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A. Louis Odom
University of Missouri-Kansas City

John Settlage
University of Utah

Jon E. Pedersen
University of Oklahoma, jpedersen2@unl.edu

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Technology Knowledge and Use: A Survey of Science Educators

A. Louis Odom,[1] John Settlage,[2] and Jon E. Pedersen[3]

1 University of Missouri-Kansas City, 5100 Rockhill Road, Kansas City, Missouri 64110.
2 Department of Teaching and Learning, University of Utah, Salt Lake City, Utah.
3 The Science Education Center, The University of Oklahoma, Norman, Oklahoma.

Corresponding author – A. L. Odom, email alodom@umkc.edu

Abstract
The purpose of this study was to determine the current state of technology use and know-how among members of the Association for the Education of Teachers in Science. A web-based survey site and an e-mail merge invited members to participate in the study. The survey examined the differences between current and desired levels of knowledge about using technology as an instructional tool, to support research, to enhance productivity in classroom applications, and to enhance data collection and analysis. Large mean differences about using technology as an instructional tool were found, including: (1) teaching students at a distance, (2) database applications, and (3) desktop publishing. Small mean differences were found for telecommunications and word processing.

Keywords: technology knowledge, classrooms application of technology, technology to enhance productivity, science education, on-line survey

Introduction

The challenge facing Americas' schools is the empowerment of all children to function effectively in a future that's marked increasingly with change, information growth, and evolving technologies. According to the National Science Education Standards (NRC, 1996), we should establish connections between the natural and designed world providing students opportunities to develop decision-making abilities.

Science as inquiry is parallel to technology as design. Observation, measurement, intervention, monitoring, diagnosis, and treatment rely extensively on technology. Therefore, how we study, learn about, and teach science must change to maintain relevance and effectiveness for researchers, practitioners, teachers, and lifelong learners (International Society for Technology in Education [ISTE], 2000). As a consequence, the use of technology by science teacher educators becomes an important link in efforts to infuse technology into the broader educational system.

Authentic scientific inquiry into student generated questions is the key to effective science teaching (NRC, 1996). Many times scientific inquiry relies heavily on technology to solve problems and support knowledge development. As science and technological knowledge increases and becomes more sophisticated, science teachers and educators must keep pace. Educators must (a) become and remain proficient at using technology, (b) understand the social, ethical, and human issues surrounding technology, and (c) be aware, capable, and able to teach technology that can enhance productivity, research, communication, problem solving, and decision-making. The challenge is to integrate technology into the classroom and make it an integral tool for learning within the context of science and science education (ISTE, 2000).

The challenge when using new innovations, ac-cording to Susan Loucks-Horsley (1998), is to make changes that occur as collective progressions from initiation to implementation to institutionalization. With recent advances and innovations in technology providing more opportunities for the use of technology as a tool for learning we sought to establish levels of use along a continuum for various technologies and innovations for a professional science education organization.

Having decided to try something new, individuals progress stepwise from mechanical to routine to integrative use of the innovation, technique or tool (Rogers, 1983). If an innovation is to become fully incorporated into a system thoughtful management by a change agent is key (Horsley and Loucks-Horsley, 1998). The process is similar whether an individual is trying to use cooperative learning for the frst time or attempting to develop a website or teach a course over the Internet.

Purpose

The purpose of this study was to determine the current state of technology use and know-how among members of the Association for the Education of Teachers in Science. The methodology was based upon a previous survey of the AETS members (Pedersen and Yerrick, 2000) with one major departure, which was the way data was collected. We used a web-based survey site and an e-mail merge to invite members to participate in the study. The survey examined the differences between current and desired levels of knowledge about using technology as an instructional tool, to support research, to enhance productivity in classroom applications, and to enhance data collection and analysis.

The major objective was to determine the group's knowledge of particular technologies, their desired levels of knowledge for each of these, and the size of the gap between current and desired levels. This particular effort was an outgrowth of AETS's participation in the National Technology Leadership Initiative which is interested in encouraging discussions related to the technology infusion in teacher preparation in the content areas (i.e., science, mathematics, social studies).

Instrumentation

The instrument was a web-based questionnaire. The questionnaire had two general sections, "technology usage" and "needs and demographics." The technology usage and needs section contained five subsections with a total of 30 items. The subsections were: (1) using technology as an instructional tool, (2) using technology to support educational research, Odom, Settlage, and Pedersen (3) using technology to enhance productivity, (4) the effects of computers in the classroom, and (5) computer usage in science. Demographic data was collected with 19 items which included: (1) highest degree earned, (2–4) degree areas, (5) teaching levels, (6) certification areas, (7) K-12 teaching experience, (8) availability of a media center at one's institution, (9) teaching responsibilities, (10) college/university rank, (11) conference attendance, (12) current publications, (13) internet training, (14) location of internet training, (15) location of internet use, (16) creation and/or maintenance of a science or science education website, (17) last year completing a science course, (18) last year completing an education course, and (19) name, address, and institution.

The questionnaire was written as a form and placed on a website using Microsoft's FrontPage. A form is a collection of fields that can be used for gathering information from people visiting a website. The data in this study was submitted directly to an Excel Spreadsheet. A back-up copy of each response was automatically e-mailed to a different site. An e-mail merge of AETS members was used to solicit participation in the survey. The e-mail message included the survey website address, how the information would be used, and a confidentiality statement. A record of invalid e-mail addresses and responses was kept and those addresses were deleted from the master e-mail list. A follow-up e-mail request to participate in the survey was sent 1 month later using the updated list.

For each survey item, the respondent was to give an indication of their present level (current) and hoped for (desired) level of technology knowledge using a 5-point Likert scale. A value of 1 represented a very low level of knowledge, while 5 represented a very high level of knowledge. This pattern of current and desired knowledge was used for all items (Fig. 1). One open-ended item asked respondents to identify technology topics that they would like to see in AETS preconference workshops.

Data Analyses and Results

An AETS officer provided a list of 893 e-mail addresses of members. After the first e-mail request to participate in the survey, 307 addresses were returned as invalid. A second e-mail request was made with a revised list. A total of 276 AETS members responded to survey, which represented a 47% response rate among AETS members with valid e-mail addresses.

The data for the study were analyzed using Microsoft's Excel statistical software. By convention, a

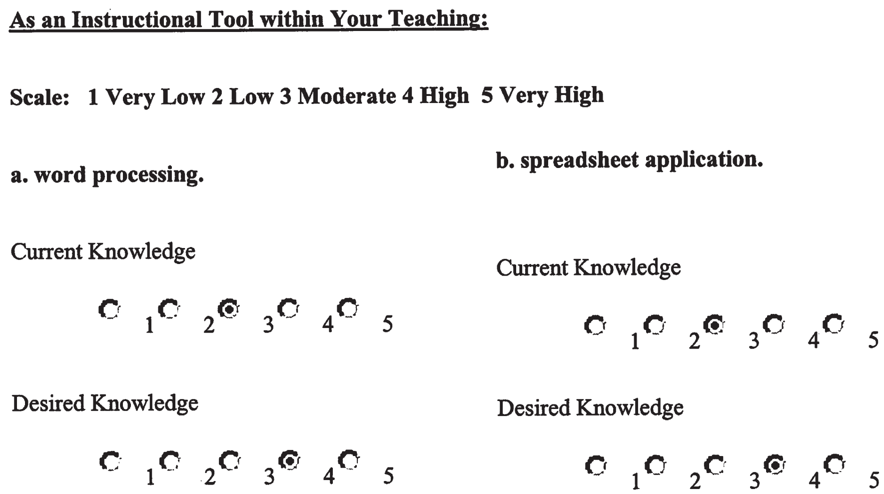

Figure 1. Sample survey item.

0.05 alpha was selected for the *t* tests (Ferguson and Takane, 1989; Hopkins et al., 1987). A paired t test was used to determine whether the sample means were statistically different. However, with a large sample size, small differences resulted in significant differences. Because of this, we will also examine the magnitude of the mean differences. The mean differences were categorized as small (<0.00– 0.50), medium (0.51–1.16), or large (>1.17) to assist in making sense of the differences between the current and desired levels for each item in the survey. The respondents indicated their rank to be assistant professor (31.2%), associate professor (23.6%), or professor (19.6%) with the remaining one fourth indicating they were "other," K-12 teachers, or in college level positions (instructor, adjunct, visiting professors). Over 81% held a doctoral degree. The respondents had high school (55.2%), middle school (22.5%), or elementary (14.9%) teaching experience. Respondents were certified in general science (16.2%) life science (14.3%), biology (13.9%), or physical science (10.9%). The most frequently taught courses were undergraduate level courses (39.4%), followed by master's level courses (38.9%) and lastly, doctoral level courses (14.6%). The respondent pool can be characterized as holding a doctoral degree, currently teaching at the university in a tenure line position, had precollege science teaching experience, and taught a balance of undergraduate and graduate level courses.

The survey revealed that 92.4% of the respondents had made a presentation at a national science education convention and 92.0% had published an article. The conventions most often attended were AETS (26.2%), NSTA (23.9%), and NARST (20.5%). Over 65% attended a national science education convention in 2001. Respondents reported a variety of technology experiences. Over 90% indicated that they were self-trained to use the Internet. Less than 4.0% learned to use the Internet through a college course. Most (56.9%) used the Internet primarily at work or the office, over 71.7% indicated that their institution had a media center, and 44.9% indicated that they maintain a website.

The following five tables provide the current and desired means, mean differences, and significance of paired t tests for the means, for each block of items within the on-line questionnaire. The responses were ranked in descending order by mean difference scores between "Current" versus "Desired" levels of knowledge.

The two items with the greatest mean difference for the instructional uses of technology was "teach students at a distance" and "database applications" (Table I). The two technology applications were substantively different within the context of instructional uses. Database application suggests respondents were interested in learning how to organize and communicate empirical data resulting from science investigations. This is supported by many of the free response comments.

Teaching students at a distance can involve database applications and desktop publishing, but is primarily providing instruction while the student and teacher are at different locations. Class interaction may be synchronous or asynchronous through the use of websites, listserv's, and e-mail and has the potential to reach large populations of students that would otherwise not be reached. However, managing large numbers of students effectively requires technological skills

Table I. Responses to "Using Technology as an Instructional Tool Within Your Teaching" Ranked by Difference Between Current and Desired Means

	Current		Desired			*n*	
Technology use	Mean	SD	Mean	SD	Mean difference	Current	Desired
Teach students at a distance	2.60	1.18	3.89	1.20	1.29**	273	273
Database application	2.93	1.05	4.23	0.88	1.29**	276	275
Desktop publishing	2.79	1.19	3.96	1.12	1.17**	276	275
Spreadsheet application	3.20	0.99	4.34	0.83	1.14**	276	274
Deliver individual computer aided learning	2.69	1.12	3.76	1.15	1.07**	273	271
Demonstrating, using commercial instructional software	3.11	1.15	3.96	1.08	0.85**	274	271
Making presentations (e.g., via PowerPoint)	3.77	1.02	4.44	0.96	0.67**	272	268
Using spreadsheets to maintain records and grades	3.66	1.15	4.19	1.09	0.53**	274	271
Telecommunications (i.e., email)	4.38	0.70	4.55	0.86	0.18**	274	270
Word processing	4.29	0.69	3.70	1.27	–0.59**	276	276

** $p < 0.01$

including those necessary to implement standards-based instructional strategies within the context of authentic inquiry activities.

It would appear that greater knowledge of distance learning and database applications could potentially improve some aspects of science instruction. In order to close the gap between current and desired knowledge levels for these technology uses, our emphasis must be software training and the development of effective teaching strategies.

Telecommunications was the tool that received the highest current level of knowledge. Interestingly, the mean difference for word processing was negative. This suggests that the average AETS member felt they knew more about word processing than was really necessary. Perhaps the ability to create columns, generate tables and otherwise fine tune the formatting of documents were regarded as detriments to one's skill as an instructor.

In contrast to the first table, Table II focuses on research uses of technology rather than instructional uses. All four of the proposed uses had statistically significant differences between current and desired knowledge levels. Knowing how to use software to work with qualitative data had the lowest current level of knowledge and the largest mean difference. In fact, this mean difference was the largest for all the measures gathered within this study. One could surmise that among the members of AETS there is a powerful need for knowledge in how to use qualitative data analysis software. It seems reasonable that this desire has multiple contributing factors; i.e., research studies reporting upon the use of computer-enhanced analyses of qualitative data are becoming increasingly common, and because of the relative newness of this type of software, many AETS members may not have had exposure to or training in its use during their doctoral studies.

Table II. Responses to "Using Technology to Support Educational Research Efforts" Ranked by Difference Between Current and Desired Means

	Current		Desired			*n*	
Technology use	Mean	SD	Mean	SD	Mean difference	Current	Desired
Working with qualitative data (e.g., HyperQual, NUDIST)	2.00	1.13	3.90	1.21	1.90**	273	273
Editing video	2.08	1.04	3.59	1.16	1.50**	271	271
Statistical analyses (e.g., SPSS, SAS, Excel)	2.84	1.13	4.04	1.10	1.20**	273	266
Accessing on-line indexes (e.g., ERIC, Educ. Abstracts)	3.75	1.08	4.41	0.91	0.65**	273	271

** $p < 0.01$

Table III. Responses to "Using Technology for Enhancing Productivity" Ranked by Difference Between Current and Desired Means

	Current		Desired			*n*	
Technology use	Mean	SD	Mean	SD	Mean difference	Current	Desired
Publishing (newsletters, CDs, PDF files)	2.82	1.14	4.11	1.01	1.29**	274	274
Aid in class management (i.e., monitor attendance, track grades)	3.36	1.00	4.39	0.89	1.02**	274	271
Time management and personal scheduling	3.25	1.23	3.83	1.25	0.59**	273	273
Word processing	4.25	0.73	4.55	0.87	0.30**	275	272

** $p < 0.01$

The data in Table III were based upon using technology to enhance one's productivity (i.e., other than for instructional or research purposes). Of the four proposed uses, only "publishing" resulted in a large mean difference. It seems that generating documents was seen as an important aspect of productivity. However, it would also be reasonable to suggest that the subsets of "publishing" (i.e., newsletters, CDs, and PDF tiles) are so broad that wide variations of publishing types were erroneously lumped into this one category. As with Table I, the mean difference for word processing is small, in contrast to desktop publishing, which had a large mean difference. The similarity of the mean differences among similar items in Tables I and III provides an indication of response consistency.

Knowledge about computers' effects upon classroom management, presentations and preparing for class all produced medium means differences (Table IV). The largest gap between current and desired means was for classroom management, perhaps indicating that computer-based strategies for this purpose were simply unknown and/or poorly understood. Overall, the responses within this category did not reveal large differences in knowledge suggesting that this area is not one about which the organization should be especially concerned.

The next category of technology use was about various purposes for using computers within science instruction (Table V). The responses showed large mean differences. This would indicate that the current to desired knowledge gap was substantial for many computer-based applications within science teaching. The greatest mean differences were for problem solving, demonstrations and modeling, collecting data using peripherals, and database storage of laboratory data. All of the items in this category showed significant differences between current and desired levels of knowledge and related directly to authentic scientific research.

The potential of computer-based technologies as an important utility beyond just desktop machines is of great interest to the respondents. The pattern of responses reveal a need to better understand how computers might be used as authentic scientific research tools, such as gathering and storing data, using computers to model and demonstrate natural phenomena, and analyzing and communicating findings. While not an especially innovative use of technology (probes have been around for almost 20 years) interest in such uses remains high. Similarly, database applications as an instructional tool show a large mean difference (Table I).

Table IV. Responses to "Effects of computer use on …" Ranked by Difference Between Current and Desired Means

	Current		Desired			*n*	
Technology use	Mean	SD	Mean	SD	Mean difference	Current	Desired
Classroom management	2.68	1.14	3.54	1.25	0.86**	270	267
Professional presentations	3.58	0.99	4.36	0.92	0.78**	270	270
Class presentations	3.48	1.00	4.18	1.02	0.70**	269	263
Class preparation	3.40	1.05	4.05	1.07	0.65**	268	264

** $p < 0.01$

Table V. Responses to "How to Use a Computer in Science For …" Ranked by Difference Between Current and Desired Means

	Current		Desired			*n*	
Technology use	Mean	SD	Mean	SD	Mean difference	Current	Desired
Problem solving	2.70	1.11	4.12	1.00	1.42**	261	260
Demonstrations and modeling	2.88	1.07	4.29	0.87	1.42**	267	267
Collecting data using peripherals	2.85	1.11	4.26	0.95	1.41**	271	271
Database storage of lab data	2.67	1.10	4.07	0.92	1.40**	271	270
Interfacing	2.52	1.11	3.85	1.09	1.33**	259	260
Spreadsheet for analysis of lab data	2.91	1.14	4.06	1.03	1.15**	268	270
Graphing	3.18	1.12	4.32	0.91	1.14**	270	268
Science/technology/ society issues	3.04	1.11	4.05	1.09	1.01**	264	265

** $p < 0.01$

In addition to the Likert scale type items, a free response section was included in the survey. AETS members were asked to list topics (related to technology and use of technology) they would like to learn more about at an AETS preconference workshop. There were 298 responses, which proved to be consistent with many of the current and desired knowledge items reported in Tables I–V. All responses were analyzed and then grouped into categories based on similar attributes. The largest number of free responses was about using technology to enhance data collection. Specifically, respondents were interested in data collection, use, and management on computers and the Internet (including peripherals, basic data management software, learning activities related to data collection/management). Another broad category of responses was using technology, computers and the Internet to enhance teaching and learning. Creating websites and learning advanced web programming language was an area of great interest (HTML, JAVA, forms etc.). As well, respondents indicated an interest related to learning more about GPS/GIS systems, and using images, photos, videos, cameras, and audio tiles.

Discussion

A survey of the members of the Association for the Education of Teachers in Science was undertaken in an effort to establish both current uses of educational technologies and to determine the gaps between current and desired levels of knowledge. The greater the gap, the more valuable it would be to the profession to address those technologies. Within the subset of questions about using technology as an instructional tool, three technology uses had large mean differences: (1) teaching students at a distance, (2) database applications, and (3) desktop publishing. Small mean differences were found for telecommunications and word processing.

The largest mean differences for the entire study emerged in the subset of technology used to support research efforts. Gaps between current and desired knowledge for working with qualitative data, editing video, and statistical analyses all produced large mean differences. In terms of using technology to enhance productivity, only publishing (e.g., newsletters, CDs, and PDF tiles) produced a large mean difference. Uses of technology for classroom management, presentations, and class preparation only produced medium mean differences.

Several uses of computers within science instruction revealed wide current-to-desired knowledge gaps with large mean differences for problem-solving, collecting data using peripherals and interfacing. Other uses of technological tools that revealed large mean differences were geographic information systems (GIS), global positioning systems (GPS), electronic white boards, personal digital assistants (e.g., Palm Pilots), MP3 players, and hypermedia. Finally, uses of the Internet that produced large mean differences were web-based instruction, customized course websites, creating electronic student dialogues, and posting readings electronically.

It appears that among AETS members there were substantial and specific areas for which technology uses were important. It would seem then that targeting the skills and tools mentioned as potential preconference workshops would be well received by many of the AETS membership. What we cannrot assess from this survey data were the affective dimensions of technol-

Table VI. Concerns for Science Education, Technology Issues, and Teacher Preparation (From Bell, 2001)

- Does technology help students accomplish the recommendations of the science education standards?
- If we teach preservice teachers to use appropriate technology, will they teach more in the way we want them to teach?
- Does technology enable students to ask questions they would not have thought of asking before?
- Do students learn science differently with technology? Is the quality, nature, or efficiency of learning improved?
- Are students learning different science content or concepts with the technology than they would have otherwise?
- Does technology enhance inquiry learning? Can technology provide an inquiry environment?
- If science educators determine that technology is worthwhile, what do they need to do, or what experiences do they need to provide, to convince preservice teachers of its benefits?
- What are the stages teachers have to go through to appropriately use technology in learning?
- Can technology help educators maintain an ongoing relationship between education faculty and new teachers in the classroom?

ogy use within science education and/or teacher preparation: What do we believe about technology, what self-efficacy dimensions may be at play, and why do we seek more information for certain technologies? In other words, what was the basis for the responses provided on this survey? Moreover, perhaps most pointedly, were these beliefs about potential benetits of technologies well founded? In his examination of 10 years of publications within the Journal of Technology Education (JTE), Petrina (1998) found several factors that should give us pause: almost 90% of the authors were men, 62% of the studies used a descriptive/conceptual methodology, and fully two thirds of the studies used adults (teachers, university students, etc.) as the study subjects. Although his closing comments were directed toward a single journal, his critique may be useful for those who consider the role of technology within science education:

> The politics of research in technology education may be reduced to two questions for dialogue. Can the JTE be shaped to become less a product of its profession and more an intervening model of force for positive, systemic change? And, is the episteme and minority demographic of technology education best served by uncritical, insular research, or by critical, outward looking studies?

In a discerning summary of last fall's National Technology Leadership Retreat, Lynn Bell (2001), raised several issues pertinent to science teacher preparation. In listing issues common across content areas, one we would like to echo, is the absence of much evidence of technology's influence upon students' science learning (McRobbie and Thomas, 2000). This limited body of knowledge parallels the concern raised above by Petrina: Just what DOES technology do for students?

More specific to science teacher preparation, Bell summarized the particular concerns of representatives from AETS (Table VI). Unlike the national technology education standards that attempt to circumvent content issues, this provocative list seeks to situate technology uses within deeper science education issues: learning, pedagogy, development, and collaborations.

We recommend that readers make their interpretations of the current-to-desire knowledge gaps by looking through the critical lens provided in Bell's list. For example, we found a large mean difference for using GPS devices yet this does not necessarily mean that training AETS members in the use of this technology ought to become a priority. If, after applying the suggestions of Bell to this or any other technology, we are somewhat confident that the technology aligns with standards, supports inquiry, advances student learning, and/or surpasses the possibilities of less advanced technologies, then we can proceed in good conscience that the time and money invested in the technology is wisely spent. The varieties of technology that could potentially be incorporated into science instruction and teacher preparation seem to be increasing at a rapid rate. Given the impossibility of adopting every new gizmo, individually and organizationally we should be wiser and more selective about the technological routes that we pursue.

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