Evidence of the NETS*S in K-12 Classrooms: Implications for Teacher Education

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The National Educational Technology Standards for Students (NETS*S) were developed to provide guidelines for effective and meaningful technology use with K-12 students. In the present study we used the NETS*S as a framework to analyze ways that teachers integrated instructional technology use and provided opportunities for their students to develop NETS*S competencies. We identified teachers' practices that reflected one or more of the NETS*S, and determined which standards had received little attention. Recommendations for addressing these neglected areas provide insights into ways that preservice teacher education can help future K-12 teachers more fully implement the NETS*S in U.S. classrooms.
Digital technology saturation in U.S. public schools has undergone a remarkable transformation over the past 25 years. In the early 1980s reports made no mention of Internet access, and only 125,000 computers were available for students' instructional use in U.S. classrooms—yielding a 168-to-1 student-to-computer ratio (Becker, 1983, 1985). In contrast, current reports indicate 92% of classrooms and 99% of schools have Internet access, with a 4.8-to-1 student-to-computer ratio, (Kleiner & Lewis, 2003). Sufficient levels of technology infrastructure to enable effective integration by teachers have been in place for several years now (President's Committee of Advisors on Science and Technology, 1997); yet critics lament teachers' limited and ineffective use of the available technologies and question the wisdom of this massive infusion of resources (Cuban, 2001; Office of Technology Assessment, 1995; Oppenheimer, 2003).

Early efforts to computerize instruction made use of computers as teaching machines to drill students in mathematics and keyboarding, and as word-processors for writing (Becker, 1983, 1991; Office of Technology Assessment, 1988, 1995). Typically housed in labs, computers were not readily accessible to teachers and their students who were assigned brief weekly sessions, or competed with other teachers in the school to schedule lab times for their students. Even in the best of cases technology use was sporadic and infrequent (Cuban, 2001; Oppenheimer, 1997, 2003).

Others, however, have noted a shift in teachers' instructional technology use that aligned with student-centered reform efforts (Becker, Ravitz, & Wong, 1999; National Center for Educational Statistics, 2000; Kleiner & Lewis, 2003). Beginning with research on the Apple Classrooms of Tomorrow project (Dwyer, Ringstaff, & Sandholtz, 1991; Sandholtz, Ringstaff, & Dwyer, 1997) in the 1980s, and bolstered by more recent work at the Center for Research on Information Technology and Organizations (CRITO), it seems teachers have begun to implement activities that integrate technology use into the existing curriculum—encouraging students to work cooperatively as they use computers to access and share information, and represent their understandings through the creation of a variety of products (Becker, Ravitz, & Wong; Riel & Becker, 2000). Reform-oriented technology integration policies were foundational in the development of the International Society for Technology in Education (ISTE) National Educational Technology Standards for Students ([NETS*S] ISTE, 1998; see http://cnets.iste.org/students/s_stands.html).

NETS*S were developed to provide standards and guidelines to help teachers effectively and meaningfully use technology with their students. Grounded in constructivist instructional philosophy and a view that the purpose of schooling is to prepare students for a changing workplace (ISTE,
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1998, 2000), NETS*S provided a vision of technology integration that promoted active student learning and engagement in higher-order thinking as they used technology to increase productivity, solve problems, conduct research, and communicate with others.

In the present study we examined ways that teachers integrated technology-related activities into their instructional practices, and the extent to which students' instructional technology use reflected the NETS*S standards. We interviewed teachers to collect stories about effective ways they had used technology with their students and analyzed their stories to determine how the described activities reflected the six NETS*S standards: (a) Basic Operations; (b) Social, Ethical, and Human Issues; (c) Productivity Tools; (d) Communication Tools; (e) Research Tools; and (f) Problem-Solving/Decision-Making Tools. This characterization—in each teacher's own words—of the current state of instructional technology use in schools provides insights into whether and how students were experiencing activities that were consistent with NETS*S standards in their classrooms. Our purpose was not to determine the degree to which teachers were aware of the NETS*S, whether NETS*S was influencing their practice, or the extent to which teachers were systematically and consciously applying NETS*S in their teaching. We used NETS*S as a framework for analyzing the technology-based teaching practice that occurred in these classrooms.

Teacher educators can use the results of this study to identify effective ways that practicing teachers use technology with their students, and share these strategies with their preservice teacher education students. More importantly, teachers' stories reveal important areas where the standards are not being adequately addressed. Through focusing efforts on addressing these shortcomings technology teacher educators can work toward preparing a new generation of teachers who have the necessary skills and knowledge to ensure their K-12 students meet the NETS*S.

METHOD

Interviewers from a consortium of eight Midwestern and Southwestern universities collected K-12 teachers' stories of technology integration over a three-year period. Participants constituted a convenience sample since we targeted technology-using teachers in schools that were proximal to consortium institutions and took stories from as many teachers as we could identify. Although we collected data from teachers across content areas and grade levels, our sample differs from the larger U.S. teaching population in several
important areas. First, interview participants were all technology using
teachers (else they could not provide a story). Further, although some volun-
teered directly, many were recommended by peers or administrators. These
factors resulted in a teacher sample that was likely skewed toward those with
reputations as advanced technology users—and probably tended to use tech-
nology more frequently than did peers. Even though we specifically stated
that teachers need not be exemplary technology using teachers to participate,
our sample may reflect a higher-level of technology usage than might be typ-
ical. Further, these teachers may be more confident and willing to be public
about their teaching because they agreed to be interviewed about their prac-
tice. In light of these considerations, caution is warranted in generalizing
findings too broadly.

Participants

Data were collected through interviews with 1,078 technology-using
teachers in K-12 schools. Participants were identified through several re-
cruitment strategies. In some instances district level technology coordinators
were contacted and helped recruit teachers and set up interview schedules at
area schools. In other cases interviewers contacted teachers, set up and con-
ducted interviews, and used those teachers as resources to identify other po-
tential participants within the school and surrounding areas.

Fifty-two percent (52%) of participating teachers taught in elementary
schools, 48% in middle and high schools. Many had less than 10 years expe-
rience (42%), 34% had 10-20 years experience, and 24% had taught for
more than 20 years. Over half (54%) of the teachers reported their school lo-
cation as suburban and the remainder were divided between rural (26%) and
urban (20%) settings. Thirty-four percent (34%) of teachers described their
student population as a mixture of all socio-economic groups. Of the re-
mainder, 38% described their schools as lower/middle class, 18% rated their
schools as poverty/lower class, 7% as poor (most families receiving public
support), and only 3% described their students as predominantly affluent.
From this dataset, we selected all cases that included a story of a technolo-
gy-based activity in one or more of the core content areas—mathematics,
science, reading/language arts, and social studies. This filter resulted in 716
usable cases for analysis. Full transcripts for all cases can be accessed on the
Knowledge Innovation for Technology in Education (KITE) website (http://
kite.missouri.edu/). Quotations presented in the present study are identified
by their KITE case number (e.g., 1001-1).
Interview Protocol

A semi-structured interview protocol was used to collect demographic information and to guide the teacher to provide a thorough narrative describing the instructional activity. An initial question prompted the teacher to describe an activity when he or she had used technology effectively with students: “In your opinion, what was your most successful use of technology in the classroom? Can you tell me a story about it?” Probes were used, when necessary, to elicit additional information, providing a rich description of the activity, their purpose for using technology, expected learning outcomes, and teacher and student roles. Interviews were audio-taped, transcribed, and coded using a framework designed by the authors.

Coding Process

Codes were developed to identify the types of hardware and software used in each activity, and to determine whether and how participating in the activity helped students develop competencies consistent with the six NETS*S standards. Code development was accomplished through an iterative process. During the first pass through a subset of the data, researchers developed initial codes relative to each standard. Additional passes through data samplings allowed us to refine the coding scheme. Three raters each read and coded one third of the dataset in 50 transcripts blocks. Double coding 10% of the data occurred during each round and reliability was established at just over 90%, Raters met frequently to discuss discrepancies and to maintain inter-rater reliability.

As we read the transcript of a given technology-integration activity we coded elements of the teachers’ description that reflected attention to one or more of the NETS*S standards. The following two excerpts from an eighth-grade language arts teacher’s interview demonstrate the coding process. She began the interview with a description of a classroom activity in which she had used presentation software:

They would then write a poem in the style of the poet. So, for the PowerPoint presentation...I said, “All right, now I want you to do a PowerPoint presentation on a poet. And, you also have to have four biographical slides on the poet. You need to have two poems by the poet and two analyses of the poets work. Then, you also need to do a poem in the poet’s style.” We focused on six American poets who wrote in the 19th Century. (8507-1)
In this example students used computers (Hardware) to create PowerPoint (Software) presentations. Since the students were the ones who created the presentation it was coded as a Student Activity (Standard 1—Basic Operations). Further, in producing the PowerPoint they were using the technology to create a Product (reflected in Standard 3—Productivity Tools), and Organizing Information into four biographical slides (reflected in Standard 5—Research Tools).

Later the same teacher described what students did with their presentations:

**Teacher:** It was more interesting for them to do the research on the poet, ...when they were doing this as a PowerPoint....when they presented the PowerPoint in the class, I had them actually read the PowerPoint to us, .... (8057-1)

This excerpt was coded to show students' use of technology to communicate information to the other students—inside the classroom (Standard 4—Communication Tools) and to report the results of their work (reflected in Standard 5—Research Tools).

Raters refrained from drawing inferences about student use of technology in the activities—only coding explicit references from the transcripts. For example, in the language arts teacher's transcript presented, one might infer that students worked together in teams because there were only six poets from which to choose. Yet the coder could not know if the example was of a small senior seminar with six students, or if more than one student might be producing a PowerPoint on each poet. This policy yielded a relatively conservative coding strategy.

**Analysis**

Analysis was guided by our assumption that narrative is a powerful tool to illuminate human action (Bruner, 1986) and that it provides useful insight into the values of a particular culture (Polanyi, 1985). We approached this task as a narrative analysis, which postulates that saliency of information, or of a particular event in a story, can be determined through examining the narrative (Alexander, 1988). People tend to remember and relate the most significant information when asked a question, and will emphasize ideas and themes they feel are significant. Further, reliability was enhanced as participants were not explicitly asked to relate their stories to the NETS*S—which
could lead teachers to embellish their stories as a form of social-pleasing behavior (Kalton & Schuman, 1982). Thus, the details teachers conveyed as they told their stories about integrating technology into classroom activities served as indicators of their most salient beliefs and practices in using technology with students.

Frequency counts of the occurrence of various codes provided initial entry into the analysis. Examining emerging patterns within the frequency analysis provided insights into the overall use of technology by participating teachers. Identifying patterns within the narrative and extracting representative quotations that exemplified categories of behaviors constituted the final phase of analysis.

RESULTS AND DISCUSSION

The six NETS*S standards were developed to ensure students had basic technology skills and understandings, understood technology’s role in society, used technology thoughtfully and responsibly to be productive, communicate with others, conduct research, and solve problems. Teachers in this study reported a wealth of activities that reflected these goals to greater or lesser degrees. Although some differences among teacher use were identified in activities across grade levels and content areas, few were significant and those that were tended to be fairly intuitive (e.g., students used data collection probes more frequently in science classes). The complete report of these findings has been reported elsewhere (Niederhauser & Lindstrom, 2006). The following sections provide insights into how teachers’ activities reflected each standard.

Standard I: Basic Operations and Concepts

Our basic assumption was that if students were to develop Standard 1 competencies they would need to be actively engaged in hands-on uses of technology that required the development of advanced skills. We examined our data relative to this standard in two ways. First, we identified whether it was the teacher or the student, who had hands-on control of the technology. For cases in which the student controlled the technology, we identified the types of hardware and software students used to determine if their use necessitated the development of more sophisticated technology skills.
Technology user. In 95% (678/716) of the cases, students had direct hands-on control of the technology. The remaining 38 Teacher-use cases were most often examples of teachers creating and showing a multimedia presentation to their students:

I have a slideshow presentation with animations and sounds. It really seems to grab their attention, because instead of me lecturing and talking, they are able to see graphics on live screen....So what I would do is, even before I get to a slide, I will ask the question that is on that next slide....After they answer the question, I say “that sounds pretty good, let’s find out if you are right.” The next slide pops up and tells them whether they are right or wrong....they see it in animation with sounds and graphics. (2112-1)

In this example, and all other teacher-use cases, students did not experience any hands-on use of the technology. Since students were not actively using the technology they were not developing Standard I basic operations and skills. All remaining analyses were based only on the 678 student-use cases.

The fact that 95% of teachers described activities in which the students were using the technology is encouraging. It appears that one of the most basic themes in the NETS*S—that students must have hands-on experiences with the technology to develop basic skills and concepts—resonated with these teachers.

Nature of use. Computers were, by far, the most pervasive technology used in these cases (648/678, 96%). The nature of student use can be addressed through examining the types of software students used while engaged in the activities. Skills and understandings necessary to effectively use different types of software can directly affect the development of students’ proficiencies. For example, little technological proficiency was required to engage in the drill-and-practice activities that were pervasive in the 1980s and 1990s. Students simply responded to prompts on the screen by keying in, or clicking on, answers to questions. In contrast, students must develop advanced computer literacy skills to complete multimedia projects or to desktop publish class newsletters. As students engage in these activities, and learn to use the associated software, they will gain the basic skills and concepts that reflect Standard I competencies.

Results reveal an encouraging trend. Teachers in our sample frequently had their students use tool software (Taylor, 1980) that required students to develop more sophisticated technological skills (Table 1). In the described activities, students used Web Browsers, Multimedia Construction Tools,
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Word-Processing/Desktop Publishing programs, Spreadsheets, and Concept Mapping software—all of which required students to develop a level of software mastery to complete projects. On the other hand, students infrequently used software that simply involved keying in responses—only 9% reported activities using drill-and-practice software and 3% described using testing software (such as Accelerated Reader; Renaissance Learning, 2005). Further use of simulation software (3%), such as Oregon Trail (Minnesota Educational Computing Corporation, 2001), allowed students to engage in conceptual thinking but provided few opportunities to develop technological expertise. In the vast majority of cases, the software used served as a tool to support student learning (596/678, 88%).

<table>
<thead>
<tr>
<th>Software Type</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Web Browser</td>
<td>276</td>
</tr>
<tr>
<td>Multimedia Construction</td>
<td>238</td>
</tr>
<tr>
<td>Word-Processing/DTP</td>
<td>183</td>
</tr>
<tr>
<td>Drill-and-Practice</td>
<td>63</td>
</tr>
<tr>
<td>Spreadsheet/graph</td>
<td>44</td>
</tr>
<tr>
<td>Concept Map</td>
<td>40</td>
</tr>
<tr>
<td>Video Editing</td>
<td>28</td>
</tr>
<tr>
<td>Visualization Tools</td>
<td>28</td>
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<tr>
<td>Graphics</td>
<td>23</td>
</tr>
<tr>
<td>Web Development</td>
<td>23</td>
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<tr>
<td>Testing</td>
<td>22</td>
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<tr>
<td>Simulation</td>
<td>21</td>
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<tr>
<td>E-mail</td>
<td>18</td>
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<tr>
<td>Information CD</td>
<td>16</td>
</tr>
<tr>
<td>Database</td>
<td>12</td>
</tr>
</tbody>
</table>

Note: \( N = 678 \)

Teachers' technology use tends to mirror their experiences during teacher training (Moursund & Bielefeldt, 1999). The current emphasis on a contextualized approach to teaching preservice teachers to use technology in introductory instructional technology courses, and distributing technology education across methods courses (Angeli, 2005; Niederhauser, Salem, & Fields, 1999; Thompson, Schmidt, & Davis, 2003) promotes a student-centered, tool-based, hands-on view of technology use that increases the likelihood that the pattern of use identified here will continue.
Standard II: Social, Ethical, and Human Issues

Central to the Social, Ethical, and Human Issues standard is the notion that technology can be used in responsible ways to promote collaboration among students. The advent of Information and Communication Technologies changed the skill set necessary for students to compete in the global economy (President’s Committee of Advisors on Science and Technology, 1997) and have fundamentally changed ways that students access information and communicate with each other both at home and at school. However, this access to communication technologies has also created concerns that students may engage in unethical and anti-social behaviors.

Results of recent research has raised concerns about student use of the Internet. More than half of 4,500 high school students from 25 high schools around the US admitted to cheating on a written assignment by copying portions of a paper from the Internet without citation (Conradson & Hernandez-Ramos, 2004). On a more positive note, Lenhart, Simon, and Graziano (2001) surveyed 754 children between the ages of 12 and 17 and found that 94% used the Internet for school research and 41% used e-mail or instant messaging to contact teachers or classmates about schoolwork. Clearly, technology has the potential to be a powerful educational tool, but it is also critical to recognize, and directly address, potential challenges and misuses.

**Ethical and responsible use.** There were only 55 instances of teachers attending to ethical and responsible uses of technology in our dataset. Of those instances, all were related to student use of the Internet. The fact that few teachers mentioned ethical and responsible use issues is disturbing given the issues previously raised and the fact that Internet Browser was the most commonly used software by students in the present study (276/678, 41%). When mentioned, concerns about ethical and responsible use tended to fall into two primary categories: necessity to cite information sources to avoid plagiarism, and monitoring students and providing guidelines to keep them from accessing inappropriate information. One reason students do not properly cite sources may be that they do not understand the concept of intellectual property as it pertains to electronic information (Conradson & Hernández-Ramos, 2004; Park, 2003). Many students are unaware of situations in which it is necessary to cite sources and do not have knowledge about ways to properly give credit for the electronic resources they use. Further, classroom teachers may also lack skills and knowledge about citing electronic sources; but for those who are aware of these issues, raising student consciousness tends to be highly salient:
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I think one of the keys is differentiating between professional sources and web pages that are not legitimate. That's huge. Citing sources, not plagiarizing, and differentiating between scholarly sources, those are, I think, the key skills that I'm here to teach. (8311-1)

Teacher education programs can help alleviate this problem by ensuring pre-service teachers have a good understanding of intellectual property principles and copyright laws, and have the knowledge and skills to effectively cite sources. More importantly, perhaps, teacher education programs should commit to helping preservice teachers develop a sense of social and ethical responsibility to instill appropriate values in their future students.

The second key element we identified relative to responsible use concerned limiting student access to inappropriate information on the World Wide Web (WWW). We found it remarkable that only 12 teachers commented on this topic given that it is clearly a major concern both in schools and in society. Concerns are apparent in a recent report that indicated 98% percent of schools had written Acceptable Use Policies (AUP) to control student use of the Internet (NCES, 2000). Further, 91% of schools adopted at least one other method (e.g., blocking or filtering software, teacher/staff monitoring and/or honor codes) to further monitor student Internet use. This attention to controlling student access to inappropriate information at the administrative level may lead many teachers to believe that this issue is not their responsibility—perhaps making it less salient to teachers when describing activities in which their students use the Internet for classroom activities.

This complacency may be unwarranted. A recent review of acceptable use policies reported that most were written in highly technical and legal terms, making it potentially difficult for parents, teachers—and especially students—to completely understand the terms of the policy and consequences of misusing the Internet (Loverro, 2002). Further, it appears highly unlikely that students will be able to translate what they read in these technical acceptable use policies to generate practical guidelines for their actual Internet use. Other forms of monitoring student access to inappropriate information also have limitations. Raising student awareness and instilling a sense of responsible use may best be accomplished through instructional interventions by teachers.

One way to accomplish this is by having teachers translate their schools' AUP into language that is accessible to parents and students. Pre-service teachers can learn strategies for helping ensure their students understand AUP during field experiences in methods classes and during student teaching. Following are some simple, yet important procedures for interpreting and translating a schools' AUP.
• Locate the district policy.
• Identify individual regulations that apply to students.
• Craft these regulations in age-appropriate language, using sample activities and examples.
• Include additional classroom-specific rules for computer use.
• Identify appropriate hierarchical consequences for failure to follow rules.
• Create a packet that includes a cover letter to parents; the "kid-friendly" AUP; the district AUP; and a permission slip to be signed by the student parents and teacher.
• Develop a measurement instrument (test) to determine level of student mastery of the "kid-friendly" AUP (Loverro, 2002).

These kinds of activities help preservice teachers use the AUP as a tool to develop a sense of ethical responsibility in their students. Students need to internalize this sense of responsibility to enable them to take responsibility for their actions. Teacher educators can promote this process by instilling a sense of responsibility in preservice teachers. This can occur when education faculty explicitly teach these concepts, model ethical and responsible use of technology in their own courses, and require preservice teachers to follow proper codes of conduct when completing assignments that require the use of electronic resources (Moursund & Bielefeldt, 1999).

**Collaboration.** The second major Social, Ethical, and Human Issues principle was using technology to promote collaboration among students. Despite early fears that computers in classrooms would isolate students and disrupt their social development, the opposite may be true. In a recent study eight-year-old children working with computers engaged in twice as many verbal and nonverbal interactions during computer-based activities when compared to other types of instructional activities (Svensson, 2000). In contrast to the image of classroom computing presented in early reports (in which students received individualized instruction, each at his or her own computer) our data suggests that cooperative and/or collaborative group work has become more pervasive. Collaborative group work was explicitly mentioned in 48% (328/678) of the activities. We identified two types of collaboration: **Intentional Collaboration and Spontaneous Collaboration.**

First, 79% (258/328) of cases involving collaboration were coded as *intentional collaboration*—in which teachers planned the technology based activity to be conducted in pairs or a small group of students, and 21% (70/328) were identified as—*spontaneous collaboration* in which students were
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encouraged to help each other and troubleshoot technical difficulties encountered during the activity without prompting from the teacher.

The relatively high proportion of collaborative activities may reflect a general shift toward increased use of collaborative activities in teachers’ practices. This shift is consistent with many current content-area pedagogical reform efforts (e.g., International Reading Association [IRA] and the National Council of Teachers of English [NCTE], 1996; National Council of Teachers of Mathematics [NCTM], 1991, 2000; National Research Council [NRC], 1996). Teacher education faculty can continue to design and implement activities that promote student collaboration during technology-based activities as collaboration appears to increase student motivation and encourage deeper understanding of course material (Brush, 1997; Roschelle, Pea, Hoadley, Gordin, & Means, 2000).

Standard III: Productivity Tools

Students engage in more meaningful learning experiences when they use technology to produce knowledge, rather than to consume knowledge (Jonassen, Peck, & Wilson, 1999). Further, development of critical thinking skills is enhanced when students engage in project-based assignments to produce a product to share with an audience (Lehrer, Erickson, & Connell, 1994). For example, use of word-processing software has enabled students to revise their own writing (MacArthur, 1998; MacArthur, Graham, Schwartz, & Schafer, 1995), and creating desktop publishing products encourages students to think more deeply about the content they are learning (Mayer, 2001). Developing multimedia presentations can help students retain information and enhances their understanding of content (Lehrer, Erickson, & Connell, 1994; Ritt & Stewart, 1996). Clearly, the NETS*S productivity standard promotes an important aspect of student technology use.

Creating products. Fully 76% (515/678) of the activities involved creation of an identifiable product. Word-processing and desktop publishing constituted a large proportion of these activities (217/515, 42%); however, nearly as many activities involved creation of a multimedia presentation (201/515, 39%). Many presentation projects involved gathering information and resources using the WWW, and presenting their completed presentations to other students. For example, this sixth-grade science teacher had her students create and present PowerPoint presentations:
I have them create their own PowerPoint presentations. We were talking about animals and...ecology and habitat, and their biomes....They had to create a PowerPoint presentation for the animal. They had to find pictures from the Internet and they had to download them into their PowerPoint. They had to present it in front of the class. (8105-2)

Students also created products such as graphics (77/515, 15%), videos (31/515, 6%), and spreadsheets (30/515, 6%); but the vast majority involved producing desktop published or multimedia-based reports.

This increase in teachers developing activities in which their students use technology to create products has occurred for a variety of reasons. Many likely adopted the *constructionist* principles (Kafai & Resnick, 1996; Papert, 1980, 1993) that are consistent with the principles underlying the NETS*S*. That is, they are helping their students engage in purposeful, authentic technology use to create products, and have directly related these activities to content area goals. Continued progress in this area will likely depend on how well these activities are perceived as meeting general content-area reform goals. Teacher development programs can support synergy among technology and content area pedagogy development by providing a coherent vision of the basic constructivist philosophies that underlie reform efforts and articulating this vision throughout the teacher preparation program—and by providing models of effective technology use in methods courses and field experiences.

**Standard IV: Communication Tools**

The use of technology-based communication tools has been widely hailed as a key factor in transforming the nature of the 21st century schooling experience (Riel, 1998). Access to information resources, opportunities to converse with experts online, and the potential to publish one's own work to be viewed and critiqued by a broad audience provide unprecedented opportunities to participate in a global community that can be highly motivating to students. Unfortunately, teachers in the present study tended not to make use of communication tools' potential to extend their students' experiences beyond classroom walls.

*Presenting information.* Although 74% of the activities (499/678) involved some form of electronic communication, use consisted mostly of communicating information, through a product like a multimedia presentation or desktop published document (466/499, 93%), to an audience that consisted of classmates and the teacher (385/466, 83%):
Perhaps my best experience with using technology was a PowerPoint project in which I assigned my twelfth graders. They were responsible for doing a PowerPoint presentation on the kingdoms, and I used that as a time for them to gather information on the kingdoms and to present to their peers a topic. This provided them an opportunity to prepare for not only the twelfth grade curriculum, but also I wanted them to get exposure and experience in doing presentations in front of an audience of their peers so they would be prepared for college.

Although having an audience of classmates may be an effective motivator for students, a much wider, and potentially more motivating audience is available through the WWW. Unfortunately, our results revealed that students used the WWW to communicate information to others beyond their school walls in only 14% (65/466) of communicating information cases. This example illustrates a fourth grade teacher's activity in which she posted her students' work to a class webpage:

Teacher: So, we went through, and first they researched the real pioneers that went west and they picked a persona. And then they wrote a biography about it. And then we had some old-fashioned clothes, so, I had all the kids dress up in those outfits, and then we took individual pictures of them. And then they had to write a first-person biography about themselves as that pioneer. And then we put the pictures in as a watermark behind them.

Interviewer: Oh, how beautiful.

Teacher: And then we uploaded those to the Internet, too.

Based on our finding that many teachers in the present study described activities in which students created products (such as PowerPoint presentations) and used these products to present information to their teacher and classmates, it appears clear that teachers have begun to implement activities that are consistent with Standard 3. However, this use of communication tools does not take advantage of the WWW's potential to transcend the current model in which students remain insulated from the world in their classrooms.

**Interacting.** Rather than simply accessing or posting information, current technologies enable students to interact with others through tools such as e-mail, discussion boards, and videoconferencing. Online collaborations can improve student motivation, attitude, and interest-in-school when they discover that their work has value in the real world (Peck & Dorricott,
Consequently, online collaborations often result in improved performance on many measures of academic achievement (Bracewell, Breuleux, Laferriere, Beniot, & Abdous, 1998; Means & Olson 1994). Activities that involved the use of online technologies to interact with others outside the classroom were rare. Only 7% (33/499) of activities involved students using technology to interact electronically with others. This Kindergarten teacher engaged her students in an e-mail project to help them learn about children in other cultures:

The kids wanted to know what it was like in other countries...what kids experienced in other countries. So I said, “how can we find that out?” We decided that we would send e-mail to kids around the world and ask them specific questions. So the kids came up with the questions and I actually let some of them type some of the words on the keyboard. Then we sent the e-mail off and each week we would hear from kids across the world and we would respond to whatever questions or whatever information was sent to us. So that was really successful because it ended up being a project that helped my kids realize that kids across the world have so much in common. (3018-1)

The activity provided these young students with an opportunity to raise their global awareness as they interacted with peers to learn directly about other cultures. Students also gained familiarity with some of the Information Age technologies that, according to Peck and Dorricott (1994), will likely be a part of their future everyday lives.

It is, perhaps, not surprising that most teachers have been slow to embrace the Communication Tools standard. Many teachers lack requisite skills, knowledge, and/or motivation to provide interactive communication activities for their students on the WWW (National Forum on Information Literacy, 1998). Most challenging may be the necessity for teachers to relinquish some control in the learning exchange (November, 2001) as students interact independently without the teacher acting as intermediary. Further, teachers and parents have legitimate concerns about a child’s safety when they interact with others that they do not know on the WWW.

There are two primary barriers that must be overcome if teacher educators are to address this challenge. First, preservice teachers will need to develop some unique logistical and classroom management skills to effectively coordinate these kinds of activities. Simply ensuring students have adequate access to technology, organizing a timeline for posting messages that allows adequate time for responses, and monitoring students’ participation and netiquette can be challenging. We are just beginning to understand
issues associated with developing and conducting appropriate interactive online communication in educational environments (Hacker & Niederhauser, 2000; Harms, Niederhauser, Davis, Roblyer, & Gilbert, 2005). While students tend to be digital natives (November, 2001)—expert in new forms of communication (e.g., text messaging, chat, video conferencing, etc.) and conversant in the current vernacular and shorthand that has emerged in text-based digital communications (e.g., “omg”...“kewl”...“lmao”), teachers are often digital immigrants—unfamiliar and uncomfortable in these contexts. This outsider perspective can be intimidating for teachers, but teacher preparation programs can take the lead in addressing this barrier by ensuring pre-service educators have experiences with digital communication technologies and receive practice leading these types of activities during coursework and field experiences.

However, providing information and strategies to structure and implement these activities addresses only part of the problem. The second barrier stems from teachers’ limited knowledge of the possibilities for implementing online communication activities in the classroom, and limited awareness of the resources available for engaging in such activities. There continues to be a marked shortage of communication-based learning activities in classrooms today (Harris, 2004), and many teachers have experienced difficulties identifying viable online interactive projects, and connecting with like-minded teachers and students with whom to collaborate.

Virtual Architecture: Designing and Directing Curriculum Based Telecollaboration (Harris, 2006), and the related websites (http://txtipd.wm.edu/ & http://virtual-architecture.wm.edu) provide a taxonomy of online communication activities. This taxonomy helps teachers become familiar with and understand the range of learning activities in which their students can engage that make powerful, worthwhile use of online tools and resources. The activity-types taxonomy helps scaffold teachers’ activity, unit, and project development by encouraging selection and combination of appropriate activity-types to address particular students’ curriculum-based learning needs. It also serves as an organizational framework for the different kinds of activities that use online tools and resources.

The taxonomy provides examples of activities including Interpersonal Exchange, in which individuals or groups communicate electronically with each other on a variety of social and academic issues; Information Exchange projects, in which students from broad geographical areas collect and submit data online to explore concepts like global weather patterns and various animals’ migratory behaviors (e.g., Monarch Butterflies); and Strategies Exchange activities, in which students collaborate to address real-world and simulated problems. Included are links to descriptions and instructions for
completing the activities, as well as links to other teachers and organizations that can be used to establish safe and reliable collaborations.

Increased awareness of possibilities and resources for conducting interactive WWW-based communication activities in the classroom, coupled with the development of knowledge and skills to effectively guide and supervise student participation in these activities, can prompt preservice teachers to more fully implement the Communication Tools standard in their future classrooms.

Standard V: Research Tools

Providing opportunities for students to actively engage in meaningful research can help instill essential logical reasoning and critical thinking skills (Sharma & Elbow, 2000) that will benefit students in their future studies and in their lives beyond school. The two primary research-based uses of technology identified by teachers in the present study included preparing research reports and conducting experimental research. Creating research reports typically included using technology to access information resources, to organize the information in meaningful ways and to present their findings using word-processing/desktop publishing or presentation software. Conducting experimental research often involved using probes to collect data, using analysis tools (e.g., spreadsheets) to process and analyze data, and reporting results in a paper or presentation.

Overall, students were involved in some form of research in 66% percent of the cases (446/678). The most pervasive research activity involved finding information on the WWW and incorporating that information into research reports and/or presentations (371/446, 83%).

Research reports. We identified two modes of web searching in these activities: locating information and collecting information. In locating information activities (145/371, 39%) students were required to actively search for information on the WWW. In completing these tasks students developed web searching skills and strategies as they used search engines and other resources to seek the information they needed:

Yes, and that was one of the things, specific searches. A lot of them wanted to type in just Africa. Unfortunately when you type in just Africa, you get, I think, one of the kids got over six million hits. Instead of searching through six million sites, what country in Africa are you doing? Chad, okay, type in Chad. He got nine hits. Big difference, so
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he went to the CIA site for Chad, popped it up, and he goes, Wow. (2029-1)

When students were made responsible for locating information themselves, they learned essential information literacy skills (National Forum on Information Literacy, 1998; Niederhauser, 1996), and engaged in a form of problem-solving (as will be discussed in the upcoming section on Standard VI).

The majority of activities, however, were coded as collect information (226/371, 61%). In these activities teachers provided links to the websites that students were to use in completing the task:

Teacher:...there is a website that, I don’t have the information on it right now but there is a website that has several primary sources from people who were involved in the slave trade. And so I have a worksheet for the students to do which asks several questions. The students are expected to go onto that website, find those primary sources, read over those primary sources and then answer the questions based on those primary sources...I call it a scavenger hunt. (8024-1)

With this type of activity, the teacher takes responsibility for students’ information searching tasks—potentially saving class time and protecting students from inadvertently stumbling upon inappropriate information—but also depriving students of an excellent opportunity to develop information searching strategies that appear to be difficult to acquire in other ways (Fidel et al., 1999; Schacter, Chung, & Dorr, 1998).

An important part of information searching/information literacy development involves being able to evaluate the validity and reliability of information—especially from sources on the WWW. Few of the locate/collection activities related by teachers in this study mentioned having students evaluate the veracity of the information they found on the Web (24/371, 6%), although those who did indicated they believed it to be very important:

We look at authority, like who created the web page, if the web page is dated, links, and especially if the links are active. If a lot of the links are not active, it means it’s an old web page. How often has it been updated? We look at stuff like tone and construction, which can fool you a lot of times. Some really well constructed pages are not the best ones. (3064-1)
Experts agree with these teachers—attending to the validity and reliability of information is an essential part of the research process (Jonassen, Howland, Moore, & Marra, 2003; November, 2001). Helping students recognize the importance of evaluating information, and acquire skills necessary to do so, grows increasingly crucial given that many students use the WWW as a primary source for authoritative information. Preservice teachers also have an essential need for developing information evaluation skills—both as consumers of information themselves, and to promote critical information literacy habits in their future students.

Promoting critical consumption of information on the WWW involves using strategies like examining the structure of web addresses, identifying the nature of the sites that link to the site in question, checking qualifications of the author of a site, and determining whether the purpose of a site is to advocate a certain position—which may reflect a bias in the information presented (November, 2001). For example, a tilde (~) in the URL indicates that the website is in a personal subdirectory and may include viewpoints that do not represent the parent organization in the link. Further, the extension at the end of an address reflects the nature of the site: .com indicates a commercial address, .org an organization's address, and .gov a government address—so http://whitehouse.gov/ (the official webpage for the U.S. President’s home) is a more reliable source of information than http://whitehouse.org/ (a spoof of the official site).

**Experimental research.** Few examples of using technology tools to conduct experimental research appeared in our dataset (75/446, 17%). Instances primarily involved the use of science probes and Global Positioning System (GPS) devices to collect and process data (17/75, 23%), and the use of spreadsheets to organize and analyze data (27/75, 36%):

We get a transparent tray of water. We put a grid under it, and the students will take digital voltage readings. They transcribe those voltage readings at every point on the grid into a corresponding point on a spreadsheet. Then they use the spreadsheet to generate a graph showing the voltage reading and the voltage variations, and they print those out and use those in writing up a lab report. (3162-1)

Based on these results it is clear that teachers in this study rarely made use of technology to engage their students in experimental research projects, despite well-documented evidence of the value of these kinds of experiences for students (Alessi & Pena, 1999; Linn & Eylon, 2000). Current cognitive constructivist science reform efforts (NRC, 1996) promote an active,
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real-world contextualized problem-solving approach to science instruction. Use of technology-based tools to support data collection and analysis in science methods classes can promote synergy between science education reform and technology integration efforts—providing authentic experiences using the tools scientists use in the real world. Introducing the use of technology tools in preservice science methods courses may prompt an increase in the use of technology tools to support experimental research with students to more effectively implement the Research Tools Standard.

Standard VI: Problem-Solving Tools

The ability to identify and creatively address problems has become increasingly important in the information age society. Standard Six, Using Technology Problem-Solving and Decision-Making Tools, reflects this trend. Problem solving is a complex process that is present in many school-based and day-to-day activities—sometimes overtly as a problem-solving task, at other times as an implicit component of larger tasks. Teachers described activities in which helping students develop problem-solving skills was the primary goal in only 18% of the cases (122/678). However, various forms of implicit problem solving was evident in many of the activities teachers described. The most prevalent of these were design activities.

Design activities tend to present the most complex and ill-structured problems that people encounter (Jonassen et al., 2003). Jonassen and his colleagues defined design problems as real-world problems—like building a house—that require designers to draw on knowledge from multiple domains. In fact, designing involves solving a series of complex interconnected problems to accomplish an overarching goal—the creation of the product.

Design problems for students often include the creation of products such as multimedia presentations, desktop published projects, webpages, and videos. As indicated in our discussion of Standard Three, having students create multimedia presentations was a common activity for these teachers—and designing and developing multimedia presentations appears to be an effective way to promote problem solving (Sharp, 1996; Jonassen, Peck, & Wilson, 1999). In completing multimedia projects students encounter a host of problems including selection, organization, and sequencing of content; effective use of graphic design principles; and structural and navigation issues—among many others.

Two important aspects of the multimedia design process relate directly to problem solving—situated learning and autonomy/responsibility. First,
situating the multimedia project in a research report activity that involves information literacy issues (recognizing that information is needed to solve the problem; and addressing problems associated with searching for and locating appropriate information, and, once found; evaluating the veracity of that information). In the following example students worked on a multi-layered problem situated in a meaningful task:

...initially in a class, I will pose six to ten questions, depending on the topic and the level of the questions, and guide the students through finding the answers on the Internet so they learn how to search on the Internet. They learn how to find information. They learn how to read through it to the best of their ability. Then they use [that information] to produce either a written document explaining their point of view or whatever bias they see...last year we spent a lot of time when Israel was coming down on the Palestinians, we spent a lot of time looking at the Palestinian side and the Israeli side of what was going on and reading international news articles on-line trying to figure out who the author was biased in favor of or against, [we] talk about those kinds of things. Then they go through and explain that in their own words....We've done HyperStudio projects, PowerPoint projects where they are taking that information, using it, turning it into something they can use to teach their peers about what they've learned. (8106-1)

Through completing these tasks students encounter a multitude of problem-solving opportunities. For example, the stated purpose of the activity was to address a social problem—conflict between Israelis and Palestinians. But they also examined problems of bias in reporting of events in the media, overcame practical problems in learning to search for and find necessary information in their web searching, and developed problem-solving skills to validate their sources. Despite an excellent opportunity for teachers to introduce their students to meaningful problem-solving activities, only 27% (55/201) of multimedia presentations situated students in a meaningful research task that drove the design of their presentations.

The second aspect of multimedia design that promotes problem solving relates to the autonomy students have and the personal responsibility they assume, for completing the task. The level of scaffolding teachers provided for students helped determine the extent to which students assumed autonomy and responsibility. In general, the more structure provided by a teacher, the fewer opportunities for students to solve naturally occurring problems that arise in the context of the activity—the less structure provided, the more students must take responsibility to solve the problems they encounter. Some
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teachers provided a level of structure that removed much of the responsibility for decision making from students and severely limiting the need for students to engage in problem solving:

So I made an example for the kids to work off of. How I wanted it to look and how I wanted them to organize it. When we started, we all started with the ocean. We all tried to make it the same font and we made it a little larger so it stuck out. Then we talked about how changing the shapes or changing the size of the letters will make it look more organized. How the lines need to be kind of organized around your central idea, so that somebody could look at this and they could track what they were doing. As we would add each ocean, we made sure that each ocean was a certain color and then the facts were a different color. All the facts then are one color. All the oceans are one color. Then the word ocean is the third color. We also do that with the shapes. The ocean is one shape. The different oceans are one shape. The facts are the third shape. So that they can find where the facts are very readily and quickly. (4070-1)

Other teachers allowed students to make design decisions, and thereby, provided students with significant opportunities to engage in design-based problem solving:

That will also involve using a PowerPoint presentation, which almost all of the students here know how to make a good PowerPoint presentation. Now that’s part of their initial training. And I usually leave things open in terms of creativity because I want to see their best work. I don’t try to limit them....My experience has been whenever you let these guys run with something, they do a better job of it and it’s usually very well done. (8006-3)

This example makes clear the teachers’ responsibility to appropriately scaffold activities so that students can work within their zone of proximal development (Vygotsky, 1978). When students do not receive adequate support they often experience frustration. However, when they receive too much support they miss out on important opportunities to engage in situated problem solving. Learning to provide an appropriate balance of support and challenge is a key component in the development of preservice teachers.
CONCLUSION

Many teachers in this study embraced the basic principles promoted by the NETS*S. They provided opportunities for students to get hands-on experiences with the technology (primarily computers), assigned projects that required students to use technology to create products, encouraged students to work together, and had students use technology to communicate information to classmates. The most frequently described activities (using a web-browser to find information on the WWW, incorporating that information into reports using desktop publishing and presentation software, and presenting their reports to the teacher and/or classmates) occurred across multiple content areas and grade levels. The prevalence of these types of activities indicate teachers may be moving away from decontextualized integrated-learning-system/drill-and-practice technology uses of technology, and toward the more student-centered constructivist approaches advocated in NETS*S. However, this research also identified some shortcomings that could be addressed through preservice teacher education.

A central finding was that most teachers did not address the responsible and ethical use issues reflected in Standard II. Few teachers described helping students understand appropriate ways to use and cite information found on the WWW despite widespread plagiarism in the schools. Further, helping students learn to search effectively and validate sources are important and necessary skills for those who wish to be successful in the information-age workplace. Teacher preparation programs can help teachers develop solid understandings of these essential topics so they can effectively promote their students’ development of necessary skills and understandings to use digital information resources responsibly and ethically.

Another area that has not yet reached its potential involves the use of technology to engage in interactive communication activities with students that reach beyond the classroom walls. A key aspect of the recent developments in telecommunications technology involves opportunities to break down cultural barriers by allowing people to communicate with each other and understand cultural and social similarities and differences. Although opportunities for classroom use of these technologies has steadily increased through the development of chat, instant messaging, e-mail, discussion boards, and desktop-video-conferencing, teachers in this study were not taking advantage of them. Following the lead of innovators in this area (e.g., Harris, 2006), teacher preparation programs can make a more concerted effort to provide experiences and resources that will help preservice teachers understand and value the richness of these activities.
Finally, many of the ways that teachers implemented technology-based activities in this study did not encourage the development of the conceptually challenging problem-solving skills in their students. This shortcoming may be more related to teachers' pedagogical development than their use of technology in the classroom. Basic constructivist principles suggest that learners make sense of their experiences when they are cognitively engaged in active mental processing; learn from activities that are purposeful, collaborative, and contextualized; and benefit from reflecting on and representing their knowledge constructions (Jonassen, 1995). Helping students formulate, take on, and solve problems is an important part of the constructivist process—and technology can be a powerful tool in supporting problem-solving activity in the classroom.

Preservice teacher education programs can promote the use of technology-based problem-solving activities in the classroom by ensuring teacher candidates get a firm foundation in constructivist learning theory and related instructional practices. With that understanding preservice teachers can begin to explore ways to integrate technology in ways that support problem solving. This can, perhaps, best occur in methods classes where problems can be contextualized in a content area and technology can be integrated in meaningful and appropriate ways to scaffold student learning.

The development of the NETS*S standards were an important milestone in the educational technology integration movement. The standards identified basic principles for student use of technology in the classroom that aligned with the broader constructivist-based content-area curricular reform efforts that occurred in the 1980s and 1990s. While many aspects of the NETS*S are reflected in the ways teachers have integrated technology into their instructional activities, teachers are still in the process of incorporating some of the most basic principles inherent in them. Technology teacher educators can play an active role in promoting effective K-12 teacher technology use by focusing on the critical shortfall areas identified here in preservice teacher education coursework and field experiences.

References


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