

Perceived Helpfulness and Amount of Use of Technology in Science and Mathematics Classes at Different Grade Levels

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Use of technology in science and mathematics classes has been increasing, but there are differences in the amount of use of and students' perceptions of its helpfulness across grade levels and subject areas. Technology was reported as used only occasionally. Technology was used most often to understand or explore in more depth concepts taught in class. The second most frequent use was as a tool of investigation or assessment. The lowest reported use of technology was as tool of communication. Students in middle school classes perceived technology as less helpful than did students in elementary or high school classes. Students in mathematics classes perceived technology as more helpful than did students in science classes. Girls perceived technology as more helpful than did boys. Additionally, teacher and student perceptions of amount of use varied with teachers reporting more use than students.

The *No Child Left Behind Act* of 2001 called upon mathematics and science educators to improve the achievement of all students. One avenue for helping to improve science and mathematics achievement is by using technology. In fact, the National Council of Teachers of Mathematics (2000) standards stated that using technology is one of the six principles of high quality mathematics. Quellmalz (1999) suggested that computers can be used by students to acquire, apply, and extend their understanding of science and mathematics. Using the National Educational Longitudinal Study data, Weaver (2000) found that computer use in school was correlated with achievement as well as gender, so increasing in-school use of computers might help both boys and girls improve their understanding of mathematics and science. In a qualitative study, Henderson, Eshet, and Klemes (2000) found that the integration of interactive multimedia improved girls' attitudes toward science and promoted growth in social and thinking skills even as early as second grade.

A framework offered by Driscoll (2002) suggested four ways in which technology could be used in classrooms to facilitate learning:

1. Learning occurs in context, including ways that technology can facilitate learning by providing real world contexts that engage learners in solving complex problems and computer simulations that offer contexts for learners to understand complex phenomena.

2. Learning is active, including the use of brainstorming, concept mapping, or visualization software.

3. Learning is social, including software that supports a networked multimedia environment.

4. Learning is reflective, including technologies that promote communication within and outside the classroom.

Alagic (2003) agreed that computers could be used to provide multiple representations in mathematics. Yet he argued that teachers need to have successful experiences with the use of technology in order to use it effectively. Winn (2003) suggested that educational technology plays two roles – one as an entrée to verbal environments and one as a means to monitor the dynamics of learning for descriptive, anecdotal, and possibly, prescriptive purposes.

Although technology is being used in classrooms, the amount of use is limited by availability of technology, curricular materials designed to optimize use, and the lack of experience of teachers in using technology effectively. In terms of availability, Kleiner and Lewis (2003) reported that there is one instructional computer with Internet access for about every five students in the U.S. In their study of technology use in different countries Knezek et al. (2000) found several barriers to the use of information and computer technologies, including (a) shortage of technology, (b) logistical problems, (c) the changing roles of teachers, (d) time, and (e) accountability in terms of the type of learning that is tested. Manoucherhri (1999) reported on a survey of high and middle school mathematics teachers that computers in mathematics classes are really being used

only for drill and practice. The implication is that the teachers have not had the opportunity to learn how to use the computers effectively and that more teacher education is necessary.

The purpose of this study is to document student and teacher perceptions of computer use in elementary, middle, and high school classrooms, as well as student perceptions of the helpfulness of different uses. In addition, the background of the teachers in terms of experience with computer assisted instruction and principal opinions of school environments is provided.

Methodology

The data presented here were collected using survey methodology over 3 years from 2001-2003. The surveys were part of an evaluation of the Collaboratives for Excellence in Teacher Preparation (CETP) program, which was funded by the National Science Foundation (NSF) to improve the preparation of preK-12 science and mathematics teachers. The design of the study presented here was naturalistic in that existing data were used to examine relationships. The goal was to present teachers' and students' reported amounts of use of technology for different activities and to determine if there were any differences in the reported amount of use among different grade levels, different content areas, and teachers and students. Additionally, the amount of helpfulness of the different activities as perceived by students was presented, and the perceptions of boys and girls were compared.

Nineteen different systemwide CETPs were funded. Data were gathered from principals, teachers, and students across the nation. Teachers trained in CETP programs as well as those trained in other programs were included. Teachers not trained in the CETP program were selected to be matched to those trained in the CETP. For example, in one school there might be two second-grade teachers with comparable levels of teaching experience, one trained through a CETP program and one trained in a different teacher preparation program. Therefore, the sample was not random but, as can be seen in the description of the sample that follows, included a wide range of teachers and schools that could be considered representative of teachers in the U.S.

Principals and teachers were asked about institutional characteristics that supported science and mathematics instruction (e.g., how adequate is the availability of computers?), their beliefs about the importance of different teaching strategies (e.g., how important is it for students to write descriptions of their reasoning?)

and barriers to instruction (e.g., are there barriers to achieving excellent science and mathematics instruction and if so what are they?). Teachers and students were asked about the frequency of use of technology in their classes. The surveys assessed technology use by asking four questions: How often were technological devices such as computers and calculators used in the class (a) to understand or explore in more depth concepts taught in class, (b) as tools of investigation to gather and analyze scientific or mathematical data, (c) as tools of assessment, and (d) as tools for communication? Use was measured on a 4-point scale and included the anchors of *never* (1), *seldom* (2), *occasionally* (3), and *regularly* (4). Students were also asked about how helpful they felt these techniques were when used. Helpfulness was measured using the same items but with a 3-point scale with anchors of *not helpful* (1), *somewhat helpful* (2) and *very helpful* (3). Students could also report that the technique did not happen, in which case no rating of helpfulness was provided. The four items were based on The International Association for the Evaluation of Educational Achievement (IEA) Computers in Education Study (Plomp, Anderson, & Kontogiannopoulou-Polydorides, 1996). All of the instruments used are available on the Web at www.education.umn.edu/CAREI/CETP.

Sample

Data are included from 370 teachers, 257 principals, and over 7,000 students, including slightly more girls than boys. There were 66 elementary school level classes, 143 middle school level classes, and 163 high school level classes. The mathematics and science comparisons were restricted to those teachers who said they taught either mathematics or science and, therefore, includes mostly middle and high school classes. There were 119 science and 90 mathematics teachers and classes. Approximately half of the students in a class reported on how often technology was used, while the other half reported on how helpful they thought the technology was when used. Approximately 1,900 boys and 2,100 girls responded to use items, and 1,600 boys and 1,700 girls responded to helpfulness items. Fewer students reported helpfulness because students did not rate the activity if it did not occur.

Teachers reported from 1-35 years of experience, with 82% of them having taught for 5 or fewer years. Forty-seven percent of the teachers reported having taken courses in computer assisted instruction in their preparation programs. School enrollments were varied, with numbers of students varying from 28 to 2,900, with

a mean of 796 students and a standard deviation of 535. The schools were mostly urban, with 44% of the principals reporting that their students came from urban environments, 18% reporting suburban, 16% reporting town or small city, and 20% reporting rural.

The schools had somewhat supportive environments with as few as 29% of the principals reporting less than adequate availability of computers, although only 14% reported that the availability meets all needs. In terms of science laboratory facilities, 38% of the principals reported less than adequate facilities, but only 8% reported the facilities as meeting all needs. In terms of money available to provide supplies for science and mathematics instruction, 43% of the principals reported less than adequate money, and only 5% reported that the amount of money meet all needs.

Principals were also asked to rate their perceived importance of eight different student behaviors. Their ratings were consistent with the recommendations of the science and mathematics standards, with mean scores on a 1-5 scale of approximately 4 for the importance of (a) students writing descriptions of their reasoning, (b) investigative activities that included data collection and analysis, (c) whole class discussions where the teacher talks less than the students, (d) using computers to support deep understanding, (e) students gathering information to answer their own questions, (f) student working in groups, and (g) using a variety of assessment techniques.

Teachers were asked about the importance of students having input into establishing assessment criteria, about how well supplied with materials for investigative instruction were teachers in their school, and about whether or not teachers in their school had a shared vision of effective instruction. Teachers were about evenly split in their agreement about these issues, with a slight tendency toward agreement.

Both principals and teachers were asked about the influence of the science and mathematics standards in their work. Thirty-five percent of the principals reported that they used standards-based criteria in their selection of teachers. Of the teachers who said their preparation program had included information about the standards, 32% said this information made a difference in their teaching. Teachers were also asked how well informed the teachers in their school were about standards. Seventy percent agreed that they and their colleagues were well informed about the standards.

Fifty-five percent of the principals reported that they felt there were barriers to achieving excellent science and mathematics education in their schools. In contrast, only 38% of the teachers felt there were

barriers that inhibited them from teaching mathematics or science in the ways most beneficial for student learning. Principals and teachers differed somewhat in how they characterized the barriers. Principals reported lack of funding specifically as the most important barrier followed by shortages of equipment. Teachers tended to emphasize the lack of things that the funding could be used for rather than funding per se. Consequently, lack of technology was lower on the principals' lists than on the teachers'. Teachers listed general lack of supplies and resources first, followed by lack of time and then lack of technology specifically. However, all of the barriers, funding, supplies, resources, etc., interact and are related to lack of technology.

Results

Answers to each of the four technology items were examined to determine if differences existed between different types of classes and students. All but the gender comparisons were conducted on class means. The mathematics and science comparisons were restricted to those teachers who said they taught either mathematics or science and, therefore, includes mostly middle and high school classes. Comparisons were conducted using the Statistical Package for the Social Sciences (SPSS). The following comparisons were conducted for each of the four items:

1. Differences in teachers' perceived amount of use, students' perceived amount of use, and students' perceived helpfulness between elementary, middle, and high school teachers and classes. This comparison was completed using three (one for teachers perceived use, one for students' perceived use, and one for students' perceived helpfulness) one-way, three-level (elementary, middle, and high school) ANOVAs followed by post hoc tests (Sheffe) for each of the four different items.

2. Differences in teachers' perceived amount of use, students' perceived amount of use, and students' perceived helpfulness between mathematics and science teachers and classes. This comparison was completed using three (one for teachers' perceived use, one for students' perceived use, and one for students' perceived helpfulness) *t*-tests (mathematics compared to science) for each of the four different items.

3. Differences in perceived use and perceived helpfulness between boys and girls. This comparison was completed using two (students' perceived use and students' perceived helpfulness) *t*-tests (boys compared to girls) for each of the four different items.

4. Differences between teacher and student perceptions of amount of use. This comparison was completed using one paired *t*-test (teacher perceptions to class mean score perceptions) for each of the four different items.

The mean scores and standard deviations for each of the four technology items for each of the comparisons are presented in tables 1-4.

The first question about using technology to understand or explore in more depth concepts already taught in class showed five significant differences. One difference was between middle and high school students for student perception of use (middle school lowest). Two were between mathematics and science: one for students' perceived use and one for perceived helpfulness (mathematics higher). One was between boys and girls for helpfulness (girls higher). The final difference was between teachers and students for use (teachers higher). Teachers reported use of technology to understand or explore in more depth concepts already taught in class at the occasional level, while students viewed it as used between *occasionally* and *seldom*. Students viewed helpfulness at slightly below the *very helpful* level.

As shown in Table 2, the second question about using technology as a tool to gather and organize information showed three significant differences. One was between middle and high school students' perceptions of use (middle school lowest). One was between boys and girls on perceived helpfulness (girls higher). The third was between teachers and students for use

(teachers higher). Overall, teachers reported that they used technology *occasionally*. Students reported that the use of technology as a tool in investigations to gather and organize information was between the *somewhat helpful* and *very helpful* levels.

As can be seen in Table 3, the third question about using technology as a tool for checking understanding showed six significant differences. One was between elementary, middle, and high school for student perception of use (middle school lowest). Three were between mathematics and science: one for teachers' perceived use, one for students' perceived use, and one for students' perceived helpfulness (mathematics higher on all). And two were between boys and girls; one for use and one for helpfulness (girls higher on both). Teachers' levels of perceived use of technology as a tool for checking understanding were near *occasionally* while student perceptual levels were between *occasionally* and *seldom*. Students viewed the technology as between *somewhat helpful* and *very helpful*.

As indicated previously this fourth question about using technology as a tool for communication showed differences between elementary, middle, and high school for student perception of helpfulness (middle school lowest) and between teachers and students for use (teachers higher). The levels of use were in the *seldom* to *occasional* range for the teachers and in the *seldom* range for the students. The students felt the use of technology as a tool for communication was slightly more than *somewhat helpful*.

Table 1

How Often Students Use Technology to Understand or Explore in More Depth Concepts Already Taught in Class

| | Teachers Perceived Use Mean (SD) | Students Perceived Use Mean (SD) | Students Perceived Helpfulness Mean (SD) |
|-----------------------|-------------------------------------|-------------------------------------|---|
| Elementary, N=66 | 3.0 (.86) ^a | 2.71 (.57) ^a | 2.43 (.33) |
| Middle, N=143 | 2.9 (.94) ^a | 2.52 (.50) ^{ac} | 2.38 (.29) |
| High, N=163 | 3.01 (.93) ^a | 2.83 (.58) ^{ac} | 2.38 (.32) |
| Science, N=119 | 2.87 (.89) | 2.57 (.49) ^b | 2.28 (.32) ^b |
| Math, N=90 | 3.01 (1.01) | 2.90 (.60) ^b | 2.44 (.32) ^b |
| Male, N=1,900/1,600 | | 2.64 (1.03) | 2.36 (.70) ^d |
| Female, N=2,100/1,700 | | 2.71 (1.06) | 2.46 (.66) ^d |

^aSignificant difference in perceived use teacher-student at alpha < .05

^bSignificant difference in science and math at alpha < .05

^cSignificant difference in ES-MS-HS at alpha < .05

^dSignificant difference in Male Female at alpha < .05

Table 2*How Often Students Use Technology as a Tool in Investigations to Gather and Organize Information*

| | Teachers Perceived Use Mean(SD) | Students Perceived Use Mean(SD) | Students Perceived Helpfulness Mean(SD) |
|-------------------------------|------------------------------------|------------------------------------|--|
| Elementary, <i>N</i> =66 | 2.85(.88) ^a | 2.71(.59) ^a | 2.40(.33) |
| Middle, <i>N</i> =143 | 2.77(.91) ^a | 2.54(.51) ^a | 2.31(.29) |
| High, <i>N</i> =163 | 2.90(.98) ^a | 2.85(.54) ^a | 2.36(.33) |
| Science, <i>N</i> =119 | 2.90(.87) | 2.71(.53) | 2.30(.35) |
| Math, <i>N</i> =90 | 2.74(1.05) | 2.76(.62) | 2.34(.31) |
| Male, <i>N</i> =1,900/1,600 | | 2.68(1.03) | 2.35(.70) ^d |
| Female, <i>N</i> =2,100/1,700 | | 2.72(1.05) | 2.40(.67) ^d |

^aSignificant difference in perceived use teacher-student at alpha < .05^bSignificant difference in science and math at alpha < .05^cSignificant difference in ES-MS-HS at alpha < .05^dSignificant difference in Male Female at alpha < .05**Table 3***How Often Students Use Technology as a Tool for Assessment*

| | Teachers Perceived Use Mean(SD) | Students Perceived Use Mean(SD) | Students Perceived Helpfulness Mean(SD) |
|-------------------------------|------------------------------------|------------------------------------|--|
| Elementary, <i>N</i> =66 | 2.77(.96) | 2.69(.57) ^c | 2.42(.29) |
| Middle, <i>N</i> =143 | 2.57(.99) | 2.48(.52) ^c | 2.31(.32) |
| High, <i>N</i> =163 | 2.62(1.04) | 2.80(.62) ^c | 2.37(.32) |
| Science, <i>N</i> =119 | 2.21(.90) ^b | 2.43(.53) ^b | 2.25(.34) ^b |
| Math, <i>N</i> =90 | 3.03(1.02) ^b | 2.91(.62) ^b | 2.45(.27) ^b |
| Male, <i>N</i> =1,900/1,600 | | 2.59(1.09) ^d | 2.34(.72) ^d |
| Female, <i>N</i> =2,100/1,700 | | 2.72(1.11) ^d | 2.42(.68) ^d |

^aSignificant difference in perceived use teacher-student at alpha < .05^bSignificant difference in science and math at alpha < .05^cSignificant difference in ES-MS-HS at alpha < .05^dSignificant difference in Male Female at alpha < .05**Table 4***How Often Students Use Technology as a Tool to Communicate*

| | Teachers' Perceived Use Mean(SD) | Students' Perceived Use Mean(SD) | Students' Perceived Helpfulness Mean(SD) |
|-------------------------------|-------------------------------------|-------------------------------------|---|
| Elementary, <i>N</i> =66 | 2.17(1.09) ^a | 2.12(.66) ^a | 2.34(.36) |
| Middle, <i>N</i> =143 | 2.23(1.02) ^a | 1.94(.47) ^a | 2.19(.35) |
| High, <i>N</i> =163 | 2.29(1.03) ^a | 2.01(.51) ^a | 2.25(.39) |
| Science, <i>N</i> =119 | 2.17(.99) | 1.97(.47) | 2.22(.38) |
| Math, <i>N</i> =90 | 2.36(1.04) | 2.01(.60) | 2.22(.40) |
| Male, <i>N</i> =1,900/1,600 | | 2.03(1.06) | 2.22(.74) |
| Female, <i>N</i> =2,100/1,700 | | 1.99(1.10) | 2.28(.73) |

^aSignificant difference in perceived use teacher-student at alpha < .05^bSignificant difference in science and math at alpha < .05^cSignificant difference in ES-MS-HS at alpha < .05^dSignificant difference in Male Female at alpha < .05

Discussion

This study provides results from a generally representative sample of schools, although the data are somewhat biased toward urban schools. The teachers tended to be near the beginning of their careers. The school environments were somewhat supportive, with many schools reporting less than adequate facilities. Barriers included funding and shortages of equipment and supplies including computers. Principals and teachers appeared aware of and supportive of the type of teaching recommended by the science and mathematics standards.

As can be seen in the data, the four questions about technology use in these schools showed unique patterns of significant differences; however, there were some similar findings across the items. The mathematics classes were higher than the science classes in perceived use and helpfulness, the middle school classes were lowest in perceived use and helpfulness, the teachers' perceptions of use were higher than the students, and the girls' perceptions of use and helpfulness were higher than those of the boys. The type of use perceived as least helpful and used the least was communication. Overall, use scores were in the *seldom* to *occasional* range. Helpfulness scores were generally in the *somewhat helpful* to *very helpful* range. There were fairly large standard deviations indicating substantial variance within the groups.

The results in this study support findings from other work. Teachers rating the use of instructional methods more highly than their students was also found by Lawrenz, Huffman, and Robey (2003). As they suggested, these differences may be the result of different perceptual lenses. Being aware of these differences, however, is important for future studies in use of technology. If "truth" is assumed to be between the two perceptions, teachers tend to overreport while students tend to underreport in-classroom use of technology.

The results (a) confirm findings by Manoucherhri (1999) and Plomp et al. (1996) that computers are not being used very much in mathematics classes and (b) extend their findings to science classes, as well. This low use is despite the fact that in 2002 the ratio of students per instructional computer with Internet access in the United States was 4.8 to 1 (Kleiner & Lewis, 2003). Both the science and mathematics standards recommend the use of technology, and other studies have linked technology use with valued student outcomes such as achievement (Christmann & Badgett, 1999) and positive attitudes (Henderson et al., 2000). Despite these positive linkages many teachers in this

study, about 40%, use technology only occasionally. Only 1 teacher out of 5 in this study reported having students regularly use technology to enhance understanding or to explore concepts in more depth and to gather and organize information. The percentage of teachers never using technology for these purposes is around 10%.

It is clear that instructional technologies are not always used to their potential. It is possible that teachers are holding on to traditional instructional strategies with which they feel comfortable and that they need more professional development in this area, as suggested by Algaic (2003) and Manoucherhri (1999). According to the National Center for Education Statistics (2000) report, many teachers do not know how to incorporate computer skills into classroom instruction. The key factor that influences teaching and learning is not the number of computers available but how computers are used in education (Lowther & Ross, 2003). Technologies, used to develop higher order thinking skills, can have a positive impact on learning (Wenglinsky, 1998). However, Salomon, Perkins, and Globerson (1991) suggest that improper use of technologies may even cognitively de-skill students. To be effective, technology should be used as a pedagogical tool and must be fully integrated as an "integral part of a well-planned pedagogy" (Burnett, 1994, p. 1).

It appears from this study that middle schools are least likely to use technology and that middle school boys, in particular, have low perceptions of its helpfulness. This result may be due to the use to which computers are put. Manoucherhri (1999) reported that computers in the middle school were used mostly for drill and practice. Perhaps this helps to explain the low ratings for the middle school students in this study. The students in this study reported using computers to understand in more depth concepts covered in class as the most helpful use, followed by using technology as a tool to gather and organize data. Perhaps if middle school teachers concentrated on these types of technology uses, middle school boys would find use of technology more beneficial.

Our data show some gender effects, especially in terms of perceived helpfulness of technology. Girls view all but communication uses as more helpful than boys do. This may provide some explanation for Weaver's (2000) finding that computer use was correlated with gender. Additionally, this finding suggests that technology use might be helpful in terms of developing more favorable attitudes toward science and mathematics in girls (Henderson et al., 2000). This might encourage them to remain in science and

mathematics and enter scientific fields. However, any changes need to be implemented with care based on the diversity of experiences and multiple gender identities documented by Vale (2002) for girls in mathematics.

In summary our results show that adapting teaching strategies to the new technologies in ways that trigger student learning and understanding remains challenging. Our results support Healy's (1998) admonition that more effort is needed both to conduct substantive research and to develop guidelines on how to use new technology in the most constructive ways.

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Author Note: This work was partially supported by the National Science Foundation (DUE 9908902). The opinions expressed are those of the authors not those of the NSF.

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SOURCE: Sch Sci Math 106 no3 Mr 2006
WN: 0606000758004

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