Secondary Science Teachers' Use of Technology in the Classroom during Their First 5 Years

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Abstract

This study examined the technology use of beginning secondary science teachers and explored factors facilitating or inhibiting their use of technology. The researchers collected and analyzed interviews and observational data from 95 teachers over a 5-year period. The results show that teachers used PowerPoint the most and other software the least over time. This pattern was consistent over the 5 years of observation, increasing in frequency of usage only slightly each year. The use of PowerPoint was statistically significant when compared to the use of lecture and procedural laboratories. One-way ANOVAs yielded several statistically significant results, in that induction treatments, teacher's gender, and SES populations were significantly correlated to the use of technology. This study urges that the value of technology used in science classrooms should be redefined to enhance inquiry-based science teaching and learning. (Keywords: beginning secondary science teachers, technology usage, teaching practices)

The 21st century science classroom now contains nontraditional teaching tools, including laptops, personal digital assistants, and digital measuring devices. With the inclusion of this technology, there is often an assumption that these devices will automatically bring about revolutionary changes in teaching and learning processes. Specifically, it is assumed that the presence of technology will transform teacher-centered instruction to student-centered instruction. In exploring this assumption, Cuban (2001) followed teachers in California's Silicon Valley and found that they either used technology to maintain their traditional teacher-centered practices or to enable their traditional instructional tasks, such as recording grades and creating databases. He concluded that technological wealth in and of itself did not alone induce reform-based educational practices and that "computers have been oversold and underused" (p. 179).

However, using technology to create student-centered learning environments in the science classroom is possible. Windschitl and Sahl (2002) found that technology could facilitate teachers' use of collaborative and project-based pedagogies. This use often depended on the teachers' beliefs about learners, their understanding of the roles of technology, and their knowledge about how technology could enhance science teaching. They concluded that when they used technology effectively, both the teachers' preparation programs and their schools' cultural milieus were important. Similarly, Sorensen, Twindle, Childs, and Godwin (2007) found that science teachers who learned about technology in their teacher preparation program were prepared to use technology in more substantive and meaningful ways. These studies and others suggest that teachers can learn to use technology effectively and that their preparation programs—and the schools in which they work—can play important roles in the ways technology is implemented in their instruction.

Using technology effectively in the classroom may be best accomplished by new science teachers, who tend to be digital natives and who are more likely to work toward adopting new technologies in their daily instruction. In the presence of school cultures that support technology use, these teachers can flourish. But what happens to science teachers when they leave their teacher preparation programs has not been well documented, nor is it known how new teachers' technology use develops over several years. This time is a critical period of transition, when new science teachers are well positioned to effectively initiate technological advances. In attempting to understand the integration of technology in science teaching in such situations, we pose the following questions to study:

- How do new secondary science teachers use technology in their classrooms during their first 5 years in the classroom?
- What seems to facilitate or inhibit the use of technology in the instruction of a new science teacher?

Related Literature

Integrating technology and science pedagogy for reform-based practices has become inevitable for the era of information communication technology (ICT). Schools throughout the nation have committed to secure laptop computers in an effort to increase student achievements (Windschitl & Sahl, 2002). Along the same lines, researchers have recently explored innovative ways of teaching and learning science with technology in order to prepare high-quality teachers and create learning environments aligned with this new technology-intensive era (Colombo & Colombo, 2007; Hickey, Ingram-Goble, & Jameson, 2009; Hotchkiss & Dickerson, 2008; Isman, Yaratan, & Caner, 2007; Songer, Lee, & Kam, 2002; Varma, Husic, & Linn, 2008; Williams, Linn, Ammon, & Gearhart, 2004).

Science Teachers' Use of Technology

Hickey et al. (2009) demonstrated how a multiuser virtual game environment, Quest Atlantis (QA), could help a teacher make connections to the learning of scientific inquiry and student achievements. Teachers taught scientific concepts such as erosion and hypothesis testing through text-based chats and structured dialogues within a three-dimensional space. The students, the players, were at the center of the learning, where they completed various open-ended quests through discourses, such as investigating why fish populations in the Taiga River had declined. The players were involved in collecting and analyzing water samples and hypothesis testing, and the scientific concepts involved were introduced within relevant contexts. Interestingly, when comparing the same content area instruction of a teacher in QA and a conventional format, the teacher in the QA environment performed as a facilitator, whereas the teacher in the conventional environment tended to lecture and include textbook assignments (Hickey et al., 2009).

Hotchkiss and Dickerson (2008) discussed how classroom teachers and students could capitalize on cutting-edge technologies available at the NASA Earth Science Remote Sensing module and the NASA Earth Observatory. They shared how students, as a team, generated questions about wetlands and used satellite imagery or aerial photography from space to make sense about changes on Earth. Again, the role of teachers in this context was that of facilitators, as their students interacted with scientists and scientific data.

Colombo and Colombo (2007) showed how science teachers improved the learning of English language learners (ELL) and gifted students through a class blog, which is essentially a multi-text website. Science teaching through the class blog consisted of journal writing, discussions, and conferences, as well as cooperative and individual group work. In this setting, teachers were able to differentiate the content and assignments to support student learning. For instance, they provided ELLs with audio-visual tools such as vodcasting and PowerPoint visuals, along with narration on the class blog, which supported their acquisition of science and language.

Songer et al. (2002) indicated that science teachers and students in high-poverty urban schools benefited from a technology-rich inquiry weather program. The teachers enacted more inquiry lessons, and the students significantly improved their understanding of the concepts that the program targeted. This study showed the practical importance of integrating technology with science pedagogy in the urban environment, as urban teachers tend to enact more direct and controlling pedagogy (Haberman, 1991).

Beginning Teachers' Use of Technology

Williams et al. (2004) advocated technology-based environments for inquiry teaching and learning. They indicated that the Web-Based Inquiry Science Environment (WISE) program helped new teachers shift their instruction toward an inquiry-based orientation, which helped students make significant progress in their understanding of plant growth. This happened as students were asked to provide evidence and to critique each other's evidence, which is an essential component of the Next Generation of Science Standards (National Research Council, National Science Teachers Association, American Association for the Advancement of Science & American Association for the Advancement of Science). More important, teachers using WISE provided more student-centered experiences in Year 2 than in Year 1 and asked more conceptual questions (e.g., "What do you think would happen if...") as opposed to logistical questions (e.g., "Did you take notes?"). They concluded that the WISE program advocated sustained interactions and reflections and provided open-ended projects and questions (e.g., "What makes plants grow?") for students.

When it comes to ICT use in the support of the instruction of new science teachers, Dawson (2008) found that new science teachers used word processing, Internet research, e-mail, and PowerPoint the most and handheld computers, Web page design, online discussion groups, and virtual excursions the least. Moreover, the technology that the new teachers used the most were aligned with types of technology they experienced during their teacher education programs (Dawson, 2008). This finding is in accordance with that of Cuban (2001) and Isman et al. (2007), in that the use of technology was limited, regardless of the availability of computers and software in schools.

Facilitating or Inhibiting the Use of Technology in the Classroom

It is evident that technology can help science teachers teach science through inquiry and reform-based inquiry, and that it can help a variety of students have meaningful learning experiences. These results stem, in no small part, from the fact that the use of technology can help students visualize abstract scientific phenomena (Verma et al., 2008). The use of technology also can address students' diverse needs, from both low- and high-level learners, because it provides meaningful contexts (Verma et al., 2008). And technology can provide novel and highly effective methods of rendering external representations, such as "modeling" (American Association for Advancement of Science, 1993).

In addition, teachers tend to use technology more when they have easy access to the Internet and to computers; when they have positive expectations, confidence, and skills; and when they value ICT use in teaching (Dawson, 2008; Sorensen, Twindle, Childs, & Godwin, 2007). Finally, science teachers use technology more when there is adequate support from the curriculum, when they are given sufficient time to reflect on their practices of student learning, and when they have good role models (Sorensen et al., 2007; Williams et al., 2004).

Conversely, there was also clear evidence regarding the limited use of technology for science teaching and learning among teachers. This stems from the facts that science teachers have to deal with laboratories and that integrating technology can be difficult

(Dawson, 2008; Verma et al., 2008). Other factors are related to a lack of confidence and skills in resolving technical problems (Sorensen et al., 2007; Verma et al., 2008), a lack of experience in the implementation of technology with their instruction, and a lack of experience aligning technology with their school curricula (Verma et al., 2008). And, of course, science teachers tend not to use technology for their lessons when the tools are excessively difficult to learn (Valanides & Angeli, 2008).

Methods

Participants

This study uses data from 60 female and 35 male beginning secondary science teachers, who came from five states in the United States and were part of a 5-year study. The teachers in the study participated in one of four types of induction programs: (a) an electronic mentoring program (eMP), (b) a science-content specific university mentoring program (SSUP), (c) a school-provided general mentoring program (GP), and (d) various mentoring support programs for alternatively certified teachers. These induction programs are described in Luft et al. (2011). During their early years of teaching, they taught an average class size of 23 students and an average school size of 1,350 students. Most of the teachers taught at schools where ELL were enrolled at levels of 0–29%. Only 32 teachers taught the discipline of science in which they were trained, whereas 33 teachers taught disciplines of science outside their areas of expertise. In general, most of the teachers entered teaching with a bachelor's degree and worked at the high school level. Table 1 presents a summary of the teachers who participated in this study.

Data Collection

We used two forms of data in this study, which included interviews about practice and observations of practice. We used interviews, which we digitally taped, to capture the lessons that the teachers planned and their experiences in the classroom throughout the school year. Approximately once per month, we called and asked each teacher to narratively describe his or her instructional practices during one week. As the teacher discussed the enacted lessons, the interviewers recorded data about the methods of instruction and the types of technology the teacher used on a check sheet. In addition, we took extensive notes following the guidelines of Bogdan and Biklen (2006) as the teacher described his/her instructional practices and the reasons for the use of certain methods. Interviews occurred in this way each month over a 5-year span, for a total of 40 interviews per teacher. We digitally recorded all of the interviews.

We conducted the observations of teachers four times each year, for a total of 20 classroom observations per teacher. During an observation, we coded the classroom instruction in 5-minute increments, following the Collaboratives for Excellence in Teacher Preparation core evaluation classroom observation protocol (CETP-COP), which Lawrenz, Huffman, Appeldoorn and Sun (2002) and by Lawrenz, Huffman, and Gravely (2007) piloted, field-tested, and refined to document the instruction of science and mathematics teachers. Appeldoorn (2004) provided detailed information on the development and characteristics of the CETP-COP. She concluded that the protocol had high internal consistency with an alpha coefficient of 0.9. Mean ratings for a sample of observers indicated that all sections were clear and understandable. Prior to using this protocol for observations, we established intra- and inter-rater consistency.

We noted a second set of instructional codes, when possible, to capture unique aspects of science instruction. In addition, we took field notes on each lesson that depicted the instructional environment (Bogdan & Biklen, 2006) and wroe a brief summary of the lesson for future reference. We also collected documents associated with the lesson, such as PowerPoint presentations, laboratory guidelines, worksheets, or quizzes, during the observation.

Table 1. Demographics of Beginning Science Teachers ($N = 95$)

Induction Program		
	eMP	23
	SSUP	26
	GP	28
	Intern	18
Gender		
	Female	60
	Male	35
In-field/Out-field*		
	All in-field	32
	Mostly in-field	19
	Equal parts in/out-field	0
	Mostly out-field	15
	All out-field	18
Size		
	School size	1,350
	Class size	23
SES*		
	0–29% free/reduced lunch	54
	30–59% free/reduced lunch	21
	60–100% free/reduced lunch	0
ELL*		
	0–29% ELL	82
	30–59% ELL	7
	60–100% ELL	0

* Missing cases were evidenced in these categories.

Data Analyses

For the analyses, we summed information contained in the weekly updates across 8 weeks to estimate how many times teachers engaged in various activities. From the sum, we computed a mean across the 5 years of the study. We chose this method because it was based on information that was available and, due to occasional missing weekly updates, because it allowed for a better estimate of the use of teaching strategies and technology use. We used the method of group mean substitution to fill in missing data (Tabachnick & Fidell, 2007). This method is not as conservative as other means of missing data imputation, but it is not as liberal as the use of prior knowledge to input missing data (Tabachnick & Fidell, 2007). Nevertheless, this method can minimize within-group variation, thus making between-group differences spuriously large (Tabachnick & Fidell, 2007).

We investigated four different types of technology in this study: PowerPoint (PPT), video (VID), Internet (INTER), and software (SOFT). We considered several independent variables, including type of induction program, gender, socio-economic status (SES), the extent of in-field and out-field teaching, types of instruction, and types of inquiry. The three types of content presentation methods were bell work (BW), lecture (LEC), and discussion (DISC). The various types of inquiry consisted of open inquiry (OINQ), directed inquiry (DINQ), guided inquiry (GINQ), verification (VERIF), and procedural labs (PROC).

Specifically, we investigated five types of inquiry in the study. First of all, open, guided, and directed inquiries were defined depending on the degree of a student's freedom and a teacher's control in asking questions and the ways made available to answer these questions. If students were at the center of formulating and asking questions and built an experiment on their own to answer the questions, this process was defined as open inquiry. By contrast, guided inquiry was defined as a teacher initiating questions and guiding students to build an experiment to answer the questions. Finally, directed inquiry was defined as a teacher asking questions and also directing students to build an experiment to answer the questions. A verification lab took place when a teacher lectured on scientific concepts first and then involved students in appropriate labs to verify the concepts learned. A procedural lab occurred when students simply followed teachers' preset procedures to obtain answers that were posed.

We conducted coding of the weekly science lesson interviews immediately after each interview on a weekly update coding sheet (WU). This coding sheet consisted of 47 items related to science teaching (e.g., classroom organization, materials/technology used, assessments used). This study used the same technology-use section that was designed to capture the technology uses of the science teachers' Monday through Friday work. If a certain type of technology was used multiple times during one lesson, we counted all uses as one. However, if a certain type of technology was used multiple times during different lessons, we then counted them separately. Furthermore, if multiple technologies were used within a certain type of lesson, we coded them both. For example, if a teacher used video clips embedded within PowerPoint slides during a lesson, we coded both the use of video clips and the use of PowerPoint. Finally, after the coding was completed, the total number of the technology uses of each of the four types investigated in the study was entered in the Excel Spreadsheet data file.

Four types of statistical tests were utilized in the quantitative analysis with alpha values set at .05. First, we conducted Pearson product-moment correlations to calculate the correlation coefficients (r) between observed variables. Also, we conducted one-way ANOVAs to test for significant differences in technology use between induction groups, the extent a teacher taught in-field/out-field, the SES of schools in which the teacher taught, and gender.

In cases where the homogeneity variance assumption in a one-way ANOVA was violated, we employed the Welch statistic because it does not require the variances to be equal (Maxwell & Delaney, 2004). In the event of significant findings, we conducted post hoc tests using the Tukey method for equal variances and the Dunnet's C method in the event variances were not equal. Additionally, we conducted one-way repeated-measures ANOVAs to determine if technology use changed significantly over time. Overall, we used the Boneferroni method to control for Type I error for all ANOVAs. Due to the two-part nature of study, we did not include Year 4 data in any statistical test. Finally, we used bivariate multiple regression to analyze interval-scale variables and their impact on technology use. In these tests, *technology use* was the dependent variable, and the independent variables are listed in Table 2 (p. 122). The findings in this table should be viewed within the context of the Year 1, 2, 3, and 5 data.

Findings

The main purpose of this study involves the technology use of beginning secondary science teachers and factors facilitating or inhibiting the use of technology. We investigated types of technology: PowerPoint, video, Internet, and software. To measure the comprehensive pattern for using these technologies (research question 1), we present the results by comparing the means of participants' technology use during their first and second years. To measure the in-depth pattern of how three of the technologies were used by the new teachers (research question 1) and to explore the factors related to the usage of these three technologies (research question 2), we present the results by computing correlations between the four types of technology and seven independent variables.

Table 3 (p. 123) describes how new secondary science teachers used the four types of technology during their first 5 years. We observed similar patterns over the 5 years in beginning science teachers' technology use of employing PowerPoint the most in their science teaching, with a mean of 4.83 (SD = 2.66), and software the least, with a mean of 0.82 (SD = 0.54) for the 5-year total. Video and Internet use were ranked as second and third most used, with a mean of 3.36 (SD = 1.57) and 2.59 (SD = 1.67), respectively. This pattern was consistent during the first 5 years, with only gradually increasing frequency of use of the technologies for their science teaching practices.

Along with these findings, the participants chose bell work the most, with a mean of 14.82 (SD = 6.65); lecture the second most, with a mean of 7.94 (SD = 3.18); and discussion the least, with a mean of 5.36 (SD = 2.18) for their method of instructional strategies. This pattern changed in their fifth year, when they started to use slightly more discussion strategies in their instruction (M = 7.55, SD = 4.88) than lecture style teaching (M = 6.57, SD = 3.80).

Finally, beginning secondary science teachers adopted directed inquiry the most (M = 4.80, SD = 2.28), followed by verification lab (M = 4.20, SD = 1.50) and procedural lab (M = 2.35, SD =

1.03). The participating teachers practiced guided inquiry and open inquiry the least in their science classrooms, with means of $M = 2.02$ ($SD = 1.12$) and $M = 0.43$ ($SD = 0.43$), respectively. This pattern changed during the first, third, and fifth years, in that guided inquiry was practiced more than procedural lab during the beginning teachers' first year. Yet the appearance of verification lab became more prominent in their third and fifth years, as it was ranked as the most practiced method at the end of their fifth year ($M = 5.35$, $SD = 3.18$).

A multiple regression analysis shows that lecture and procedural lab were significantly related to PowerPoint use, $b = .18$, $b_{constant} = 3.38$, $t(93) = 2.20$, $p < .01$ and $b = -.60$, $b_{constant} = 6.25$, $t(93) = -2.30$, $p < .01$, respectively. We also found significant correlations between the use of video to the classroom discussion, directed and guided inquiry, $b = .15$, $b_{constant} = 2.58$, $t(93) = 2.99$, $p < .01$, $b = .21$, $b_{constant} = 1.60$, $t(93) = 2.84$, $p < .001$, and $b = .57$, $b_{constant} = 1.45$, $t(93) = 3.96$, $p < .001$, respectively.

The use of the Internet has a statistically significant relationship with the classroom discussion and bell work as a choice of instructional strategies, $b = .27$, $b_{constant} = 1.14$, $t(93) = 3.66$, $p < .001$ and $b = -.06$, $b_{constant} = .03$, $t(93) = -2.40$, $p < .01$, respectively. Again, the directed and guided inquiry methods were shown to have a statistically significant relationship with the use of Internet, $b = .21$, $b_{constant} = 1.60$, $t(93) = 2.84$, $p < .001$ and $b = .57$, $b_{constant} = 1.45$, $t(93) = 3.96$, $p < .001$, respectively, as well as the use of software, $b = .08$, $b_{constant} = .43$, $t(93) = 3.4$, $p < .01$ and b = .26, $b_{constant} = 30$, $t(93) = 5.95$, $p < .001$, respectively. Finally, the use of software had a statistically significant relationship with the bell work, $b = -.03$, $b_{constant} = 1.21$, $t(93) = -3.29$, $p < .01$. The results of all of the individual correlation coefficients were weak.

In summary, new secondary science teachers use PowerPoint and video the most, and they incorporate them either within their lectures, classroom discussions, or procedural inquiry labs. Also, there was a high likelihood that these new secondary science teachers would use video, Internet, and software, and when they did, it was for directed and guided inquiry-based teaching and learning. They also used Internet and software during bell work and classroom discussions.

Table 2. Statistically Significant Bivariate Regression Models (N = 95)

Dependent Variable	Independent Variable	*b* (95% CI)	$b_{constant}$	*t*(93)	R^2a
PPT	PROC	-.60 (-1.11,-.83)	6.25	-2.30*	.05
PPT	LEC	.18 (.02, .35)	3.38	2.20*	.05
VID	DINQ	.16 (.02, .30)	2.58	2.35*	.06
VID	GINQ	.45 (.18, .73)	2.45	3.26**	.10
VID	DISC	.15 (.00, .29)	2.58	2.99*	.04
INTER	DINQ	.21 (.06, .35)	1.60	2.84**	.08
INTER	GINQ	.57 (.28. .51)	1.45	3.96**	.14
INTER	BW	-.06 (-.11, -.01)	.03	-2.40*	.06
INTER	DISC	.27 (.13, .42)	1.14	3.66**	.13
SOFT	DINQ	.08 (.03, .13)	.43	3.4*	.11
SOFT	GINQ	.26 (.17, .34)	.30	5.95**	.28
SOFT	BW	-.03 (-.04, -.01)	1.21	-3.29*	.10
SOFT	DISC	.09 (.04, .14)	.34	3.71**	.13

Note. The general model depicted by the table is: Dependent Variable = *b* (Independent Variable) + $b_{constant}$. a. R^2 indicates the amount of the variance in the dependent variable accounted for by its linear relationship with the independent variable.

* $p < .01$, ** $p < .001$

As for the factors facilitating or inhibiting the use of technology, the one-way ANOVAs and repeated-measures ANOVAs yielded several statistically significant results. The induction group had a significant impact on the dependent variable of software use, with $F(3,91) = 7.78$, $p < .001$. Post-hoc testing showed that the intern group used software over the 5 years of the study significantly less than the other three induction groups. Induction groups also had a significant impact on the dependent variable of Internet use, with $F(3,91) = 2.80$, $p < .05$. Post-hoc tests indicated that the intern group used the Internet significantly less over the 5 years of the study compared to the other three induction groups.

We found a significant difference between male and female beginning science teachers in their uses of technology. Specifically, means' comparisons showed that male science teachers used PowerPoint and software significantly more than female science teachers, $F(1, 51.475) = 5.40$, $p < .05$, and $F(1, 94) = 4.57$, $p < .05$, respectively. Interestingly, when we explored correlations between contextual factors and technology use, only socio-economic status (SES) was negatively correlated with PowerPoint use. Finally, there were a couple of trends in the findings where the slope associated with the intern group was significantly lower than the referent general group, and the interaction between bell work and the e-mentoring group yielded a significantly more positive slope than the referent general group.

In summary, gender and SES were significant factors that either facilitated or inhibited the use of technology—specifically PowerPoint and software use. Moreover, types of induction programs either positively or negatively affected the use of technology.

Conclusions

This study explored how beginning secondary science teachers use technology and attempted to identify the most important factors that facilitated or inhibited their use of technology in teaching science. Results indicate that beginning secondary science teachers used PowerPoint the most and software the least. Induction treatments, teachers' genders, and SES populations were revealed to be additional significant factors influencing teachers' usage of technology.

Less than optimally, the uses of technology by beginning science teachers in this

Table 3. Means and Standard Deviations of Observed Variables Averaged over 5-Year Total and Year by Year

	Variable	Total		Year 1		Year 2		Year 3		Year 4		Year 5	
		M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Use of Technology	PowerPoint (PPT)	4.83	2.66	4.73	4.14	5.69	4.21	5.64	3.92	2.38	4.01	5.72	3.93
	Video (VID)	3.36	1.57	3.59	2.25	4.04	2.36	3.95	2.68	1.33	2.08	3.91	3.04
	Internet (INTER)	2.59	1.67	2.81	2.90	2.34	1.87	3.88	3.46	0.85	1.51	3.09	2.29
	Software (SOFT)	0.82	0.54	1.09	1.36	0.75	1.09	1.21	1.37	0.00	0.00	1.04	0.97
Types of Instruction	Bell Work (BW)	14.82	6.65	18.66	10.26	17.27	10.00	17.28	14.04	3.90	6.23	16.20	10.12
	Lecture (LEC)	7.94	3.18	10.75	5.84	10.82	6.06	9.64	5.90	1.91	3.23	6.57	3.80
	Discussion (DISC)	5.36	2.18	6.57	3.95	5.79	3.94	4.40	2.75	2.47	3.35	7.55	4.88
Types of Inquiry	Open Inquiry (OINQ)	0.43	0.43	1.13	1.38	0.29	0.53	0.52	1.16	0.00	0.00	0.22	0.78
	Directed Inquiry (DINQ)	4.80	2.28	5.20	3.51	5.20	3.51	4.39	3.17	4.87	3.48	3.94	2.49
	Guided Inquiry (GINQ)	2.02	1.12	3.08	2.21	2.32	1.78	2.75	2.70	0.10	0.34	1.87	1.73
	Verification (VERIF)	4.20	1.50	4.64	2.88	4.40	2.98	4.91	3.11	1.72	2.35	5.35	3.18
	Procedural (PROC)	2.35	1.03	2.49	1.61	2.74	1.80	3.37	2.14	0.38	0.90	2.77	2.39

study were relatively limited, in that the teachers used technology for assisting traditional teaching and learning, not necessarily for implementing reformed-based teaching practices. For instance, they used PowerPoint for teacher-centered lecture-style classes, whole-class setting arrangements, or reviewing facts for exams. Furthermore, they used websites mostly for one-way communication during their science teaching by either showing video clips or pictures found on relevant sites to help students understand the scientific facts they learned. They did not use websites nearly as often for generating class discussions, promoting collaborative learning, or creating knowledge.

The beginning teachers participating in this study were generally located at the adaptation level, where they had not yet integrated technologies integrated into their inquiry-based learning processes but rather married them to traditional teaching styles, according to Sandholtz, Ringstaff, and Dwyer (1997). These researchers grouped teachers based on five sequentially adept levels of technology integration: Entry, Adoption, Adaptation, Appropriation, and Invention. These levels range from those exhibited by teachers who are novice users of computers to those exhibited by teachers who have been integrating technology into their daily curricula in advanced—even cutting-edge ways—for some time, to enhance and contemporize their student-centered inquiry-based instructional processes as much as possible.

Initiating Changes for Student-Centered Inquiry Teaching Practices

According to the science teaching standards in the National Science Education Standards (NSES; NRC, 1996, 2000), science teachers are encouraged to seek sources outside the school and to regard students within the community of science learners as reformed-based science teachers. Based on the findings of this study, we suggest that it would be most effective for secondary science teachers to initiate or increase technological enhancements in their teaching practices at natural insertion points where they were already comfortable using various types of technology.

PowerPoint was the tool most commonly favored by the new science teachers; yet they typically used it only for assisting teacher-centered lectures. This fact would seem to beg the question: What precisely are the missing pieces that connect this preference for PowerPoint with possibilities for successfully introducing other forms of technology that could be put to good use in classrooms? More specifically, how can we deepen and dissect our understanding of this seemingly natural affinity for PowerPoint so that we can begin to knowledgably modify, adapt, incorporate, and thus maximize other analogous computer- and Internet-based technologies to "fit" teachers' capabilities for incorporation into existent inquiry-based science learning and teaching?

Palloff and Pratt (2005) envisioned that technology must ideally be connected with the philosophy of constructivism, where social aspects of education and context-related activities are sufficiently respected. The foundations of constructivism also incorporate the concept of learning communities—associations of teachers based on trust, integrity, and concern for the wellbeing of others. Within this philosophical framework, it is important to establish workable and truly helpful types of technology in science classrooms. Teachers are advised to have systematic plans that (a) help set the stage for collaboration, (b) help students facilitate the creation of learning communities, and (c) provide adequate and appropriate guidelines for the final evaluation stages. They suggested 13 collaborative activities that could bridge learning in the real classroom and learning within online contexts (e.g., role playing, simulations, case studies, virtual teams) (Palloff & Pratt, 2005).

ICT-Integrated Induction Programs for New Science Teachers

Some researchers advocate recognizing the importance of teacher learning during their early teaching years (Britton, Paine, Pimm, & Raizen, 2003; Luft et al., 2011). During these formative years, beginning teachers are striving to make sense of their own roles as teachers within the contexts of their schools, as well as expanding the knowledge and skills that would allow them to be accepted by their communities of practice (Lave & Wenger, 1991). Therefore, it is critical to have induction programs that will guide these new teachers in learning how to weave science with technology for meaningful student learning.

One question that would seem to be of natural interest in this regard is: Is this developmental point in their careers, where fledgling teachers are learning about useful programs like PowerPoint and becoming familiar with them, significant? If so, is this a logical and potentially viable insertion point where other computerized programs and Web-based platforms can be successfully introduced? Furthermore, can such computer- and Internet-based technological tools be made more user friendly and palatable, such that they will persist as familiar, useful, labor-saving devices that will ultimately enhance learning science teachers' inquiry-based methodologies later, when they finally enter the workforce as real teachers?

To begin with, the results of our study indicate that the group of beginning teachers in the e-mentoring program used the Internet most for their science teaching practices, whereas the teachers in the Intern group used the Internet the least. This finding alone indicates that the online mentoring treatment helped beginning science teachers get familiar with core concepts that computers and the Internet are indispensible sources for science teaching and student learning. As for the teachers in the Intern group, the data showed that they were not sufficiently adept at expertly gleaning resources from the Internet in the first place and that, rather than maximizing educational resources already available on the Web, teachers still tend to teach material based predominantly on textbooks, including teacher's versions provided for them.

Based on these findings, we encourage teacher educators, school districts, and policy makers to provide induction programs that are ICT integrated. With these kinds of technology-combined-induction models, teachers are not only welcomed into the teacher community, but are also offered ways to meaningfully interact with others through technology before they begin seriously thinking about what they can do with other types of relevant technologies. This argument also integrates elements of the natural processes of the learning cycle which indicate that applying knowledge comes only after first exploring knowledge (Bass, Contant, & Carin, 2009).

According to Bang (2013), beginning science teachers who participated in technology-embedded mentoring programs, using such technologies as virtual environments and handheld digital devices, learned to collaboratively explore available technological tools, how to share resources, and finally how to begin combining technologies they modeled with their science lesson plans and during science teaching. Furthermore, Huang (2008) found that there were statistically significant positive relationships between the ways math and English teachers used technology and their corresponding student achievement levels when the teachers were trained by integrating technology into their curricula.

Digital Equity

This study also found that gender and SES were factors that significantly influence beginning science teachers' use of technology. Male teachers used more technology than female teachers. Teachers working at high-SES-population schools used technology less than those who worked at low-SES-population schools. These results were consistent with the literature (e.g., ISTE, 2006; Morales, Bang, & Andre, 2012; Van Dijk, 2006; Warschauer, 2004). Furthermore, the findings encourage all concerned to cultivate a grassroots dialogue about the digital inclusion of technology in the era of 21st century science education, where most jobs will be ICT intensive.

The International Society for Technology in Education (ISTE, 2006) provides a toolkit for digital equity to achieve "the social-justice goal of ensuring that everyone in our society has equal access to technology tools, computers, and the Internet" (p. 1). This group conceptualizes digital equity as a process built on and integrated with five elements, including infrastructure, leadership and support, professional development, teaching and learning, and, finally, family and community. This toolkit can be used as a starting point for unpacking the factors that provide the underpinnings for this digital divide and otherwise seeking workable solutions for effective educational and social change.

Implications

This study emphasizes that the value of technology, as it is used in within science classrooms, needs to be constantly updated and redefined. We are, as yet, only scraping the surface. Many deeper uses will inevitably be developed both at the hardware and software levels, and we need to anticipate and be ahead of the curve so as to remain competitive at a worldwide level. Technology can be practiced not only by using computers and programs or by learning how to use technology tools, but also by beginning to proactively integrate otherwise previously inaccessible educational elements into science curricula now. We can also use technology to find new ways to connect students through social media tools, and we can configure these connections such that they can optimize student learning and enthusiasm, especially within the sciences.

This sea change from textbooks to cyberspace will inexorably occur via increasingly powerful handheld devices, which, although sometimes now less than familiar to adults, will be ubiquitously available to almost all students of the next generation. These devices, and their software, are increasing in power exponentially. Newer devices and their software will be cheaply manufactured and distributed like common calculators and allow full Internet access to students everywhere and of all socioeconomic strata.

We have no choice but to remain ahead of the curve and help shape the character and content of the educational aspects that must be intelligently incorporated into this swiftly arriving technology. Furthermore, teacher educators and school districts need to explicitly stay informed about how the unique features of technology can be used to transform specific content domains (Valanides & Angeli, 2008).

The concepts of technology stewarding and the digital habitat, defined by Wenger, White, and Smith (2009), provide a model that can be adapted to this situation. Stewarding means "selecting and configuring technology, as well as supporting its use in the practice of the community" (p. 25). Digital habitat is understood as a community's learning habitat that has "technology-based connections and places in addition to physical ones" (p. 38).

At the core of technology stewardship is an understanding of the needs of the community and the awareness of technological development within that community before making decisions about technology. It should also be noted that the Wenger et al. (2009)'s digital habitat consists of four elements: tools, platforms, features, and configuration. It is the interweaving of these four elements with the findings of the study that provide the next step: to have the science teacher community establish a digital habitat that consists of digital tools that promote critical thinking and inquiry-based activities. Wenger et al. (2009) also emphasize the importance of the adaptation and transitional stages where members of the community are given time to learn new ways of integrating technology into their everyday practices. The results of this study inform the science-teacher community of the needs and increasing awareness of the involved technology elements.

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