Intertwining Digital Content and a One-To-One Laptop Environment in Teaching and Learning: Lessons from the Time To Know Program

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Abstract

This study provides a comprehensive look at a constructivist one-to-one computing program's effects on teaching and learning practices as well as student learning achievements. The study participants were 476 fourth and fifth grade students and their teachers from four elementary schools from a school district in the Dallas, Texas, area. Findings indicated consistent and highly positive findings of the efficacy of a constructivist one-to-one computing program in terms of student math and reading achievement, differentiation in teaching and learning, higher student attendance, and decreased disciplinary actions, suggesting a range of possible educational benefits that can be achieved through a comprehensive one-to-one computing educational environment. (Keywords: one-to-one laptop, academic outcomes, differentiated instruction, return on investment)

Background and Rationale

Educational Challenges

Increasing percentages of children born in the United States and other member countries of the Organisation for Economic Cooperation and Development (OECD) grow up in societies where Internet connections, smartphones, and videogame consoles are readily available to them. In the school settings, the investments in technology, intended to facilitate its adoption, has generally been impressive in the United States. However, it is well known that real adoption did not match the initial expectations at all (U.S. Department of Education, 2010). One of the main challenges for education systems is to leverage the learning sciences and modern technologies to develop engaging, authentic, and personalized learning experiences (Bransford, Brown, & Cocking, 1999; Collins & Halverson, 2009; Fullan, 2007; Marzano & Kendall, 2007; U.S. Department of Education, 2010).

Technology-rich learning environments are becoming more prevalent in the classroom and have been used as intellectual partners for active participation in construction of knowledge (Jonassen, 2008; Jonassen & Reeves, 1996; Lajoie, 2000; Salomon & Perkins, 2005; Weston & Bain, 2010). However, despite high-profile efforts and significant investments of resources, educational technology programs have revealed mixed effects (Bernard, et al, 2009; Cuban, 2001; Donovan, Green, & Hartley, 2010; Means, Toyama, Murphy, Bakia, & Jones, 2010; Tamin, 2011). Not surprisingly, findings from a series of empirical studies have consistently shown a peripheral use of technology by teachers and students (Bebell & O'Dwyer, 2010; Cuban, 2001; Kerr, Pane, & Barney, 2003; Zucker & Hug, 2007). In most cases, the technology is implemented for traditional practices, while paradigmatic change in teaching, learning, and assessment in technology-rich environments is rare. Some designers and educators, in their enthusiasm for implementing cutting-edge advanced technology, take a technology-centered approach to educational technology without sensitivity to how people learn (e.g. Mayer, 2003; Salomon & Perkins, 2005). In contrast, other designers and educators take a learner-centered approach, in which they begin with an understanding of learning processes and attempt to infuse technology as an aid to student learning (Mayer, 2001; Rosen & Salomon, 2007; Weston & Bain, 2010).

To achieve this change, a school system must go through major processes. It requires setting new educational objectives, preparing new curricula, developing digital instructional material aligned with learning standards, designing a new teaching and learning environment, training teachers, creating a school climate that is conducive to educational technology, and so on. Innovative approaches in learning science, technology, and assessment, combined with professional development for teachers, can provide a foundation for new and better ways to enhance students' knowledge and skills.

Studying the effects of paradigm-change-oriented educational technology programs on teaching and learning processes and outcomes is crucial to determining the efficiency and impact of the digital age instruction. The purpose of this article is to provide a comprehensive look at what can be achieved by intertwining a digital core curriculum in a constructivist-oriented one-to-one computing environment among elementary schools, in terms of possible changes in teaching and learning practices as well as student achievement.

According to the National Education Technology Plan (U.S. Department of Education, 2010), the main goal for leveraging learning is to promote engaging and empowering learning experiences that prepare learners to be active, creative, knowledgeable, and ethical participants in a global networked society. Technology can play a central role in transforming U.S. education. The model suggested by the National Education Technology Plan is technology that supports learning by providing engaging environments and tools for understanding and remembering the content. The students are at the center of learning environments that give them opportunities for taking ownership of their learning. Technology provides access to wider and more flexible learning facilitators, including teachers, parents, and mentors outside the classroom. Learning experiences can be individualized or differentiated with flexibility in content to fit the interests and prior experience of each student. Furthermore, qualitatively different learning environments offer different kinds of learning experiences and thus serve different educational goals. Past research has shown that a technology-rich learning environment can more effectively promote social-constructivist educational goals, such as higher-order thinking skills, learning motivation, and teamwork, in comparison to traditional settings (Rosen, 2009; Rosen, & Salomon, 2007). It is possible that educational technology can play a social role in bridging the achievement gap between students and in promoting higher-order thinking skills (e.g., Jackson, von Eye, Biocca, Barbatsis, Zhao, & Fitzgerald, 2006; Rosen, 2009; Rosen & Rimor, 2009; Warschauer, 2003; Warschauer & Matuchniak, 2010). One of the possible ways to achieve these effects is by implementing rich one-to-one computing in a social-constructivist learning environment among young students.

The Time To Know program (http://www.timetoknow.com) was initially developed in 2004 in response to the lack of what was seen as meaningful change in education practices and the many challenges facing schools worldwide. The program is made up of an interactive core curriculum and a digital teaching platform designed for computing classrooms. It is currently available for fourth and fifth grade math and English language arts (ELA), with planned expansion to science and additional subjects and grade levels. An online platform with teaching and learning tools provides a teacher-driven, student-centric program combined with a curriculum that meets state standards and engages students in learning.

Differentiated Teaching and Learning

There is much agreement among contemporary educators that the traditional paradigm of schooling is shifting (e.g. Creemers & Kyriakides, 2008; Hayes & Greaves, 2008; OECD, 2009). Tapscott (1997) defined the changing role of the teacher as less of an “instructional transmitter … [but] more of a facilitator of social learning whereby learners construct their own knowledge” (p. 148). He further envisioned the teacher’s role in the classroom as one where the teacher interacts with students closely in one-on-one conversations that are possible while fellow students are learning experientially through computer programs. The teacher as facilitator in these one-on-one verbal interactions is also an important element in the theory of social constructivism. The teacher as facilitator helps to define “the role of language in cognitive development through interactions with those more knowledgeable than ourselves” (Lucas & Claxton, 2010, p. 177). Recent research (Hattie, & Timperley, 2007) documents that teachers can contribute significantly to student achievement when interacting often with individual students engaged in discovery learning. The establishment of warm, positive, healthy, teacher–student relationships is crucial to promoting meaningful student engagement in the learning process (Beutel, 2010). These interactions can also promote and provide differentiation of instruction. Differentiated teaching and learning refers to providing students with different avenues to acquiring content; to processing, constructing, or making sense of ideas; and to developing teaching materials so that all the students within a classroom can learn effectively, regardless of difference in ability (Tomlinson & Allan, 2000; Levy, 2008; Heacox, 2009). In a differentiated learning environment, students are placed at the center of learning processes. Differentiation-oriented learning rests upon an active and meaning-making approach facilitated by the teacher.

Despite a broadly accepted premise that educational technology provides differentiated teaching and learning in classrooms, findings from a series of empirical studies have consistently shown only peripheral change in educational practices (Bebell & O'Dwyer, 2010; Cuban, 2001; Kerr et al., 2003; Rosen & Salomon, 2007). In most cases, the technology is designed and implemented for traditional practices, while paradigmatic change in teaching, learning, and assessment in technology-rich environments is rare. As a worldwide trend, several laptop initiatives have been started in many countries, including Australia (Newhouse & Rennie, 2001), Canada (Sclater, Sicoly, Abrami, &Wade, 2006), France (Jaillet, 2004), and New Zealand (Cowie et al., 2008). Over the past decade, there has been a growing interest in one-to-one laptop technology initiatives in the United States, whereby the teachers and the students have full access to a technology-rich learning environment (Bebell & O'Dwyer, 2010; Lei & Zhao, 2008; O'Dwyer et al., 2008; Penuel, 2006; Shapley et al., 2009; Weston & Bain, 2010; Zucker & Light, 2009). However, most of these initiatives use a technocentric approach (use of technology for technology-related activities) rather than an innovative, technology-rich learning environment conceptually designed and practically implemented as a method for paradigmatic change of teaching and learning (Cuban, 2003, 2006; Salomon & Perkins, 2005; Weston & Bain, 2010). In addition, very few studies attempt to compare evidence on return-on-investment aspects in the context of blended and traditional learning, such as possible changes in student attendance and discipline, while increasing access to educational opportunities (e.g. Figlio, Rush, & Yin, 2010).

Time To Know Program

Pedagogically, the program is designed to be implemented in a blended, teacher-driven, student-centered, computing learning environment. It consists of five main components:

- **Infrastructure:** This consists of a one-to-one laptop environment with a workstation for the teacher.

- **Interactive yearlong core curriculum:** The curriculum includes recommended sequences of interactive learning activities that are aligned with state standards. Teachers can modify these sequences by uploading their own "best practice" materials directly into the lesson flow.
- **Digital Teaching Platform (DTP):** This platform enables the teacher to plan and conduct a lesson and receive formative and summative assessment reports during and after the lessons.
- **Pedagogical support:** Every teacher who joins the program takes part in a professional development course and receives ongoing guidance from a coach who has specialized in the field of knowledge in which the teacher is working.
- **Technical support:** Technical support is available during all classroom hours in every school where the program is in operation.

The program contains a structured math and ELA curriculum of guided learning sequences for elementary schools that include open-ended applets and discovery environments, multimedia presentations, practice exercises, and games. For example, in math, the teacher opens the lesson with an animation that is used as a trigger for a specific learning topic, such as fractions. Next, a class discussion on the topic increases the curiosity of the students, who then explore the topic and perform guided experiments individually using the fraction applet. The students then submit their work to the class digital gallery, where the teacher projects the work and engages the students in a discussion.

Another example is the use of the Live Text applet to explore written text in a language arts context. The student can highlight and emphasize different parts of the text, such as words and paragraphs. The student can also use the textual navigator, which automatically emphasizes different units, such as verbs, pronouns, and emotions. The student can then review predefined "hot words" to view additional explanations or information about those words. The DTP was designed to present differentiated materials to different groups simultaneously and to support diverse learning levels for the same topic. The class may be divided into homogenous groups of students with similar mastery levels on a given topic. In this way, every student works according to his or her own ability. The program is currently implemented in more than 500 classrooms in the United States and Israel and is expanding to Europe and Asia.

Studying the effects on the teaching and learning practices of students and teachers who implemented the program in Texas in the Grand Prairie Independent School District (GPISD), as compared with those of similar background who were teaching and learning in traditional modes, was crucial to determining the efficiency and impact of the program and its one-to-one computing practices as an integral system representing a substantially new paradigm of teaching and learning in the digital age.

Research Questions

The study addressed the following research questions regarding the effects of the constructivist one-to-one laptop program:

1. What is the impact of the program on students' math and reading performance (as measured by the analyses of students standardized test performance), compared to the traditional settings?
2. What is the impact of the program on student attendance and disciplinary records (as measured through analyses of school records), compared to the traditional settings?
3. What is the impact of the program on instructional and learning practices with emphasis on differentiated teaching (as measured by classroom observations), compared to the traditional settings?
4. What is the impact of the program on student learning motivation and attitudes toward learning with computers (as measured by student surveys), compared to the traditional settings?

Method

Design and Procedure

The study was based on the mixed-methods design (Onwuegbuzie & Teddlie, 2003) and used standardized assessment scores, school records on attendance and discipline, student questionnaires, and observations in experimental and control classes. The researchers collected beginning-of-the-year data in November and December 2010 (to ensure stability of the program implementation starting from November 2010) and collected end-of-the-year data near the completion of the yearlong school program, in April and May 2011). Overall, the researchers conducted 55 one-hour observation sessions in the experimental and control classes. The district collected the achievement data as well as the school records on achievement and discipline. Both authors focused on data collection from observations and questionnaires but were not involved in program development and implementation.

Research Population

The study participants were fourth and fifth grade students and their teachers from four elementary schools from the GPISD Dallas-area district. Gender distribution was close to even. The researchers selected two experimental schools on the basis of their participation in the program for a second year. We purposely sampled two control schools to "match" the two experimental schools on the basis of known demographics (e.g., neighborhood characteristics, teacher and student characteristics) and a recommendation of the school district administrators. In all, 476 students participated in data collection (grade 4: 129 experimental and 77 control students; grade 5: 154 experimental and 116 control students) and 20 teachers (12 experimental and 8 control teachers).

GPISD student population is diverse, serving 63.1% Hispanic students, 17.6% black students, 15.1% white students, 3.7% Asian students, and 0.5% American Indian students. Toward the goal of achieving the student success described in the GPISD mission statement, GPISD and the program team conducted a collaborative study that examined teaching and learning processes in two schools that implemented the program math and ELA educational technology program for a second year, as compared to traditional teaching and learning processes found across two schools of matched comparison settings in the same district.

The total number of minutes each day devoted to the subjects of math and ELA was consistent among all schools. The experimental schools scheduled a total of 90 minutes each day for math and for ELA. The control schools also scheduled 90 minutes per day for both subjects. The time that the experimental schools scheduled for ELA was also used to teach writing separate from the program. Though a Time To Know writing program is integrated within the ELA curriculum, it was not the driver for the writing program at the experimental schools in this study. GPISD has a required writing curriculum that was implemented in all four of the study schools.

Use of the program within the scheduled math and ELA times in the experimental schools varied. Teachers who were in their second year teaching with the program tended to use the program for longer time periods and more frequently within the scheduled time than did those teachers who were learning to use the program for the first time. Content-specific instructional coaches supported the teachers' planning and implementation of the program by meeting with each teacher individually each week, meeting with teaching teams each week, observing classes, and modeling implementation techniques. The instructional coaches also provided the experimental teachers with a 3-day training session before the school year began so they could learn how to use the program. Time To Know content experts trained and funded the instructional coaches to provide a comprehensive professional development for participating teachers. Control school teachers had access to professional development through the school district. Mandatory professional development was the same for all four of the study schools. Optional professional development opportunities (e.g.,academic courses) were available for control schools' teachers as well as for experimental teachers based on teacher interest and/or administrator referrals.

Tools and Measures

The study consisted of multi-measure quantitative and qualitative tools to provide a comprehensive look at a constructivist one-to-one computing program's effects on teaching and learning practices as well as student learning achievements, as described below.

- **Learning achievement:** Math and Reading Texas Assessment of Knowledge and Skills (TAKS) 2010 and 2011 as released by Texas Education Agency (http://www.tea.state.tx.us/) were used to examine the impact of the program on student achievement. TAKS 2010 student-level scores were used as a pr-test and TAKS 2011 were taken into the analysis as posttest scores.
- **Unexcused absences and discipline:** GPISD schools systematically collect records on students' unexcused absences and discipline issues during the school year. Those records allow empirical examination of the impact of the program on return on investment–related student attendance and discipline. Specifically, a decrease in one unexcused student's absence produces a savings of $32.83 for a district/school.
- **Student questionnaire:** At the beginning and end of the school year, a research assistant asked experimental and control students to provide information about math and reading learning motivation and their attitudes toward learning with computers. Filling out the questionnaire lasted for about 15 minutes. Participants reported the degree of their agreement with each item on a 5-point Likert scale (1=strongly disagree, 5=strongly agree) on the following six items regarding learning motivation (separately for math and reading):

  1. I like math/reading.
  2. I'm usually bored in math/reading class.
  3. Math/reading is hard for me.

  The reliability (internal consistency) of the questionnaire was .76. A measure on use of the computer as a partner for learning was applied based on the following three items (1=strongly disagree, 5=strongly agree):

  1. I like to use a computer for learning.
  2. I learn more things when I use a computer than using schoolbooks.
  3. I can find better information on computers than from schoolbooks.

  The reliability (internal consistency) of the questionnaire was .72. The researchers adopted the items for the questionnaire from a previous study on educational technology initiatives and calculated a mean score measure for each domain (math motivation, reading motivation, and computer as a partner for learning), including converting negative expression items to a positive motivational scale (Rosen, 2009). This study provides further psychometric information on the questionnaire. The study, while not a pilot study for this research, is appropriate, as the researchers constructed it for another computer program within the context of elementary and secondary students.
- **Observations:** The researchers qualitatively analyzed and coded data from 55 observations on experimental and control lessons (Strauss & Corbin, 1998; Zepeda, 2009). two education graduate students independently coded

the observations scripts. The researchers assessed inter-rater reliability of coding on the basis of their judgments; inter-rater agreement reached 92%. The observation matrix was based on Heacox (2009) differentiated learning strategies. The observation tool was piloted in New York elementary school fourth and fifth grade classrooms and was adopted by this study. The matrix included the following categories:

1. One-to-one teacher-student learning interaction: Teacher-to-student learning interactions were noted as those interactions separate from any teacher-to-student interactions that occurred during teacher-to-whole-group or teacher-to-small-group presentation.
2. Interaction initiator: Every teacher-student interaction was classified by the identity of the initiator – a teacher or a student.

- **Instructional modalities:** The lesson's components were classified by the following modalities:

1. Independent learning: Opportunities for students to increase their responsibility for learning
2. Intellectual challenge (rigor): Teacher provides activities that reflect rigor that requires learners to stretch beyond their comfort zone
3. Teacher modeling: Teacher provides modeling, guided practice, and scaffolding
4. Instructional adjustment: Teacher adjusts the instruction in response to learning progress and students' interests
5. Feedback: Teacher providing descriptive feedback to the class on the learning process

Results

Impact on Learning Achievement

The results of increased achievement scores based on the TAKS tests administered in March and April 2010 (before the program) and April and May 2011 (after a yearlong participation in the program) demonstrated that fourth grade experimental students significantly outperformed the control students in reading scores (M = 621.9 compared with 665.9) and in math scores (M = 597.6 compared with 673.9). During the same period, the findings showed only a small increase in the control group (reading: M = 643.0 compared with 650.3; math: M = 611.6 compared with 660.1). Fifth grade experimental students significantly outperformed the control students in reading scores (M = 652.5 compared with 713.7) and in math scores (M = 654.7 compared with 700.6). The findings showed only a small increase in the control group during the same period (reading: M = 656.0 compared with 696.1; math: M = 646.4 compared with 674.1). Table 1 (p. 234) summarizes the results in the context of the impact on student learning achievement.

Table 1. Effects of the Program on Math and Reading Learning Achievements, as Measured by Texas Assessment of Knowledge and Skills (TAKS)

Group	Grade	Domain	Pretest (TAKS 2010) *M (SD)*	Posttest (TAKS 2011) *M (SD)*	*t (df)* Within Paired-Samples	*t (df)* Ind. Samples (Exp. vs. Control)
Experimental	4	Math	597.6 (92.0)	673.9 (83.9)	12.1** (108)	2.7**(179)
		Reading	621.9 (94.1)	665.9 (93.6)	6.1**(112)	.3.5**(183)
	5	Math	654.7 (75.9)	700.6 (78.3)	7.8** (130)	2.1*(219)
		Reading	652.5 (82.5)	713.7 (71.8)	10.1**(136)	2.2*(243)
Control	4	Math	611.6 (71.4)	660.1 (71.1)	5.7** (71)	
		Reading	643.0 (89.0)	650.3 (88.7)	1.1(71)	
	5	Math	646.4 (89.6)	674.1 (80.5)	4.6** (89)	
		Reading	656.0 (86.5)	696.1 (78.2)	5.2**(107)	

** $p < .01$, * $p < .05$

Impact on Student Attendance and Disciplinary Issues

In attempting to determine a return on investment for the district from the program, based on data supplied by GPISD, it was determined that experimental students' unexcused absences decreased, while the control students' measure increased. As a result of the program, the percent of unexcused absences reported in school records was reduced by 29.2% from the beginning to the end of the school year (240 compared with 170 unexcused absences), whereas in the control classes, the unexcused absences increased by 56.6% (228 compared with 357). These findings can be translated into a net financial impact for GPISD, saving the district $116.88 per student per school year, when taking into account the $32.83 rate charged for each student's unexcused absence.

In addition, it was found that the program reduced students' discipline issues, while the control students' discipline issues did not change. The percentage of decrease in disciplinary issues in the experimental classes was 62.5% (40 compared with 15 discipline records), whereas in the control classes, disciplinary issues decreased by 15.4% (39 compared with 33 discipline records).

Impact on Teaching and Learning Practices

The results indicated that participation in the program contributed significantly to higher frequency of one-to-one teacher-student interactions. The findings indicated that on average, 40.3 one-to-one student-teacher interactions were observed in the experimental classes during the third and fourth months of the school year (23.5 teacher and 16.8 student initiated), whereas 17.0 interactions on average were observed in the control classes (15.3 teacher and 1.7 student initiated). During the eighth and ninth months of the school year, the average frequency of teacher-student interactions was 51 in the experimental classes (30.0 teacher and 21.0 student initiated), whereas 30 interactions on average were observed in the control classes (12.0 teacher and 18.0 student initiated). An initiator's interaction analysis shows that the program's advantage in the number of interactions was achieved by a significant growth in both teacher and student initiation. In the control classes, the growth was achieved mostly by student initiation, with a low growth in teacher-initiated interactions. In 100% of the experimental classrooms, the content areas are grouped according to performance level of the students, as compared with only 29% of control classrooms.

Regarding differentiated instructional modalities, the observations findings indicated more differentiated teaching in the experimental lessons, whereas teacher modeling was emphasized among control lessons. During the third and fourth months of the school year, the observations showed that:

- Every experimental lesson implemented independent learning, compared to half of the control lessons (experimental: 100% vs. control: 50%). Examples of independent learning include those where the teacher provided opportunities for students to increase their independence, responsibility and self-management.
- Intellectual challenge teaching strategy was observed in 67% from the experimental lessons, compared to 40% in the control. Examples of this indicator describe instances within the class period, where the teacher provided activities that reflect intellectual engagement that requires learners to stretch beyond their comfort zone.
- Teacher modeling was implemented in 75% from experimental lessons, whereas it was a dominant part in all control lessons (100%). These are examples where the teacher provided modeling, guided practice, and scaffolding as appropriate. In the three experimental class observations where the teacher did not model the concepts for the students, the program was serving as an independent practice tool for concepts previously taught.
- Teachers were observed adjusting the instruction in response to learning progress and students' interests in 83% of experimental lessons vs. 30% in the control settings. These indicators occurred within a lesson when the teacher adjusted the instruction in response to ongoing learning progress.
- Teachers were observed providing descriptive feedback to the class on the learning process in 58% of the experimental settings, compared to 50% in the control lessons. Observations of this indicator included the teacher providing descriptive feedback to the class on the learning process. Findings from the eighth and ninth months of the school year indicated:

    1. Independent learning: experimental 84% vs. control 14%
    2. Intellectual challenge: experimental 63% vs. control 29%
    3. Teacher modeling: experimental 84% vs. control 63%
    4. Instructional adjustment: experimental 42% vs. control 21%
    5. Feedback: experimental 84% vs. control 85%

Table 2. Effects of the Program on Math and Reading Learning Motivation, as Measured by Student Questionnaire

Group	Grade	Measure	Pretest	Posttest	*t (df)*	*t (df)*
			M (SD)	*M (SD)*	Within Paired-Samples	Ind. Samples (Exp. vs. Control)
Experimental	4	Math motivation	3.7 (.8)	4.2 (.8)	3.6** (107)	1.4 (172)
		Reading motivation	3.6 (.7)	4.1 (.7)	3.7**(107)	3.0**(172)
	5	Math motivation	3.7 (.8)	4.1 (.8)	3.1** (125)	.7 (207)
		Reading motivation	3.3 (.9)	3.9 (.9)	5.1**(125)	2.2*(207)
Control	4	Math motivation	3.7 (1.0)	3.8 (1.0)	1.4 (65)	
		Reading motivation	3.5 (1.0)	3.4 (1.0)	-1.0(65)	
	5	Math motivation	3.6 (1.1)	3.9 (1.0)	1.3 (82)	
		Reading motivation	3.2 (1.0)	3.4 (1.1)	.8 (82)	

** $p < .01$, * $p < .05$

- Impact on student learning motivation and attitudes toward learning with computers

Table 2 shows the results on student learning motivation. The analysis indicated that both fourth and fifth grade students' learning experiences with the program positively affected motivation to learn math and reading, compared to the traditional settings.

In addition, the researchers analyzed student attitudes toward computers as tools for learning. Table 3 shows that the program positively affected student attitudes toward computers as an intellectual partner for learning, in comparison with the traditional settings.

Discussion

Researchers, practitioners, and policymakers are engaged in vigorous debate about the effectiveness and future promise of educational technology in K–12 educational systems. The goal of this study was to examine the impact of a comprehensive teaching and learning one-to-one computing environment on student achievement, discipline, attendance, and attitudes, as well as differentiated teaching and learning practices. The findings showed that learning in the program significantly increased learning achievement, reduced students' unexcused absences, and improved student discipline. The study showed that the program promoted differentiated teaching and learning in the classrooms by effectively implementing a constructivist technology-enriched model. According to the social constructivism paradigm, knowledge is not transferred from teachers to students, but is the result of collaborative activities that take place in a rich and engaging learning environment (Fosnot, 2005; Von Glasersfeld, 1995). Observations in classrooms that used the program as core curriculum and used the recommended lesson protocol, the researchers observed higher teacher-student interaction, a greater number and types of teaching models per class, more frequent and complex examples of differentiation processes and skills, more

Table 3. Effects of the Program on Attitudes Toward Computers as Tools for Learning, as Measured by Student Questionnaire

Group	Grade	Pretest	Posttest	*t (df)*	*t (df)*
		M (SD)	*M (SD)*	Within Paired-Samples	Ind. Samples (Exp. vs. Control)
Experimental	4	3.5 (1.0)	4.5 (.5)	8.9** (107)	5.0**(172)
	5	3.8 (.9)	4.4 (.6)	5.9** (125)	2.7**(207)
Control	4	3.7 (.9)	3.8 (.8)	1.5 (65)	
	5	3.9 (.8)	4.0 (.9)	.9 (82)	

** $p < .01$, * $p < .05$

frequent opportunities for student collaboration, and significantly higher student engagement.

The teaching pedagogy observed in the classrooms differed significantly from that observed in more traditional classrooms. Though the teachers in the control schools commented on their frustration with effective implementation of differentiation in their classrooms in interviews, the experimental teachers commented that they had a differentiated curriculum available at their fingertips through the program, which made planning and implementing differentiation more feasible and more consistently functional. The three-tiered model of differentiation, which differentiates content, process, and product according to the students' readiness, interests, and learning profile through varied instructional and management strategies (Tomlinson, 2000), was apparent in greater complexity and frequency in the experimental than in the control classrooms. The areas of differentiation that include rigor, teacher feedback, collaboration, and instructional scaffolding were also apparent more often in the experimental classrooms than in the traditional classrooms of the control schools. In addition, the effects of higher student attendance and fewer disciplinary actions can be perceived to impact the achievement scores and learning attitudes of students learning in the program. Overall, teachers and students report high levels of satisfaction from the program while also suggesting several aspects for program improvement.

Most of the criticism when evaluating the impact of technology on cognitive skills is related to taking assessments immediately after implementation, whereas the cumulative effect of educational technology is not sufficiently examined. This study focused on a second-year implementation of the educational technology program, showing how educational processes and outcomes can be achieved in a more stable pedagogical and technological environment. As mentioned, the National Education Technology Plan (U.S. Department of Education, 2010) calls for promoting engaging and empowering learning experiences. This study sheds light on just such effective educational practices, based on blended, teacher-driven, student-centered educational technology in one-to-one computing settings.

Recommendations for Further Research and Limitations

The research explored differences in learning practices and achievement in a context of math and reading learning. An unanswered question is whether learning in a constructivist-oriented one-to-one environment makes a difference in other contexts as well, such as science and social studies. In addition, a remaining question is whether learning with the program affects additional aspects of knowledge, skills, and competencies such as critical thinking, reasoning, and information communication technology (ICT) literacy. Taxonomy of technology for learning can potentially provide a useful framework for enrichment measurement and assessment by suggesting exploring four dimensions for innovation (Bruce & Levin, 1997; Lei & Zhao, 2008): (a) laptop use for specific learning tasks with explicit learning goals; (b) laptop use for communication, such as e-mail, instant messaging, and online chatting; (c) laptop use for expression, such as writing and publishing; and (d) laptop use for exploration, such as working on multimedia products and playing computer games.

Participants in the study were fourth and fifth grade students. It remains to be determined whether results would have been different with students and teachers in other grade levels. Regarding the factors affecting educational technology integration, previous research offers extensive lists of school- and teacher-level factors, including professional development, availability of resources and technical support, and teacher readiness to integrate technology (Inan & Lowther, 2010; Penuel, 2006). The question of scalability of the program's methodology and its educational effects to other districts and states requires large-scale research, including random participant assignment.

Author Notes

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