may be assigned students of higher academic ability, and this practice may unwittingly contribute to inequalities of opportunity within the school building. These tendencies, it should be noted, are *not widespread*, and indeed many fail to reach statistical significance. However, it is important that some vigilance be applied in individual school settings to avoid the emergence of within-school inequalities in resource access.

Overall, the National School Network's membership represents many independent efforts to promote reform instruction through exploiting the Internet's communications and information resources. These efforts are bringing to a broad cross-section of schools important curricular and technical expertise and the potential for building a community of effective, innovating teachers and schools. The relatively modest-sized biases and inequities unearthed in our analysis suggest that, on balance, the innovating NSN schools are contributing more to developing our capabilities of exploiting the Internet for all students than they are giving birth to problems of inequality of access and use. Although responsible leaders will continue to be alert to equity issues in promising innovations such as Internet use, this problem remains relatively small and highly variable among the leading edge Internet-using schools in this study.

APPENDIX: SCHOOL-LEVEL NETWORKING DIFFERENCES BY SOCIO-DEMOGRAPHIC INPUTS

Table A-1: Bivariate Correlations

	Socio-economic Status of Community	Percent Eligible for Chapter I	Percent Disadvantaged Minorities
Teachers' use of electronic mail	.13	.09	–.01
Students' use of electronic mail	–.01	.03	–.04
Number of types of network learning activities occurring at all	–.28***	.34***	.27***
Percent of teachers participating given any at all (scale)	–.07	.10	.11
Percent of students participating given any at all (scale)	.00	.10	–.04
Indications of teacher and student involvement in Web page development	–.14	.19**	.04
Incentives provided for staff development and use of Internet	–.04	.06	–.04
Support for school networking from local political actors (scale)	.16*	–.18*	–.21**
Teachers talk to each other about Internet-related things (scale)	–.08	.14	.11
Teacher participation in planning and development of school networking	–.04	.03	–.01

Note: *N* ranges between 104 and 112.
*$p < .10$
**$p < .05$
***$p < .01$

APPENDIX:

Table A-2: Multiple Regression Analysis

	Outcome Variables with Significant Bivariate Correlations					
	Breadth of Network Learning Activities		Web-Publishing		Outside Support of School Networks	
	R-sq.	Sig. *F*	*R*-sq.	Sig. *F*	*R*-sq.	Sig. *F*
Control Variables (school level, size, metro/non-metro)	.03	n.s.	.12	$p < .005$	.09	$p < .05$
Additional increment due to socio-demographic variables (Chapter I, ethnicity, SES)	.11	$p < .005$	.06	$p < .05$	.08	$p < .01$
Individual predictors	partial *r*		partial *r*		partial *r*	
High Socioeconomic Status Communities	–.30***		–.14		+.14	
Percent Chapter I	+.32***		+.13		–.25**	
Percent from Disadvantaged Minorities	+.26***		–.02		–.34***	

Note: Partial correlations control on school level, size, and metro/non-metro location.
*$p < .10$
**$p < .05$
***$p < .01$

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