Teachers' beliefs about using educational technology in the science classroom

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Abstract

Current science education reform documents include educational technology as a key idea in school science programs. Teachers' beliefs about curriculum and instruction may play an important role in the implementation of reforms. In this study, we sought to examine the influence of K-12 teachers' beliefs on their intent to use educational technology in their classrooms. The Theory of Planned Behavior was used to examine the influences of K-12 teachers' attitudes, subjective norm (social support), and perceived behavioral control (external influences). Specific suggestions for addressing teachers' beliefs about using educational technology and staff development ideas are offered.

Introduction

Currently, two major national projects are underway in the United States that are designed to restructure science education and develop scientific literacy. The National Science Education Standards (NRC, 1996) and Project 2061: Science for All Americans (Rutherford & Ahlgren, 1989), while developed parallel to each other, have common goals and recommendations. The BSCS group (1994) summarized ten common reform strands into a questionnaire about reform, and additional reform ideas gleaned from The National Science Education Standards and Project 2061 led us to conclude that common reform topics are: constructivism, learning styles, thematic approach, classroom management, assessment and evaluation, equity, STS, educational technology, science subject matter, cooperative learning, hands-on/minds-on, and the nature of science.

During the last decade, considerable time and effort has gone into to developing and implementing these suggested science education reforms. However, many of these reform reports have ignored beliefs of classroom teachers. Studies warn of the inherent problems associated with ignoring classroom teachers' beliefs about reform. For example, the Rand Change Agent Study found that effective change and program implementation depended more upon local factors than federal program guidelines or other "top down" methods (McLaughlin, 1990). Cuban (1990) suggests that reforms return again and again because policy makers ignore logical factors required to make change including individual's beliefs. Bybee (1993), in reflecting upon restructuring science education, emphasized that the classroom teacher is the decisive component in reforming science education. Classroom teachers, he stated, will determine whether reforms in science education falter and fail (p. 144). Consequently, Tobin, Tippins, and Gallard (1994), in reviewing science education research, summarized this need to examine teachers' beliefs by stating,

Future research should seek to enhance our understanding of the relationships between teacher beliefs and science education reform. Many of the reform attempts of the past have ignored the role of teacher beliefs in sustaining the status quo. The studies reviewed in this section suggest that teacher beliefs are a critical ingredient in the factors that determine what happens in classrooms. (p. 64)

Review of the Literature

Educational Technology

The need and urgency for developing technological literacy, although not a new idea, emerged with greater emphasis in the early 1980's when A Nation at Risk (1983) cited computer competence as a fourth basic skill that was both an important and empowering experience in the world in which we live since this skill was needed for both subsequent formal education as well as for one's individual life experiences (Marshal & Bannon, 1988; Naron & Estes, 1986; Gilder, 1993). With this increasing awareness and interest, technology quickly was recognized as a powerful vehicle for curricular restructuring and offered educators innovative ways to enhance student learning (Campoy, 1992; US Office of Technology Assessment, 1988). From a constructivist perspective, researchers affirmed that computer technology provided abundant opportunities for students to build or modify their personal knowledge through the rich experiences that technology affords (Bruder, Buchsbaum, Hill, & Orlando, 1992; O'Brien, 1991; Papert, 1980; Papert, 1993). With the growing interest, professional organizations were increasingly active in developing formal guidelines for technology education. In the early 1990's, the International Society for Technology in Education (ISTE) established standards defining technological literacy for teacher education (ISTE, 1992). The ISTE standards recommend that all teachers should be prepared in the following areas:

A. Basic Computer/Technology Operations and Concepts. Teachers should use computer systems to access, generate and manipulate data; and to publish results. They should also evaluate performance of both hardware and software components of computer systems and apply basic troubleshooting strategies as needed.
B. Personal and Professional Use of Technology. Teachers should apply tools for enhancing their own professional growth and productivity. They should use technology in communicating, collaborating, conducting research, and solving problems. In addition, they will plan and participate in activities that encourage lifelong learning and will promote equitable, ethical, and legal uses of computer/technology resources.
C. Application of Technology in Instruction. Teachers should apply computers and related technologies to support instruction in their grade level and subject areas. They must plan and deliver instructional units that integrate a variety of software, application, and learning tools. Lessons developed must reflect effective grouping and assessment strategies for diverse populations. (ISTE, 1992).

Today, the use of educational technology is recommended in most of the nation's educational policy reports (AAAS, 1993; Rutherford & Ahlgren, 1989; NRC, 1996). In discussing ways to help students overcome science anxiety, -Project 2061 (Rutherford & Ahlgren, 1989) urges teachers to provide students with abundant experience in using tools including computers (p. 205). Moreover, the authors list the development of computer systems and software to enhance learning science as a "next step" in educational reform (p. 227-228). Benchmarks for Science Literacy (AAAS, 1993) highlights the need for students to possess the ability to engage in information processing. The National Science Education Standards (NRC, 1996) stress that students as early as grade 5 should be able to "use appropriate tools and techniques to gather, analyze, and interpret data." The use of computers for the collection, summary, and display of evidence is part of this standard. As such, students should be able to "access, gather, store, retrieve, and organize data, using hardware and software designed for these purposes" (p. 145). This content standard is reiterated as an essential skill for students in grades 9-12 (p. 175). Similarly, many states have adopted frameworks and curricula standards that stress the use of technology. In Ohio, for example, technology is emphasized in the "conditions of learning" strand of Model Competency-Based Science Program (SBE, 1994).

Although national, state, and local policies establishing goals for educating a technologically literate society are well underway, one could question whether educators share these goals. In a study conducted by Brownell, Haney, and Sternberg (1997), teachers and building administrators were asked about their perceived needs for technology professional development experiences for teachers. Seventy-seven percent of the respondents reported that their district's teachers had a positive attitude toward classroom technology, while 90% reported that the same is true for their administrators. However, only 17% perceived that teachers in their district were skilled in integrating technology into their teaching. When asked about their specific desires for classroom technology training, the respondents "Strongly Agreed" or "Agreed" with the need for the following three prominent ideas: integrating technology into instruction (90%), using technology to teach problem solving (86%), and using technology as a management function (85%). Similarly, Lehman (1994) found in a survey of eighty schools that elementary teachers used computers in science and mathematics instruction most often for drill and practice games thereby suggesting that experts in technology believe that teachers needed staff development in order to learn how to use technology more effectively.

The Role of Teachers' Beliefs

Teacher's educational beliefs are strong indicators of their planning, instructional decisions and classroom practices (Pajares, 1992; Clark & Peterson, 1985). Tobin et al. (1990) determined the most pervasive influence on classroom transactions was the teacher's beliefs about teaching and learning. This makes "the investigation of teacher's beliefs a necessary and valuable avenue of educational inquiry" (Pajares, p. 326). As stated earlier in this report, Tobin, Tippins, and Gallard (1994), in the Handbook of Research on Science Teaching and Learning, clearly delineated the need to focus on teachers' beliefs. This critical relationship between the beliefs of teachers regarding implementation of reform efforts and instructional decisions is well documented (Cornett, Yoetis, & Terwilliger, 1990; Crawley & Salyer, 1995; Haney, Czerniak & Lumpe, 1996; Hashweh, 1996; McDevitt, Heikkinen, Alcorn, Ambrosio, & Gardner, 1993).

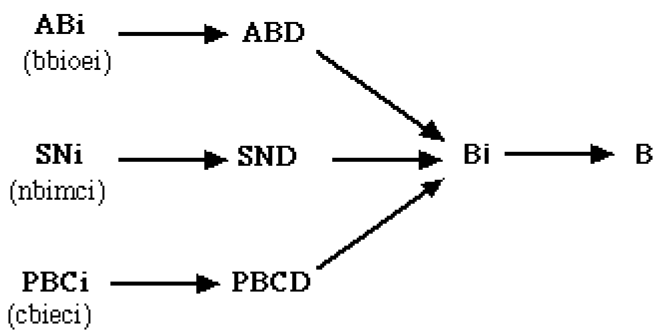
Historically, however, reform efforts have taken a "top-down" approach and generally failed. Those reforms which took into account local factors, such as teachers' beliefs, were more effective in promoting change (McLaughlin, 1990). Fullan and Miles (1992) state that "change cannot be accomplished from afar" but that "local implementation...is the only way that change happens" (p. 752). Munby (1984) also articulated, "...teachers' beliefs and principles are contextually significant to the implementation of innovations ..." (p.28). However, although beliefs and ideas influence the adoption of innovations, positive beliefs don't necessarily result in changes being manifested. Cuban (1990) maintains that reforms return repeatedly because policy makers discount individual's belief factors that are needed to make change occur. Since local implementation of reform policies is critical to their success, teacher beliefs play an important role in educational reform.

Both prospective and inservice teachers have developed their beliefs about teaching from two primary extensive experiences, namely, the years spent in the classroom as both students and teachers (Perry, 1990). These beliefs may arise out of systemic factors such as the lack of technical support or material resources. These beliefs about teaching are well established by the time students begin their teacher education programs in college (Buchmann, 1987; Florio-Ruane & Lensmire, 1990; Wilson, 1990). Disconcertingly, the beliefs of teachers are not necessarily consistent with the literature about best practice in teaching (Battista, 1994; Haney, Czerniak, & Lumpe, 1996). Since teacher beliefs appear to be crucial for lasting reform, identifying and investigating the role of these beliefs on teacher behavior is necessary. The Theory of Planned Behavior (Ajzen & Madden, 1986) provides such a framework for an investigation of the role of teacher beliefs in the implementation of educational reform.

According to the Theory of Planned Behavior (TPB), three direct variables are needed to predict intention and behavior: 1) attitude toward the behavior (AB); 2) subjective norm (SN); and 3) perceived behavioral control (PBC). In this theory, these three constructs influence a person's intent to engage in a targeted behavior, called behavioral intention (BI). Behavioral intention, in turn, influences a person's actions or behavior (B). Measures of the three primary constructs (AB, SN, PBC) are directly influenced by a person's antecedent salient beliefs and evaluations of those beliefs. These salient beliefs represent specific beliefs about the target behavior and yield indirect measures of the three constructs (ABi, SNi, PBCi). As a result, the TPB consists of direct measures of three constructs: attitude toward the behavior (ABD), subjective norm (SND), and perceived behavioral control (PBCD) (see Figure 1). The Theory of Planned Behavior links a person's behavior to his or her beliefs, attitudes, and social support (see Figure 1). The theoretical structure is causal and unidirectional.

Attitude toward the behavior (AB) encompasses the beliefs about the consequences of performing a particular behavior and the evaluations of those consequences. In other words, the AB represents a personal dimension.

Figure 1. Theory of Planned Behavior (D)



Key:
bbi = behavioral beliefs
oei = outcome evaluation
nbi = normative beliefs
mci = motivation to comply
cbi = control beliefs
eci = evaluation of controls

Subjective Norm (SN) represents a social dimension regarding an individual's belief about the extent to which other people, important to his/her life, think the behavior should be performed. Perceived behavioral control (PBC) refers to beliefs regarding the existence of both resources and obstacles related to engaging in the behavior (Crawley & Koballa, 1992).

Salient beliefs and the evaluations of those beliefs influence a person's ABD, SND, and PBCD. The salient beliefs represent a collection of the specific AB, SN, and PBC beliefs about the target behavior, thus, they produce indirect measures of the three constructs (ABi, SNi and PBCi). Together, the AB, SN, and PBC constructs theoretically influence a persons' intent to engage in a particular target behavior called behavioral intention (BI). In turn, behavioral intention directly influences a persons' actions or behavior (B). Ultimately, the TPB links a persons' behavior to attitudes, social support, and beliefs about both internal and external control factors. The TPB theoretical model is causal and unidirectional.

Both social science researchers and science educators have used the TPB to trace the relationship of beliefs and intention (see Crawley & Koballa, 1992; and Koballa & Crawley, 1992 for an extensive review of this research). However, few studies used the TPB to examine the beliefs and intentions of science teachers with regard to reform efforts. Crawley (1990) found that attitude was the greatest predictor of science teachers' intent to use inquiry based teaching methods in their classrooms. Haney, Czerniak, and Lumpe (1996) used the Theory of Planned Behavior to determine the factors influencing teachers' intentions to implement science education reform strands associated with a state curriculum model. They concluded that teachers' attitude toward implementing the suggested reform strands was the greatest predictor of intent. Similarly, Crawley and Salyer (1995) found teachers' beliefs critical to reform efforts in Texas.

Objectives

Recent science education reform reports call for the inclusion of educational technology in today's science programs. Teachers' beliefs may play a crucial role in the actual implementation of reform recommendations since beliefs may lead to specific actions in the classroom. In a study conducted by Czerniak and Lumpe (1995), only 16% of teachers reported using technology almost every day, whereas 28% reported using it several times a week, 29% reported using it about once a week, 26% reported using it less than once a week, and 1% reported never using educational technology. However, this study reported only the percentage of teachers who used educational technology and revealed little about the nature of teachers' beliefs and reasons for adopting this reform strand. Other studies regarding the impact of teacher beliefs on the implementation of educational reform policies are scant. Consequently, it seems essential that teachers' beliefs about the current reform efforts be examined. This examination may reveal areas where teachers' beliefs are inconsistent with reform efforts thereby enabling reformers and curriculum developers to target potentially problematic conflicts.

With this concern in mind, this paper examines three primary questions: 1) What are science teachers' belief-based affects concerning the implementation of educational technology in the classroom? 2) Do teachers' belief-based affects influence their intent to implement educational technology in their own classrooms? and 3) Do teachers' intentions influence their perceived implementation of educational technology in the classroom?

Methods

Subjects

Two samples of teachers were used for this study. The first sample consisted of 33 K-12 teachers from Northwestern Ohio. The sample was purposely selected to solicit salient beliefs regarding the implementation of educational technology in the classroom (see questionnaire construction below), and the teachers represented a variety of experience and grade levels.

The second sample of teachers used for this study consisted of randomly selected K-12 teachers from schools listed the Ohio Schools Directory (ODE, 1993) and the State of Wisconsin Department of Public Instruction list of public school science teachers. The Ohio publication includes all school districts in Ohio (public and private) and is divided by school type: city, county, and exempted village. A random sample of 250 teachers was selected from each list. Each teacher was twice sent the questionnaires and a follow-up postcard. Teachers in this sample taught all grade levels ranging from kindergarten to grade twelve. Two hundred four teachers returned usable questionnaires resulting in a forty-one percent return rate.

Demographic results for the second sample of teachers indicated that 50.8 percent held bachelor's degrees, 45.2% had master's degrees, and 4.0 had specialists degrees. Sixty-five percent of the teachers were female. Kindergarten through fourth grade teachers represented 30.4 percent of the sample. Teachers of grades five through eight represented 27.3 percent of the sample. High school teachers represented 41.2 percent of the sample. The remaining one percent of teachers taught multiple grade levels. Ninety-five percent of the respondents were White. The average years of teaching experience was 11-15 years.

Questionnaire Development

Using Ajzen and Fishbein's (1980) technique for developing standard questionnaires to assess subjects' salient beliefs related to participating in a given target behavior, the first sample of K-12 teachers were asked to answer open-ended questions regarding their beliefs about using educational technology in their classrooms. The teachers were given a definition of educational technology adapted from the BSCS (1994) reform questionnaire. It stated, "For each item on this rating scale, respond by marking the line that best represents your opinion about using *educational technology* in science instruction. By *educational technology* we mean: The teacher uses a wide range of educational technologies (computers, video, print, and manipulatives) to promote student learning. For example: using microcomputer-based laboratories or laser disks in science." As part of the open-ended questionnaire, the teachers were asked to indicate advantages and disadvantages of using educational technology, their beliefs about who might approve or disapprove of using educational technology, and what things would encourage or discourage them from using educational technology.

The responses to these open response questions were compiled, content analyzed, and 5 point, bipolar semantic differential items were constructed using the salient beliefs that the sample group held about using educational technology. According to Ajzen and Fishbein (1980), only those salient beliefs representing a majority of beliefs are to be selected to questionnaire item construction. These semantic differential items comprised the indirect measures of the three major constructs: attitude toward the behavior (ABi), subjective norm (SNi), and perceived behavioral control (PBCi). Based on Theory of Planned Behavior, the salient beliefs were combined according to the linear equation described by Ajzen and Fishbein (1980) to form indirect measures.

Bipolar scales designed to assess the direct measures of attitude toward the behavior (ABD), subjective norm (SND), perceived behavioral control (PBCD), and behavioral intention (BI) were constructed according to Ajzen and Fishbein's (1980) standard technique. To measure perceived use of technology in the science classroom (behavior), the teachers were asked to indicate how many times per month they used twelve technology-based strategies (email, internet sources, teleconferencing, adaptive technology, calculators, probes, multimedia, use for problem solving, use for drill and practice, use for direct instruction, use to create a product, and use to manage instruction). Contact the authors to obtain a copy of the questionnaire.

Test-retest correlations for reliability for the three direct measures (ABD, SND, and PBCD) were found to be acceptable (from .73 to .92) in previous research (Haney, 1994; Hartzell, 1997; Beck, Czerniak, & Lumpe, in press) with a similar sample of teachers. Reliability indices for all of the measures were calculated using Cronbach's alpha internal consistency coefficient (ABi = .94, SNi = .81, PBCi = .89, ABD = .86, SND = .66, PBCD = .87, BI = .92, B = .77).

Validity of the scales for the indirect and direct measures of the TPB can be inferred from a variety of sources. First, content validity can be inferred for the indirect measures since the salient beliefs emerged from teachers' own responses to the open-ended questions. Second, construct validity can be inferred from the significant correlations of the direct measures of the theory constructs with behavioral intention as indicated in the TPB. Third, the indirect measures are correlated with the direct measures.

Data Analysis

Teachers' responses to the open-ended questionnaire were compiled and content analyzed by categorizing the responses. Similar responses were combined and general category descriptions were developed. These categories were used for the simple descriptive information to answer Research Question 1 and to construct the semantic differential items.

To address Research Questions 2 and 3, a three stage causal model was employed (Pedhazur, 1982). In stage one, the indirect measures, the linear combination of beliefs and evaluations, were correlated to their respective direct measures of the theory constructs. In stage two, the three direct measures of the theory constructs were correlated to behavioral intention. In stage three, behavioral intention was correlated with perceived behavior. All paths represented direct effects; therefore, path coefficients are represented by betas from multiple regression models. The betas were used to determine the relative contribution of each variable. The computer statistical package SPSS Version 6.1 for the Macintosh (SPSS, 1994) was used to calculate the descriptive statistics and regression models.

Results

The open-response items used to construct the ABI, SNI, and PBCI scales were used to address Research Question 1. Many of the advantages for using educational technology listed by the teachers focus on improving instruction and meeting students' needs. Teachers believed that technology would accomplish this by providing a variety of instructional strategies which would meet more students' needs, making science more fun and interesting for students, modernizing the science curriculum, individualizing the science curriculum for students, motivating students in science classes, helping students learn new techniques and skills, providing students with knowledge and skills they will need the rest of their lives, and providing up-to-date science information to students. The approving and disapproving groups of people include many of the groups who commonly interface with schools such as school administrators, students, other teachers, college professors, parents, and school board members. Teachers also felt that community members and business and industry leaders would favor the use of technology. However, teachers indicated that tax payers who think schools spend too much money would not want to pass levies to fund technology. Some teachers indicated that staff development opportunities, smaller classes of students, a classroom structure that supports use of technology (proper electrical connections, moveable tables, not blowing fuses/circuit breakers, and space), and support from administration, technology resource teachers, volunteer parents, and school district would encourage them to use educational technology. Some teachers were concerned about the time it took to time to learn, plan, and implement educational technology. Many teachers complained about a severe lack of resources (funding, equipment, software, laptop computers, connections from computer to TV, overhead projector, and LCD pad) and limited access to the Internet (T1 line, wiring, etc.). Some indicated that quality software programs did not exist for the subject they taught.

Table 1. Advantages and Disadvantages of Using Educational Technology in the Classroom as Listed by Classroom Teachers (D)

Advantages	Disadvantages
• Provide a variety of instructional strategies to meet more students' needs. • Make science more fun and interesting for students. • Modernize the science curriculum. • Individualize the science curriculum for students. • Motivate students in science classes. • Help students learn new techniques and skills. • Provide students with knowledge and skills they will need the rest of their lives.	No items attained the 75% quota.

• Provide up-to-date science information to students.	

Table 2. People Who Approve or Disapprove of Using Educational Technology in the Classroom as Listed by Classroom Teachers (D)

Advantages	Disadvantages
• School administrators (principals, curriculum director, superintendent, etc.) • Students • Teachers in general • School board members • College Professors • Parents in general • Software companies • Community members • Business and industry leaders	• Parents • Older teachers resistant to change • Taxpayers who think schools spend too much money and don't want to pass levies

Table 3. Things That Would Encourage or Discourage the Use of Educational Technology in the Classroom as Listed by Classroom Teachers (D)

Advantages	Disadvantages
• Having available resources (funding, enough equipment, more software, etc.) • Staff development opportunities on technology (how to use programs, the equipment, etc.) • Access to the Internet (T1 line, wiring, etc.) • Quality software programs on the subjects I teach • Classroom structures that support use of technology (proper electrical connections, moveable tables, now blowing fuses/circuit breakers, and space) • Support (administration, technology resource teacher, volunteer parents, school district, etc.) • Time to learn, plan, and implement educational technology • Time to let students use the technology • Smaller classes of students	• Lack of resources and funding • Lack of time • No professional development • Lack of support

• Laptop computers • Connection from computer to TV, overhead projector, or LCD panel	

Descriptive statistics for the model variables can be seen in Table 4. The teachers generally possessed positive beliefs concerning attitude (ABi). The low mean for PBCi indicates that the teachers don't feel that specific external control factors such as staff development and resources will be present in order to help them use educational technology. The mean for ABD indicates a fairly positive attitude regarding the use of educational technology. The mean of SND indicates that on average, the teachers are influenced somewhat by other people. The mean of PBCD indicates that they are split about their perception that they could easily implement educational technology in their own classrooms. The mean for behavioral intention (BI) indicates that the teachers believe that they are slightly likely to implement educational technology in their own teaching. The mean for behavior indicates that approximately half of the teachers report using educational technology now in their classrooms.

Table 4. Descriptive Statistics (D)

Scale	Mean	SD	Range	Minimum	Maximum
ABi (bbioei)	21.55	11.45	56	-22	34
SNi (nbimci)	11.66	10.45	66	-22	44
PBCi (cbieci)	2.12	20.08	88	-44	44
ABD (direct attitude toward behavior)	21.74	4.13	21	7	28
SND (direct subjective norm)	11.79	2.42	12	4	16
PBCD (direct perceived behavioral control)	16.17	4.47	19	4	23
BI (behavioral intent)	13.61	2.68	15	3	18
B (behavior)	28.6	9.10	39	12	51

Figure 2 represents the significant pathways found in the regression analyses. The path coefficients in Figure 2 represent the betas from regression models (see Tables 5-9) and were used to determine the relative weights of each variable. The indirect measures of the theory constructs were correlated to the direct measures. The indirect measure of attitude (ABi) significantly influenced the direct measure of attitude (ABD) ($F = 9.58$, $p = .0022$, $R = .21$) and accounted for 5% of the variance. The indirect measure of subjective norm (SNi) significantly influenced the direct measure of subjective norm (SND) ($F = 43.42$, $p = .0000$, $R = .42$) and accounted for 18% of the variance. The indirect measure of perceived behavioral control (PBCi) significantly influenced the direct measure of perceived behavioral control (PBCD) ($F = 37.94$, $p = .0000$, $R = .40$) and accounted for 16% of the variance.

Regression analyses were used to address the second research question, Do teachers' belief-based affects influence their intent to implement thematic instruction in their own classrooms? Results revealed that the behavioral intention was regressed on all three of the direct measures of the theory constructs. Two of the three direct measures (SND and PBCD) were significantly linked to behavioral intention (BI) ($F = 110.30$, $p = .0000$, $R = .79$). The SND and PBCD direct measures accounted for 62% of the variance in the teachers' intent to use educational technology in their classrooms (BI). Perceived behavioral control provided the strongest influence on behavioral intention as indicated by its beta, which is larger than the beta for subjective norm. Subjective norm provides the next strongest influence, while attitude toward the behavior did not have a significant influence on intention.

Regression analysis was used to answer research question 3, Do teachers' intentions influence their perceived implementation of educational technology in the classroom? Behavioral intention influenced perceived behavior (teachers' self-report use of educational technology) (F = 44.26, p = .0000, R = . 42) and accounted for 18% of the variance.

Figure 2. Path Model (D)

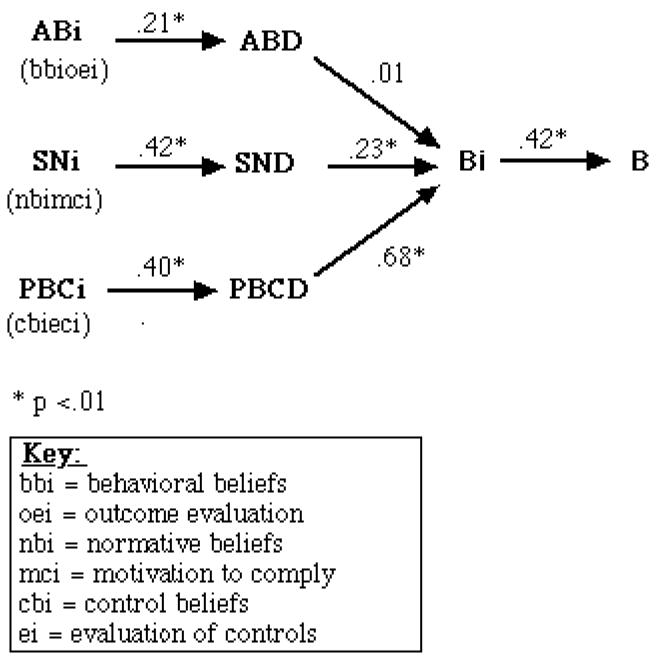


Table 5. Summary of the Regression Analysis for ABD (D)

	R	R sq.	F	Sig. F	df
	.21	.05	9.58	.0022	202
Predictors	**B**	**Beta**	**SE Beta**	**T**	**Sig. T**
ABI	.08	.21	.02	3.10	.0022

Table 6. Summary of the Regression Analysis for SND (D)

	R	R sq.	F	Sig. F	df
	.42	.18	43.42	.0000	202
Predictors	**B**	**Beta**	**SE Beta**	**T**	**Sig. T**
SNI	.10	.42	.01	6.59	.0000

Table 7. Summary of the Regression Analysis for PBCD (D)

	R	R sq.	F	Sig. F	df
	.40	.16	37.94	.0000	202
Predictors	**B**	**Beta**	**SE Beta**	**T**	**Sig. T**
PBCI	.09	.40	.01	6.16	.0000

Table 8. Summary of the Regression Analysis for BI (D)

	R	R sq.	F	Sig. F	df
	.79	.62	110.30	.0000	202
Predictors	**B**	**Beta**	**SE Beta**	**T**	**Sig. T**
ABD	.01	.01	.03	.30	.76
SND	.25	.23	.05	4.93	.0000
PBCD	.41	.68	.03	13.89	.0000

Table 9. Summary of the Regression Analysis for B (D)

	R	R sq.	F	Sig. F	df
	.42	.18	44.26	.0000	202
Predictors	**B**	**Beta**	**SE Beta**	**T**	**Sig. T**
BI	1.44	.42	.22	6.15	.0000

Discussion

The body of literature is growing regarding teachers' beliefs about contemporary science reform (Beck, Czerniak, & Lumpe, in press; Czerniak & Lumpe, 1996; Czerniak & Lumpe, 1995; Czerniak, Lumpe, & Haney, in press; Haney, 1994; Haney, Czerniak & Lumpe, 1996; Hartzell, 1997; Lumpe, Haney, & Czerniak, 1998), and it is becomingly increasingly clear that teachers' attitudes towards the reform and their perceptions of the presence of needed support structures and/or barriers to reform are strongly related to their intentions to implement these ideas. Specifically, teachers in this study share the belief that educational technology enhances student learning and that the integration of technology into their teaching is both desirable and needed. Yet, they do not perceive that sufficient support structures are in place to enable them to achieve the outlined technology education standards.

This study suggests that support structures are needed in five areas: 1) the teachers' subjective norm (colleagues, parents, community members, university faculty, and business/industry leaders), 2) resources (funding, enough equipment, more software, projection devices, access to the Internet, and quality software), 3) classroom structures that support use of technology (proper electrical connections, moveable tables, proper fuses/circuit breakers, and space), 4) staff development opportunities on technology (how to use programs, the equipment, etc.), and 5) time to learn, plan, and implement educational technology.

First, policy makers, administrators, and community members who fund schools need to make a genuine and long lasting commitment to teachers. Contrary to popular belief, the ability to implement an educational reform goal isn't just a matter of possessing an "I think I can, I think I should" attitude. Teachers must do more that just believe in the reform. They must have strong encouragement and high expectations from people who matter to them (administrators, business and industry representatives, parents, etc.) (Hord, 1988; Valencia & Killian, 1988; McLaughlin, 1990).

Access to quality software, sufficient equipment, and classroom structures is needed to support technology use. This finding is consistent with a report by the National Coordinating Committee on Technology in Education and Training (1994) that indicated that 90% of our nation's schools do not, for example, have adequate access to telephone lines for using the Internet. Issues of access of technological equipment are serious, and this study suggests that of lack of resources continues to be a problem. The State of Ohio's SchoolNet Program (http://www.enc.org/ssrp/) provides an example of this needed commitment to technology reform. The state recently earmarked over $500 million dollars to provide access to technology to K-12 students and to provide technology training for school personnel. The SchoolNet project, in itself, is an unlikely panacea, but it begins to pave the way so that local programs and classroom teachers can make a lasting difference.

Teachers in this study indicated a need for professional development opportunities, and this is reiterated in a US Congress report on teachers and technology (OTA, 1995) which indicates that the majority of teachers do not understand how they can use technology in their jobs, and most new teacher graduates from teacher preparation institutions continue to have limited knowledge of ways technology can be used to improve teaching. Interestingly, as Brownell, Haney, and Sternberg (1997) indicated, teachers are emphatically interested in gaining technological skills and knowledge to enhance their ability to teach. Although 96% desire some sort of learning opportunities, 39% reported that they would be interested in pursuing a Master of Education in Classroom Technology if needed support structures were available (tuition waivers, release time, etc.).

Finally, teachers must have both ample and continuous time to learn about new technologies. Therefore, professional development opportunities need to be long term, sustained efforts rather than one-shot workshops. Specifically, teachers' beliefs regarding technology should be identified, a critical mass of school personnel should be involved in active training sessions designed to address the identified beliefs, training should be followed by classroom implementation of technology, and support structures such as mentoring and technical assistance should be provided (Haney & Lumpe, 1995).

Teachers in this study indicated they needed time to use technology with their students. Many schools in our country are turning to block scheduling as a way to provide teachers, particularly at the middle, junior, and high school levels, with larger segments of time to teach (Canady, 1995). A 90 minute segment of time in a block schedule (rather than the traditional 45 or 50 minute periods) may afford teachers the necessary time to use technology with their students and improve learning.

This study consisted of a sample of teachers from Wisconsin and Ohio (samples accessible to the authors), and 95% of the sample was White. Further research should examine the beliefs of teachers from more diverse populations. Gender may be a factor that could be examined. Breakdowns in urban and rural teachers may be of interest.

In conclusion, within the limitations of this study, it appears that if science reform efforts of the 1990s expect to be successful, future research efforts should focus on understanding how teachers' beliefs can facilitate rather than limit reform efforts. Educators should examine teachers' beliefs before planning classes, workshops, or seminars. Restructuring efforts should consider teachers' concerns about software materials, funding, supplies, time, and support structures. Failure to do so may prove to be unproductive in terms of time and money.

References

Ajzen, I. (1985). From intentions to actions: A theory of planned behavior. In J. Kuhl & J. Beckman (Eds.), Action Control: From Cognition to Behavior. New York: Springer-Verlag

Ajzen, I., & Madden, T. J. (1986). Prediction of goal-directed behavior: Attitudes, intentions, and perceived behavioral control. Journal of Experimental Social Psychology, 22, 453-474.

Ajzen, I., & Fishbein, M. (1980). Understanding attitudes and predicting social behavior. Englewood Cliffs, NJ: Prentice Hall.

American Association for the Advancement of Science (1993). Benchmarks for science literacy. New York: Oxford University Press.

Battista, M. T. (1994). Teacher beliefs and the reform movement in mathematics education. Phi Delta Kappan, 2, 462-470.

Beck, J. (1997). Teacher beliefs regarding the implementation of constructivism in their classroom. Unpublished doctoral dissertation, The University of Toledo, Toledo, OH.

Brownell, G., Haney, J., Sternberg, L. (1997). Developing and implementing a master of education in classroom technology. Bowling Green, OH: Bowling Green State University.

Bruner, I, Buchsbaum, H. Hill, M., & Orlando, L. (May/June, 1992). School reform: Why you need technology to get there? Electronic Learning, (11), 22-28.

BSCS. (1994). Innovations in science education survey instrument. Colorado, Springs, CO: Author.

Buchmann, M. (1987). Teaching knowledge: The lights that teachers live by. Oxford Review of Education, 13, 151-164.

Bybee, R. W. (1993). Reforming Science Education. New York: NY: Teachers College Press.

Campoy, R. (1992). The role of technology in the school reform movement. Educational Technology, 32 (8), 17-22.

Canady, R. (1995). Block scheduling: A catalyst for change in high schools. Princeton, NJ: Eye on Education.

Clark, C. M., & Peterson, P. L. (1985). Teachers' thought processes. In M. C. Wittrock (Ed.),Handbook of research on teaching (pp. 255-296). New York: Macmillan.

Cornett, J. W., Yoetis, C., & Terwilliger, L. (1990). Teacher personal practical theories and their influence upon teacher curricular and instructional actions: A case study of a secondary science teacher. Science Education, 74, 517-529.

Crawley, F. E. (1990). Intentions of science teachers to use investigative teaching methods: A test of the Theory of Planned Behavior. Journal of Research in Science Teaching, 27, 685-697.

Crawley, F. E., & Koballa, T. R. (March, 1992). Attitude/Behavior change in science education: Part I - Models and methods. A paper presented at the Annual Meeting of the National Association for Research in Science Teaching, Boston, MA.

Crawley, F. E., & Salyer, B. A. (1995). Origins of life science teachers' beliefs underlying curriculum reform in Texas. Science Education, 79 (6), 611-635.

Cuban, L. (1990). Reforming Again, Again, and Again. Educational Researcher, 1, 3-13.

Czerniak, C. & Lumpe, A. T. (November, 1996). Relationship between teacher beliefs and science education reform. Journal of Science Teacher Education, 7 (4), 247-266.

Czerniak, C. M., & Lumpe, A. T. (April, 1995). Relationship Between Teacher Beliefs And Science Education Reform. A paper presented at the Annual Meeting of the National Association for Research in Science Teaching, San Francisco, CA.

Czerniak, C. M., Lumpe, A. T., & Haney, J. J. (1999). Teachers' beliefs about thematic units in science. Journal of Science Teacher Education, 10(2) 123-145.

Florio-Ruane, S., & Lensmire, T. J. (1990). Transforming future teachers' ideas about writing instruction. Journal of Curriculum Studies, 22, 277-289.

Fullan, M.G., & Miles, M.B. (1992). Getting reform right: What works and what doesn't. Phi Delta Kappan, 73, 745-752.

Gardner, D. P. (1983). A Nation at Risk. Washington, D. C.: The National Commission on Excellence in Education, U.S. Department of Education.

Gilder, G. (March, 1993). The information revolution. The Executive Educator, (15), 16-20.

Haney, J. J., (1994). The determinants of Ohio science teachers' intentions to implement the four strands of the state science model into their classroom instruction. Unpublished doctoral dissertation, The University of Toledo, Toledo, OH.

Haney, J. J., & Lumpe, A. T. (1995). A teacher professional development framework guided by reform policies, teachers' needs, and research. Journal of Science Teacher Education, 6, 187-196.

Haney, J. J., Czerniak, C., & Lumpe, A. T. (1996). Teachers' beliefs and intentions regarding the implementation of science education reform strands. Journal of Research in Science Teaching, 33, 971-993.

Hartzell, L. (1997). Teachers' beliefs about accommodating students' learning styles in science classes. Unpublished masters thesis, The University of Toledo, Toledo, OH.

Hashweh, M. Z. (1996). Effects of science teachers' epistemological beliefs in teaching. Journal of Research in Science Teaching, 33, 47-63.

Hord, S. M. (1988). The principal as teacher educator. Journal of Teacher Education, 39(3), 8-11.

International Society of Technology Education (ISTE) Accreditation Committee

(1992). Curriculum Guidelines for Accreditation of Educational Computing and Technology Programs. Eugene, Oregon: ISTE.

Kagan, D. M. (1992). Implications of research on teacher belief. Educational Psychologist, 27, 65-90.

Koballa, T. R., & Crawley, F. E. (1992). Attitude/Behavior change in science education: Part II - Results of an ongoing research agenda. A paper presented at the Annual Meeting of the National Association for Research in Science Teaching, Boston, MA.

Lehman, J. R. (1994). Technology use in the teaching of mathematics and science in elementary schools. School Science and Mathematics, 94, 194-202.

Lumpe, A. T., Haney, J. J., & Czerniak, C. M. (1998). Teachers' beliefs about science, technology, society reforms. Journal of Science Teacher Education, 9, 1-24.

Marshall, J. C., & Bannon, S. (1988). Race and sex equity in computer advertising. Journal of Research on Computing in Education, 21, 15-27.

McDevitt, T. M, Heikkinen, H. W., Alcorn, J. K., Ambrosio, A. L., & Gardner, A. L. (1993). Evaluation of the preparation of teachers in science and mathematics: Assessment of preservice teachers' attitudes and beliefs. Science Education, 77, 593-610.

McLaughlin, M. W. (1990). The Rand change agent study revisited: Macro perspectives and micro realities. Educational Researcher, 12, 11-16.

Munby, H. A. (1984). A qualitative approach to the study of a teachers' beliefs. Journal of Research in Science Teaching, 21, 27-38.

Naron, N. K., & Estes, N. (1986). Technology in the schools: Trends and policies. AEDS Journal,20, 31-43.

National Coordinating Committee on Technology in Education and Training, (March, 1994). The national information infrastructure: Requirements for education and training. Alexandria, VA: Author.

National Research Council. (July, 1994). National Science Education Standards: Discussion Summary. Washington, DC: Author.

O'Brien, T. (April, 1991). Computers in education: A Piagetian perspective. Communicator,(66), 32-34.

Office of Technology Assessment (April, 1995). OTA report summary, Teachers & technology: Making the Connection. Washington, DC: Author.

Ohio Department of Education, (1993). Ohio Schools Directory. Columbus, OH: Author.

Pajares, M. F. (1992). Teachers' beliefs and educational research: Cleaning up a messy construct.Review of Educational Research, 62, 307-332.

Papert, S. (1980). Mindstorms: Children, computers, and powerful ideas. New York: Basic Books.

Papert, S. (1993). The children's machine: Rethinking school in the age of the computer. New York: Basic Books.

Perry, C. M. (April, 1990). A pilot study of preservice and inservice teachers' beliefs about effective teaching. Paper presented at the annual meeting of the American Educational Research Association, Boston, MA.

Pedhazur, E. J. (1982). Multiple regression in behavioral research (2nd ed.). Fort Worth, TX: Holt, Rinehart, & Winston.

Rutherford, J., & Ahlgren, A. (1989) Science for All Americans: Project 2061. New York: Oxford University Press.

SPSS (1994). SPSS 6.1 Base System Users Guide. Chicago, IL: Author.

State Board of Education (1994). Model Competency-Based Science Program. Columbus, OH: Author.

Tobin, K., Kahle, J., & Fraser, B. (1990). Windows into science classrooms: Problems associated with higher-level cognitive learning. London: Falmer Press.

Tobin, K., Tippins, D. J., & Gallard, A. J. (1994). Research on instructional strategies for teaching science. In D. L. Gabel (Ed.). Handbook of Research on Science Teaching and Learning (pp. 45-93). New York: Macmillan.

US Office of Technology Assessment. (1988). Power on: New tools for teaching and learning. Washington, DC: U.S. Government Printing Office.

Valencia, S. W., & Killian, J. P. (1988). Overcoming obstacles to teacher change: Direction from school-based efforts. Journal of Staff Development, 9(2), 2-8.

Wilson, S.M. (1990). The secret garden of teacher education. Phi Delta Kappan, 72, 204-209.
