Measuring Student Attitude and Knowledge in Technology-rich Biology Classrooms

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Abstract

The use of technology in schools is now ubiquitous but the effectiveness on the learning environment has mixed results. This paper describes the development and validation of an instrument to measure students' attitudes toward and knowledge of technology with the aim of investigating any differences based on gender after a course *where the science department made use of technology as an integral part of teaching biology. In this study, conducted in one school in the state of New York, in the United States of America the Students' Attitudes toward and Knowledge of Technology questionnaire was administered to nearly 700 high school science students. A principal component and principal factor analysis resulted in new scales from the validation of the instrument that demonstrated high reliabilities. There were statistically significant gender differences in all the scales of the questionnaire in favor of males.*

Keywords: technology integration, gender, high school science, high school biology, test validation

Introduction

The present study primarily utilized and revalidated an existing questionnaire to investigate students' attitudes toward and knowledge of technology in secondary school technology-enriched biology classrooms. Further, the study draws on past evaluations of educational innovations (Fisher and Khine 2006; Koul et al. 2011; Zandvliet 2003) from the field of computer-based learning environments, especially those research studies on technology-rich learning environments which have illustrated the effectiveness of the use of technology in teaching science and its relationship with selected learner outcomes (Aldridge et al. 2004; Aldridge and Fraser 2003). Attitude measures provide an effective means for investigating the impact of the use of technology in teaching science at the secondary level (Fraser 2003).

Use of Student Perceptual Data

Until the late 1960's, a very strong tradition of trained observers coding teacher and student behaviors dominated classroom research. Indeed, it was a key recommendation of Dunkin and Biddle (1974) that instruments for research on teaching processes, where possible, should deal with the objective characteristics of classroom events. Clearly, this low-inference approach to research which often involved trained observers coding teacher and student behaviors was consistent with the behaviorism of the 1960's. The study of classroom psychosocial environments broke this tradition and used student perceptual data in the late 1960's. Since then, the strong trend in classroom research has been towards this high-inference approach with data collected from the teachers and students. Walberg (1976) supports this methodological approach where student learning involves student perceptions acting as mediators in the learning process. Walberg (1976) also advocates the use of students' perceptions to assess learning environments because students seemed quite capable of perceiving and weighing up stimuli and rendering predictively valid judgments of the social environments of their classes.

Technology in the Classroom

According to the National Education Association Policy brief (2008), an effective high school program aligns curriculum, instruction, and assessment with high standards and high expectations focusing on the integration of skills and knowledge. Furthermore, Ross et al. (2010) demonstrated that students' attitudes are positive when technology is integrated as a learning tool, and when there are increases in higher-order thinking, writing and problem solving. Success in the 21st century requires mastery of subject areas such as biology combined with learning and thinking skills, and information and communications technology literacy. Technology use can increase students' academic performance, and proficiency in a topic area such as the biology course referred to as The Living Environment taught in New York State.

Technology supports students taking responsibility for their own learning and therefore promotes building the necessary skills to become lifelong learners (United States Department of Education National Education Technology Plan 2010). As digital technology resources pervade schools and classrooms, educators are rethinking the nature of teaching and learning and refocus education from teacher to student and from teaching to learning (Owston 1997). Today's learners must think critically, analyze and synthesize information to solve technical, social, economic, political, and scientific problems, and work productively in groups. Additionally, when using technology in the classroom, it is necessary to measure the impact of technology on student achievement and accountability and to ascertain whether, and to what degree, technology affects student achievement (McMahon 2009).

Schroeder, Scott, Tolson, Huang, & Lee (2007), demonstrated positive effects on achievement as indicated by test scores when educational technology was implemented. Bälter, Enström, & Klingenberg (2013), investigated the use of computer-based generic quizzes in two universities - one in Stockholm, Sweden and one in Massachusetts, United States of America. They concluded that when students were offered short, formative on-line quizzes and when constructivist learning was encouraged early in the course, academic outcomes improved and study habits changed, yielding a positive effect.

Depending on how teachers use technology in the classroom, technology can positively affect teaching and learning "by being a source of knowledge, a medium for transmitting content, and an interactive resource furthering dialogue and creative exploration" (Levin and Wadmany 2008 p. 234). Hennessy, Wishart, Whitelock, Deaney, Brawn, la Velle, McFarlane, Ruthven, & Winterbottom, (2007) concur that the use of technology in the classroom encourages students to be actively engaged in whole group activities and can build upon and address current knowledge, prior knowledge, and challenge alternative conceptions. Furthermore, technology can enhance understanding while still making students feel that they are receiving individualized learning and attention. Teacher beliefs and attitudes toward the effectiveness of technology compared to traditional teaching methods also can affect their use of technology in the classroom.

According to Tang and Austin (2009), "it is not the technology, but the instructional implementation of the technology that contributes to learning effectiveness" (p. 1243). Students' learning styles and the type of technology utilized in the classroom affects student outcomes. Tang and Austin (2009) also noted that students' perception of the professors' "effective" application of technology in the classroom affected their attitude. In both the middle-school and college level studies, some reference has been made to students' self-reported efficacy in learning when technology is implemented, indicating that technology affects students' own perceptions of their academic achievement. Furthermore, in a study conducted in New Zealand by Ward and Parr (2010), 199 secondary school teachers explained their level of the use of technology by citing their perceptions of the benefits to effect positive student outcomes which then motivated them to use that technology.

When students have high self-reported academic grades, the professors' teaching performance was perceived as a student achievement motivator. When a technology-enhanced learning environment was evaluated for improvement of student achievement, it was noted in Korean (Hsieh, Cho, Liu, & Schallert, 2008), and United States studies (Park, Khan, & Petrina, 2009), that science students had improved academic achievement, and that improved achievement influenced their attitude toward science. Other factors related to students' perception and attitude toward science and improved achievement in the technology-rich learning environment in science include gender.

Gender Differences in Technology Learning Environments

Numerous studies have been conducted to understand whether gender differences influence students' attitude toward learning with technology. Plumm (2008) indicated that educational software was designed with a female bias such that the characters represented in educational software favored males and were difficult for females to identify with. Heemskerk, ten Dam, Volman, & Admiraal, (2009), investigated gender inclusiveness and differences in the learning experiences of females and males when technology was implemented in the educational setting of 81 ninth grade students aged 14-15 years. They concluded that the type of technology used influences the learning experience of males and females, and that those technological tools used might be more inclusive to males. Furthermore, the study found that after investigating the way designers and developers of educational technology for specific users, these "user representations" or "scripts" are unintentionally designed with males in mind (p. 255). While the study was small scale, Heemskerk et al. (2009), noted that when females were interested in the educational tool, learning performance improved whereas males' learning experience was not affected by the type of educational technology tool used. In interviews, both males and females reported agreement that they liked working with technology in school. Chang and Yang (2010) implemented a web-based curriculum and measured 105 11th grade students' responses to cognitive load. The findings indicated that male and female students had different preferences when it comes to web-based curriculum instruction. The sample showed that male students believed that reading on-line articles was a strain, and female students showed higher engagement in chat rooms and information searches" (p. 679). The studies by Chang and Yang (2010), Heemskerk et al. (2009), and Plumm (2008) concurred that in order to engage students, curriculum design should be more mindful of gender preferences of technology use.

In another study by Bain and Rice (2006), the Computer Attitude Questionnaire (CAQ) and the PATT-USA were used in a small-scale study of 59 sixth grade students aged 11 and 12 years. A major finding in their study was that "gender differences in attitudes, perceptions, and uses of computers were not found to be significant" (p. 128). However, for the participants of the study, "males indicated they were better at using the computer than females," Overall, the results of the study for this group indicated that "gender uses of computers are changing" (p. 129) and that "all participants indicated a positive attitude toward technology at home and at school" (p. 129).

Research by Plumm (2008) supports the work of Bain and Rice (2006/2007) insofar as males reported having more experience using computers at home when it came to game playing and computer searching so that their reported experiences using computers at school were positive, while females used technology more for social purposes or completing tasks of schoolwork. In a study by Kay (2009), 659 students (327 males and 327 females) were sampled on their attitude toward the use of Interactive Classroom Communication Systems (ICCS or clickers). Results indicated that males reported that they were more motivated and engaged when using ICCS in the classroom.

Additionally, Cooley and Comber (2003) investigated the computer use of 11-12 year olds and 15-16 year olds in the United Kingdom. Findings indicated that despite increased computer usage in schools, there was still gender differences towards computer usage with girls responding that they “use computers less, like them less and evaluate their computing skills less than do boys” (p. 164). This study concurs with Bain and Rice (2006) and Heemskerk, ten Dam, Volman, & Admiraal, (2009), in that continued progress needs to be made toward integrating technology into the classroom that is inclusive toward both genders.

Achieving Benchmarks

In conjunction with the National Educational Technology Standards for Students (2010), the International Society for Technology in Education (ISTE) has developed grade-level benchmarks to describe the technological experiences students should encounter during their educational career. Grade levels include Pre-K-grade 2 (age 4-8), grades 3-5 (age 8-11), grades 6-8 (age 11-14) and grades 9-12 (14-18).

Smarkola (2008) conducted research using a mixed-methods study which “builds upon prior grade-level educational technology studies” (p. 389). The study investigated 160 student teachers and 158 experienced teachers who were surveyed using the Computer Usage Survey to determine if teachers of different grade levels were meeting ISTE standards. Results indicated that while all grade levels integrate technology, varying degrees and types of technology are used depending on the grade level. Smarkola's study (2008) concluded that elementary grades are more in compliance with meeting the ISTE grade-level standards than upper grades.

In contrast, according to research conducted by Gorder (2008) on 300 teachers who attended the Advanced Technology for Teaching and Learning Academy in South Dakota, and who taught grades K-12, results for the 174 respondents indicated that "teachers in grades 9-12 tend to integrate and use technology more than teachers in grades K-5 or grades 6-8" (p. 73).

These studies revealed that while teachers have good intentions when it comes to the integration of technology across grade-levels, more attention must be given to meeting NETS-S and ISTE standards to develop students to meet the needs of the 21st century and to help students develop skills necessary for higher education. Additionally, Ottenbreit-Leftwich, Glazewski, Newby, & Ertmer (2010), concurred that technology was not being utilized by teachers in the classroom to support curriculum instruction in the most efficient way to facilitate improved or increased student learning.

Research Methodology

Research Design and Research Questions

As there was no random assignment of students and variables within and among classrooms were not controlled (Shulman 1997), a quasi-experimental design was used comprising quantitative and qualitative research methods. According to Creswell (2002), in the quasi-experimental design "the investigator determines the impact of an intervention on an outcome for participants in a study" (p. 314), In this case, the technology intervention was examined to determine if there was any influence on attitudes to technology and to determine how these attitudes compared between genders.

Consequently, this study was designed to (1) develop and validate the *Students' Attitudes toward and Knowledge of Technology* questionnaire and (2) investigate any differences based on gender in the learning environment in terms of students attitudes and knowledge of technology following the technology integrated teaching and learning of the Living Environment course.

Context

In an effort to supplement curricula and meet the State and Federal guidelines (United States Department of Education, 2007), in 2008 the school district where this research study was conducted initiated a district-wide Technology Plan. In the 2009-2010 school years, the high school Science Department made use of technology as an integral part of teaching. One laptop cart and three sets of hand-held Student Response Systems (SRS) were shared among the teachers. Each classroom had newly installed Interactive White Boards with *Easiteach* software and access to interactive multi-media including the use of *Google, g-mail, photostory,* and *podcast* software. Additionally, teachers could make use of a digital video library. Web 2.0 tools were embedded into lessons at each teacher's discretion to increase student learning through motivation and engagement and increase student interest, attitudes and achievement.

Sample

A co-educational sample represented a diverse population in a large suburban school district in New York State. Participants were enrolled in 38 sections taught by 11 teachers in The Living Environment course in one high school. New York State mandates that all students must pass the Living Environment course for graduation; consequently, the sample included students in grades 9-12. Of the 885 students enrolled in the Living Environment, nearly 700 students from grades 9-12 responded to the online version of the *Students' Attitudes toward and Knowledge of Technology* questionnaire.

Instrumentation

The *Students' Attitudes toward and Knowledge of Technology* questionnaire comprised attitude scales from the Pupils' Attitude to Technology (PATT-USA) (Bame et al. 1993) and one scale from the modified Technology-Rich Outcome-Focused Learning Environments Instrument (TROFLEI) (Gupta 2007). The original version of PATT-USA, developed almost three decades ago, was long (101 items) and lost its significance for usability in terms of the variety of technology available today and the language used to identify what constitutes technology. The PATT instrument was previously revised for use in seven states in the United States, (Boser, Palmer, & Daugherty, (1998) but no factor structure was determined. Items were scored using a 5-point Likert scale. In addition to the questionnaire, questions related to specific technologies made available by the district for use by classroom teachers were added to make the research more meaningful to students. Furthermore, the investigation of specific technology tools to support instruction provides the insight into recommendations suggested by previous researchers in examining whether technology supports student learning and is gender-inclusive or at least, the technology being used is well-received by both genders.

Data Analysis

Following factor analysis, descriptive statistics and reliabilities were calculated for each scale of the questionnaire. Also, multiple regression analyses, involving all scales, were conducted to provide information about multivariate associations between the learning environment and attitudes and students' knowledge of technology.

Results

Validity and Reliability of the Students' Attitudes toward and Knowledge of Technology questionnaire

To respond to the first research question, data collected from a New York high school were analyzed in various ways to establish validity and reliability of the questionnaire. As Table 1 shows, a principal components factor analysis followed by varimax rotation confirmed a refined structure of the attitude part of the instrument (PATT-USA) comprising of 54 items in 5 scales with a loading of at least 0.30 on their *a priori* scales. The descriptive statistics and Cronbach alpha reliability values for each scale and an analysis of variance (ANOVA) used to determine the ability of the each scale to differentiate between the attitudes and knowledge of students in different grades are shown in Table 2. The one-way ANOVA for each scale involved class membership as the independent variable. Using the individual as the unit of analysis, the discriminant validity results (mean correlation of a scale with other scales) for the scales ranged from 0.18 for the Consequence of Technology scale to 0.44 for the Knowledge of Technology. Mean scores above three for Consequences of Technology and Technology Teaching show overall positive student perceptions of technology. The mean score for Knowledge of Technology (1.67 out of 3) indicates that students believed that they were somewhat confident regarding their knowledge of technology. However, for the scales General Interest in Technology and Attitudes to Technology the mean results were less than three indicating a less than positive perception of technology. Results confirm that students perceive technology as very important in life and that technology is a subject of the future. The scale of Attitude Towards Technology demonstrated negative mean correlation with the other four scales suggesting that although students had positive perceptions and knowledge of technology, they did not have positive attitudes toward technology. These data support the contention that the Students' Attitudes to and Knowledge of Technology questionnaire is a valid and reliable instrument for assessing students' attitudes to and knowledge of their technological environments at the high school level in New York State. The questionnaire is shown in Appendix A.

Table 1 In contrast, according to

for the Students' Attitudes toward and Knowledge of Technology questionnaire

Item No	Interest in Technology	Consequences of Technology	Attitude Towards Technology	Teaching Technology	Knowledge of Technology
1	0.65				
2	0.44				
3	0.52				
4	0.65				

5	0.77				
6	0.48				
7	0.80				
8	0.53				
9	0.49				
10	0.41				
11	0.68				
12	0.42				
13		0.70			
14		0.71			
15		0.69			
16		0.56			
17		0.53			
18		0.41			
19		0.42			
20			0.41		
21			0.52		
22			0.5		
23			0.43		
24			0.46		
25			0.45		
26			0.51		
27			0.41		
28			0.40		
29				0.53	
30				0.63	
31				0.57	
32				0.66	
33				0.58	
34				0.53	
35				0.62	
36				0.66	
37				0.42	
38				0.41	
39				0.63	
40				0.56	
41					0.55
42					0.47
43					0.48
44					0.41
45					0.64
46					0.56
47					0.47
48					0.42
49					0.46
50					0.47
51					0.50
52					0.49

53					0.55
54					0.64
% Variance	21.75	7.11	4.74	4.50	3.47
Eigen Value	13.27	4.33	2.89	2.74	2.11

Table 2 Scale mean, standard deviation, internal consistency (Cronbach Alpha Reliability) and ability to differentiate between classrooms (ANOVA Results) for the Students' Attitudes toward and Knowledge of Technology questionnaire

Scale	No of Items	Mean	S D	Alpha Reliability	Eta^2	Mean Correlation
General Interest in Technology	12	2.96	0.76	0.88	0.00	0.23
Consequences of Technology	7	3.73	0.72	0.80	0.00	0.18
Attitude Towards Technology	9	2.68	0.65	0.78	0.00	-0.28
Technology Teaching	12	3.30	0.79	0.90	0.03***	0.24
Knowledge of Technology	14	1.67	0.36	0.83	0.07***	0.44

***P<0.001 N=697 students

Gender Differences

The associations between male (357) and female (340) students' perceptions on the scales of the Students' Attitudes Toward and Knowledge of Technology questionnaire and students' gender were analysed as shown in Table 3. To examine the gender differences in students' perceptions of the classes, the within-class gender subgroup mean was chosen as the unit of analysis in order to eliminate the effect of class differences due to males and females being unevenly distributed in the sample. In the data analysis, male and female students' mean scores for each class were computed and the significance of gender differences in students' perceptions of the Living Environment science classroom culture were analysed using an independent t-test. As can be seen in Table 3**,** the gender differences in the responses of males and females were found to be statistically significantly different on all the five scales. Gender differences were found to be statistically significantly different on all five scales with t-values ranging from 2.74 to 10.24; effect sizes ranged from 0.22 - 0.77. (Cohen (1998) has defined the effect size as being small when d = 0.2, medium when d = 0.5 and large when d = 0.8.) Overall, male students perceived the technological learning environment more positively that did females.

Table 3 Item mean, item standard deviation and gender differences in students' perceptions measured by Students' Attitudes toward and Knowledge of Technology questionnaire

Scale	Mean		Stand Deviation		t-value	Effect Size (*r*)
	Male	Female	Male	Female		
General Interest in Technology	3.23	2.68	0.73	0.68	10.24***	0.77
Consequences of Technology	3.83	3.62	0.69	0.73	3.83***	0.29
Attitude Towards Technology	2.58	2.78	0.65	0.63	4.01***	0.31
Teaching Technology	3.44	3.14	0.77	0.78	2.74***	0.38
Knowledge of Technology	1.71	1.63	0.35	0.37	5.16***	0.22

Sample Size = 697(Males =357) and (Females =340) ***p<0.01*

Educational Significance/Recommendations

The research reported in this article on developing and validating the Students' Attitudes Toward and Knowledge of Technology questionnaire and examining its use with technology-rich classrooms is important for three reasons. First, for attitudes, a new precise and concise version of the previous

PATT-USA scales has been validated for use in a technological learning environment. The revalidation exercise of this questionnaire—now with 54 items—provides a readily usable instrument for other interested researchers. The questionnaire can be used by school districts and teachers to pre-assess students attitude and knowledge toward technology at the beginning of the school year, introduce and use the technology tools provided by the district in which they work and finally, re-assess the impact of the use of technology on students attitude and knowledge toward learning and achievement in a technology-rich classroom.

Second, this study has shown that scales of the new questionnaire, Students' Attitude Toward and Knowledge of Technology, can be used in complex studies where many interrelated variables are assessed. These findings assisted in identifying the associations between the scales of the questionnaire including students' knowledge of technology. In a report by the Alliance for Excellence in Education (2012) *The Digital Learning Imperative: How Technology and Teaching Meet Today's Education Challenges*, engaging students in the use of technology improves their knowledge of how technology can positively affect learning and achievement in the content area (Schwartzbeck and Wolf 2012).

Third, in order to bring about desired changes in the educational system, interested teachers and school districts can use this information to identify the effect of technology integration on students' attitudes and achievement within a science classroom learning environment. Educational technology tools can increase interest within the learning environment as teachers apply them to enhance lessons. Furthermore, teachers must examine their own epistemology when it comes to making pedagogical changes to their curriculum by embedding technology in a way that affects constructivist learning environments. Attaining an increase in achievement results by embedding technology will require more effort on the part of school districts to provide professional development to teachers. Teachers must be given more time collaborating so that they may incorporate technology into their curriculum in a more meaningful way to not only supplement lessons but to increase student interest

Lastly, makers of educational Information and Communication Technologies (ICT) would better serve the learning community by eliciting input from students and teachers who use the technology when it comes to creating instructional technology which is gender inclusive and that would provide a more constructivist, student-centered learning environment approach to increase engagement and achievement with those technologies. Further, more qualitative studies are necessary to examine the technologies being used in the classroom and their effect on increasing engagement and achievement of both genders. A collaborative effort is warranted between school districts, teachers and students together with ICT manufacturers to assess the effectiveness of educational technology being created. In working toward positively integrating technology in a gender-neutral way, students may be more apt to engage with technology in a positive way thus improving learning and achievement.

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Appendix A

Students' Attitudes to and Knowledge of Technology

INTEREST IN TECHNOLOGY		AGREE	TEND TO AGREE	NEUTRAL	TEND TO DISAGREE	DISAGREE
1	I will probably choose a job in technology	5	4	3	2	1
2	I would like to know more about computers	5	4	3	2	1
3	I like to read technological magazines	5	4	3	2	1
4	If there was a school club about technology I would certainly join it	5	4	3	2	1
5	I would enjoy a job in technology	5	4	3	2	1
6	I should be able to take technology as a school subject	5	4	3	2	1
7	I would like a career in technology later on	5	4	3	2	1
8	There should be more education about technology	5	4	3	2	1
9	I enjoy repairing things at home	5	4	3	2	1
10	Technology as a subject should be taken by all pupils	5	4	3	2	1
11	Working in technology would be interesting	5	4	3	2	1
12	With a technological job your future is promised	5	4	3	2	1
CONSEQUENCES OF TECHNOLOGY						
1	Technology is good for the future of this country	5	4	3	2	1
2	Technology makes everything work better	5	4	3	2	1
3	Technology is very important in life	5	4	3	2	1
4	Everyone needs technology	5	4	3	2	1
5	Technology has brought more good things than bad	5	4	3	2	1
6	Technology lessons help you to train for a job					
7	Technology is the subject of the future	5	4	3	2	1

ATTITUDE TOWARDS TECHNOLOGY						
1	You have to be smart to study technology	5	4	3	2	1
2	I do not understand why anyone would want a job in technology	5	4	3	2	1
3	To study technology you have to be talented	5	4	3	2	1
4	You can study technology only when you are good at both mathematics and science.	5	4	3	2	1
5	Using technology makes a country less prosperous	5	4	3	2	1
6	Working in technology would be boring	5	4	3	2	1
7	Most jobs in technology are boring	5	4	3	2	1
8	I think machines are boring	5	4	3	2	1
9	A technological hobby is boring	5	4	3	2	1
TEACHING TECHNOLOGY						
1	I find learning science in the technology classroom interesting	5	4	3	2	1
2	I am able to learn faster through the technology classroom	5	4	3	2	1
3	I am more attentive in the technology classroom	5	4	3	2	1
4	I find the technology supported science class to be lively.	5	4	3	2	1
5	I am able to get additional information and update my knowledge in the technology classroom	5	4	3	2	1
6	I find the audio and visual effects in the content matter to be appealing	5	4	3	2	1
7	I am motivated to learn further in the technology classroom.	5	4	3	2	1
8	I look forward to learning science through the technology classroom.	5	4	3	2	1
9	My teacher uses technology in his/her lessons.	5	4	3	2	1
10	Our school is doing a good job of putting technology into the classroom	5	4	3	2	1
11	Technology improves my understanding of science.	5	4	3	2	1
12	Using technology in science improves my grades	5	4	3	2	1

KNOWLEDGE OF TECHNOLOGY		Agree	Disagree	Don't Know
1	I think science and technology are related	2	1	0
2	In technology, you can think up new things	2	1	0
3	Working with information is an important part of technology	2	1	0
4	Technology is as old as humans	2	1	0
5	Technology has a large influence on people	2	1	0
6	I think technology is often used in science	2	1	0
7	Working with hands is part of technology	2	1	0
8	In everyday life, I have a lot to do with technology	2	1	0
9	The government can have influence on technology	2	1	0
10	I think the conversion of energy is also a part of technology	2	1	0
11	In technology, you use tools	2	1	0
12	Technology is meant to make our life more comfortable	2	1	0
13	Working with materials is an important part of technology	2	1	0
14	There is a relationship between technology and science	2	1	0