
The New Learning Ecology of One-to-One Computing Environments: Preparing Teachers for Shifting Dynamics and Relationships

Hiller A. Spires, Kevin Oliver, and Jenifer Corn

North Carolina State University

Abstract

Despite growing research and evaluation results on one-to-one computing environments, how these environments affect learning in schools remains underexamined. The purpose of this article is twofold: (a) to use a theoretical lens, namely a new learning ecology, to frame the dynamic changes as well as challenges that are introduced by a one-to-one laptop computing initiative; and (b) to highlight the shifting dynamics and relationships in the new learning ecology that emerging research has shown have implications for better preparing teachers and students to manage the change. The new learning ecology is an evolving attempt to create a multifaceted theoretical frame that takes into account the complexity of one-to-one teaching and learning environments. Future scholarly activity on one-to-one environments should provide coherence around research and theoretical agendas so that practitioners can better operationalize findings in their practice. (Keywords: New learning ecology, 1:1 computing, teacher preparation)

A computer in the hands of every child is no longer a farfetched idea. In fact, one-to-one laptop computing has emerged as a key context for educational innovation (Lei, Conway, & Zhao, 2007) with several states having implemented large-scale one-to-one computing initiatives. North Carolina currently has 74 middle and high schools implementing ubiquitous computing programs and participating in a statewide one-to-one learning collaborative (NCILC, 2008); it is within this context that the authors have con-

structed their perspective on one-to-one learning environments. Recent research provides a positive picture of the impact of one-to-one learning environments in terms of technology use. For example, a meta-analysis by Penuel (2006) showed positive effects on technology use, technological literacy, and writing. Similarly, Sclater, Sicoly, Abrami, and Wade (2006) reported positive impacts on secondary reading and writing scores. A recent special edition of the *Journal of Technology, Learning, and Assessment* presented four empirical studies that provided evidence of increased teacher and student engagement and modest student achievement gains (Bebell & O'Dwyer, 2010). Despite an abundance of activity, how one-to-one student laptop computing affects the broad environment of learning in schools remains underexamined. The purpose of this article is twofold: (a) to use a theoretical lens, namely a new learning ecology, to frame the dynamic changes as well as challenges that are introduced by a one-to-one laptop computing initiative; and (b) to highlight the shifting dynamics and relationships in the new learning ecology that emerging research has shown have implications for better preparing teachers and students to manage the change.

New Learning Ecology as a Theoretical Lens for One-to-One Computing

In 2009, prompted by one-to-one learning environments, Spires, Wiebe, Young, Hollebrands, and Lee introduced the idea of a new learning ecology. Building on earlier work (Barron, 2006; Brown, 1999; Greenhow, Robelia, & Hughes 2009), they used the metaphor of ecology to capture some of the teaching and learning dynamics that are apparent in the one-to-one setting. More

than a decade ago, John Seeley Brown (1999) introduced a knowledge ecology by using the definition of “an open system, dynamic and interdependent, diverse, partially self-organizing, and adaptive” (p. 3). He claimed that the evolving technology landscape was prompting a different way of perceiving knowledge and, by association, learning. More recently, Barron (2006) provided additional contextual specificity to the concept by defining a learning ecology as the “set of contexts found in physical or virtual spaces that provide opportunities for learning,” which may include formal and informal settings (p. 195). In light of the presence of the Read/Write Web, Greenhow, Robelia, and Hughes (2009) referenced a learning ecology perspective as useful in conceptualizing learning and teaching across Web 2.0 spaces of home, school, work, and community. Ecological systems theory harkens back to Bronfenbrenner (1986; 1989), who claimed: “The ecology of human development is the scientific study of the progressive, mutual accommodation throughout the life course between an active, growing human being and the changing properties of the immediate settings in which the developing person lives” (p. 188). A key assumption of Bronfenbrenner’s theory—and one that applies to the contemporary educational setting infused with technologies—is that the environment can both affect and be affected by the person’s dispositions and actions.

Building on these previous views of ecology in relationship to learning, Spires et al. (2009) defined a new learning ecology as an emergent concept, which involves a set of unique conditions for teaching and learning that include: (a) immediate and constant

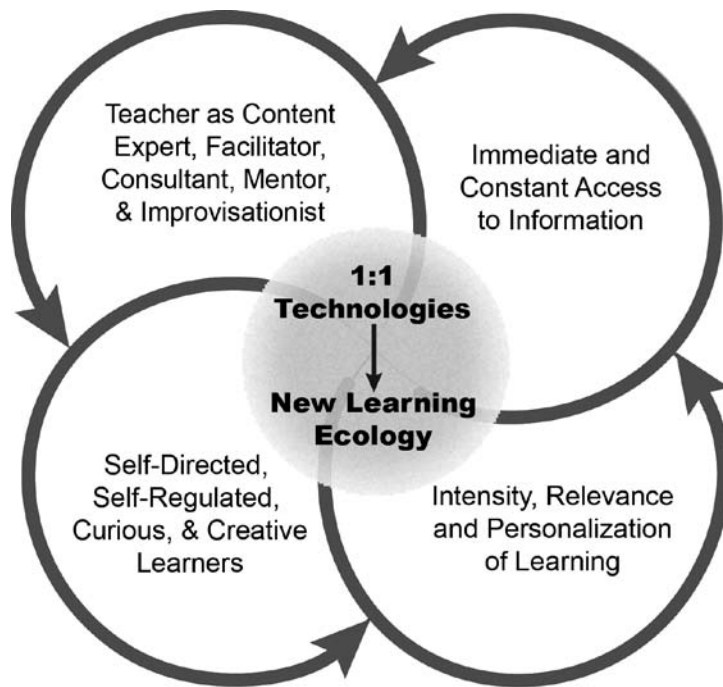


Figure 1. The four conditions of the new learning ecology in one-to-one settings. (Used with permission: Spires, H., Wiebe, E., Young, C., Hollebrands, K., & Lee, J. [2009]. *Toward a new learning ecology: Teaching and learning in one-to-one learning environments.* Friday Institute White Paper Series. NC State University: Raleigh, NC. Available at <http://www.fi.ncsu.edu/podcast/white-paper-series/2009/04/22/toward-a-new-learning-ecology/>)

access to information and a global community; (b) intensity, relevance, and personalization of learning; (c) highly developed student dispositions for self-direction, self-monitoring, creativity, and curiosity; and (d) highly developed teacher capacities for facilitation, improvisation, consulting, and mentoring (see Figure 1). This type of ecology, which is dynamic rather than static, provides a range of learning contexts for students as technological affordances are leveraged for ongoing learning actions.

Results from a research study that sought to investigate how and to what degree the four preceding conditions were instantiated in the one-to-one classroom revealed that the teachers in the study leveraged access to information in very different ways (Lee, Hollebrands, Spires, Young, & Wiebe, under review). The findings illustrated the utility of the new learning ecology as an emerging theoretical context for research within and across disciplines and for re-evaluating existing findings of technology infusion in instructional settings. Specifically, in reference to

condition 2, all four teachers in the study engaged in some tension with the notion of the personalization of learning. In the new learning ecology, we suggested that the use of one-to-one laptop computers with constant and immediate access to information and teacher and learning dispositions supporting self-directed, self-regulated, and creative learning would be coupled with increased personalization, relevance, and intensity in learning. The National Educational Technology Plan (2010) refers to personalization as “instruction that is paced to learning needs, tailored to learning preferences, and tailored to the specific interests of different learners” (p.12). Lee, Hollebrands, Spires, Young, and Wiebe (under review) indicated that in many instances, the one-to-one environment in the classroom pushed teachers toward instructional personalization through triage, or the sorting and prioritizing of students’ needs, rather than through the teachers embracing personalization as a vehicle for instructional transformation.

Based on the research results of Lee, Hollebrands, Spires, Young, and Wiebe (2011) as well as additional evaluation results of the NC1LC (2008), Figure 2 conceptualizes an expanded ecological view of one-to-one environments. In this conceptualization, referred to as new learning ecology 2.0, the emphasis shifts from teaching and learning at the classroom level to a broader view of the ecological system in which a one-to-one initiative abides. The new learning ecology 2.0 is important for teacher educators, as it projects the changing roles and relations teachers need to be prepared for in contemporary schools.

We envision the new learning ecology 2.0 as an evolving theoretical and conceptual model that will change as one-to-one environments become more pervasive and as they continuously adapt with emerging technologies. As a starting point to provide additional grounding for the model, we have conducted a review of existing literature that provides insights into the changing relations at various levels within the ecology, with implications for better preparing teachers and students to manage key changes.

Current Research and the New Learning Ecology 2.0

Ecologies involve relations between organisms and their environment. When one-to-one computing is infused into a school ecology, many researchers have reported changes in school-level relations between teachers, between students, and between teachers and students. Less common but perhaps no less important are changing relations among teachers, students, and other levels of the ecology as community, pedagogy, and the context are accessed and leveraged differently under one-to-one computing conditions, resulting in increased student learning. This section highlights research findings to illustrate the types of changing relations teachers and students begin to initiate and/or work to incorporate when their ecology is tipped with one-to-one computing. The researchers have used the New Learning Ecology 2.0 framework to sort findings, beginning with changing relations at the

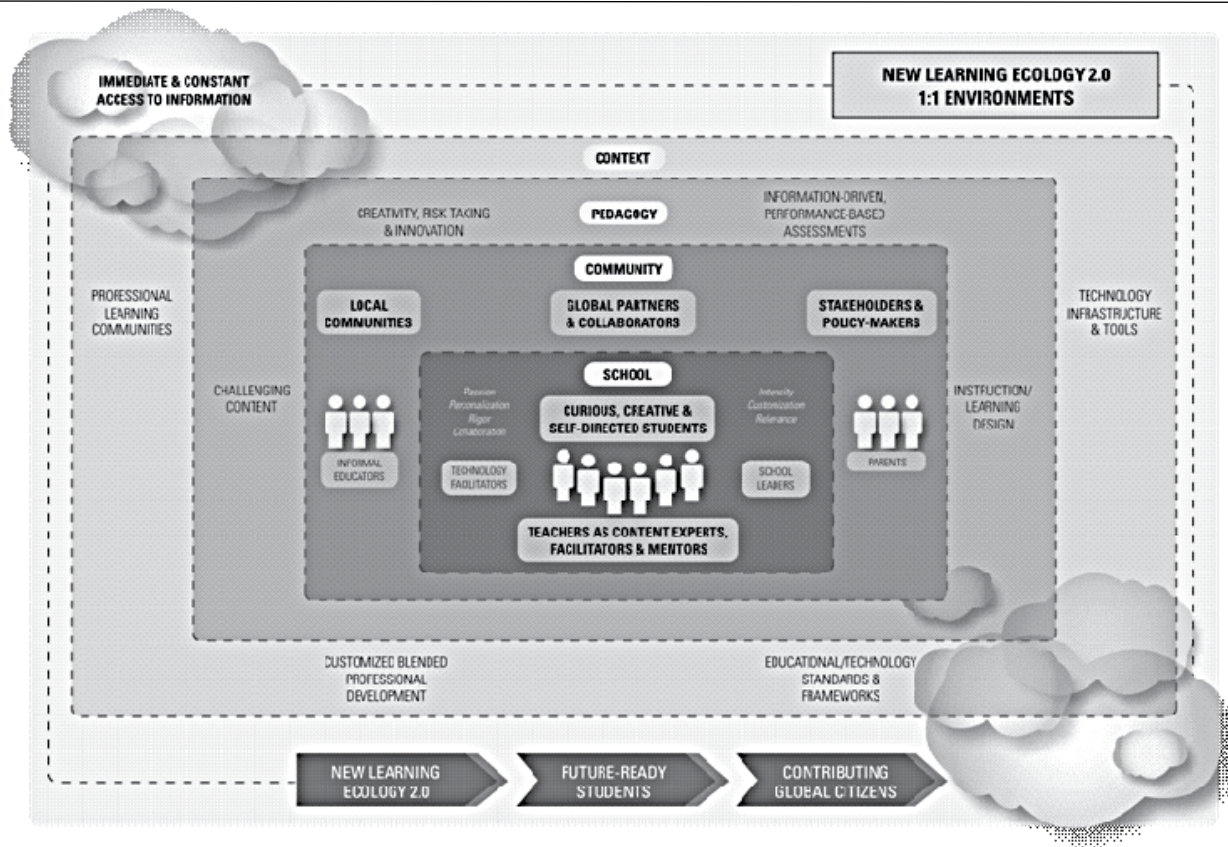


Figure 2. New Learning Ecology 2.0. diagram. (Created by a Friday Institute working group comprised of Hiller Spires, John Lee, Kevin Oliver, Verna Lalbeharie, Emmy Coleman, Eric Wiebe, Jeni Corn, and Lee Sartain)

school level, and extending to changing relations between the school and community, pedagogy, and context. This article places emphasis on the changing relations teachers and students face while acknowledging that other “organisms” in the school ecology likely face additional changes beyond the scope of this paper (e.g., technology facilitators, media coordinators, principals).

Changing Relations at the School Level

Relationships that change under one-to-one computing conditions within the school level include those between students, between students and teachers, between teachers, and between teachers and administrators. Several studies of one-to-one computing have reported on changes in student–student communication. Increased student–student communication may stem from available tools and purposeful pedagogy. Lei and Zhao (2008) reported that middle school students regularly used discussion boards in the ASPIRE course management

system to ask questions and critique one another in activities such as mathematical proofs. Students also quickly learned to use a variety of communication tools such as e-mail and chat for both formal school communication and informal peer communication. Mouza (2008) reported increased peer interaction in elementary laptop classrooms stemming from cooperative, project-based work. Dunleavy, Dextert, and Heinecke (2007) detailed student asynchronous and synchronous communication fostered by a collaborative poetry writing project. Using online tools for communication reduced management issues and encouraged further collaboration than similar offline tasks as well as increased students’ merging and revising of texts. The authors noted, however, that teachers must prepare and clearly articulate instructions for complicated group tasks or risk procedural confusion among learners.

The amount of increased student–student communication varies widely by study. For example, less than half of

the teachers in a multischool pilot study of one-to-one computing reported that student collaboration with peers had increased, but a majority (69%) reported traditional students had increased in their “ability to work independently” (Bebell & Kay, 2010, p. 25). Increasing student–student interaction may involve purposeful pedagogical choices, so as to ensure that student dialogue is productive rather than detrimental to the learning process. For example, Donovan, Green, and Hartley (2010) reported student off-task behaviors in a middle school one-to-one laptop program (e.g., discussing topics other than the one assigned, using computers for unassigned purposes). They promoted the notion that off-task behaviors were less harmful to the learning process in one-to-one classrooms with constructivist, project-oriented tasks, as students could still finish assigned work over the extended project period. In one-to-one classrooms where teachers assigned more low-level worksheets

or research-oriented assignments due at the end of the day, off-task behaviors were suggested to be more detrimental.

Studies of one-to-one computing also report increased student-teacher interaction. Knowing each student has a laptop allows teachers to create websites for communicating classroom information, and students in one-to-one laptop programs have reported one of their most frequent computer activities involves accessing teachers' websites for course-related information (Bebell & Kay, 2010). Knowing that students have laptops also allows teachers to design more inquiry-based, cooperative, and active-learning environments (Lowther, Ross, & Morrison, 2003), for which teachers must be prepared to take on more facilitative and communicative roles. In addition to changes in communication around classroom activities, Mouza (2008) described increased interactions between students and teachers around technical support, as teachers grew to rely on their tech-savvy students for assistance when computer issues arose. In such situations, students expressed pride over being able to help their teacher. Lei and Zhao (2008) reported that laptops increased opportunities for students to ask questions of their teacher, particularly for students who might have been shy in class. Almost all of the 28 middle school teachers in their study (96.4%) believed laptops helped them communicate with students. Laptop programs even extend student-teacher communication outside of the traditional school day, such as teachers helping students with homework using synchronous communication tools like instant messaging (Bebell & Kay, 2010). In one-to-one programs, teachers may need to set office hours or parameters for after-school communication to effectively manage this increased potential for contact. Peer groups or whole-class wikis where students can post their questions could help to distribute responsibilities.

Considerable research has reported on increased teacher-teacher communication in one-to-one initiatives. These new interactions will be detailed in the forthcoming section on "changing

relations between school and context," as increased teacher-teacher communication usually centers on professional development and structured teacher planning. In a one-to-one computing study across 21 middle schools, the extent of teachers' technology integration was associated most heavily with collective teacher buy-in for one-to-one computing ($r = .67$), thus structures for teacher preparation and mutual support seem especially important to stimulate (Shapley, Sheehan, Maloney, & Caranikas-Walker, 2010).

Finally, studies of one-to-one computing have reported necessary changes in communication from administrators to teachers, usually in the form of administrators encouraging teachers to adopt the innovation. Leaders may have the strongest role to play in terms of building buy-in among staff, which is critical, given that Shapley et al. (2010) reported higher levels of technology immersion in schools where teachers collectively bought into the innovation. Dexter and Seashore (n.d.) reported on six technology-intensive school cases and noted that effective school leaders conveyed trust for teachers and encouraged teachers to experiment and take risks with technology without fear of repercussions. Further, Shapley et al. hinted at leadership behaviors that might constitute a changed relationship between teachers and leaders, including "involving staff in decisions," and "encouraging and participating in professional development events" (p. 24). Also, Donovan, Green, and Hartley (2010) suggested that leaders might limit variability in technology use across classrooms by adopting consequence policies for students not bringing laptops to school (i.e., if teachers could expect all students would have their laptops, they could plan more technology-infused lessons accordingly). Detrimental leadership behaviors, on the other hand, include micromanaging with restrictive rules and security measures (e.g., Internet blocking), which tend to frustrate teachers (Drayton, Falk, Stroud, Hobbs, & Hammerman, 2010). Also, it is difficult to obtain teacher buy-in, if school

leaders fail to convey a compelling rationale for one-to-one computing. Teachers in one school implementing one-to-one computing were less willing to adopt classroom technology because they tied the initiative to unpopular accountability efforts (Drayton et al., 2010).

Changing Relations between School and Community

Some argue that the relations between the school and the community are the most important to foster in support of a one-to-one computing program, yet these relations are often minimal. Laptops have been reported to increase teacher communication with parents by e-mail (Bebell & Kay, 2010; Lei & Zhao, 2008), but the nature of this communication is unclear and may simply be one-way teacher reporting of grades rather than two-way discussions of laptop use. Changing relations also include parents and students together attending laptop orientations where care, safety, and operations of the laptop are discussed, as well as rules for appropriate use and consequences for damages (Donovan, Green, & Hartley, 2010). Schools typically establish policies related to students taking laptops off campus, which might involve parents signing responsibility waivers and/or purchasing low-cost theft or damage insurance. In summarizing a number of one-to-one computing studies, the Abell Foundation (2008) reports that most "states and districts have engaged parents only to guarantee supervision of the equipment" (p. 19). Penuel et al. (2002) summarized technology programs with an aim of connecting home and school, noting that data were typically available only regarding parental perceptions of technology programs, not regarding how parents were actually involved in student learning. A few studies have reported parental involvement in student learning, but they are rare. For example, Lei and Zhao (2008) reported parents in a study of one-to-one computing at a northwestern middle school increased in the time spent "working with their children on their homework and on their computers," although it is unclear why that may have been the case (p. 114).

Weston and Bain (2010) outline a more extensive, six-step process to engaging an entire community (i.e., teachers, students, school administrators, and parents) in framing the purposes and rules for one-to-one computing in a school and providing feedback on how the program is working over time. Rather than assuming individual teachers will adopt the innovation consistently and appropriately, or that parents will understand how they can contribute to the program's success, designing a "shared conceptual framework for practice" better ensures that all members of the community will play their necessary roles for one-to-one computing to truly become "systemic and ubiquitous" (p. 13).

Adopting a community-based focus for one-to-one computing is clearly a challenging task, as demonstrated by research evidence. In a study of 21 Texas middle schools implementing one-to-one computing, Shapley et al. (2010) reported only minimal uses of computers in the home for school-based activities or homework. Perhaps teachers were not assigning homework, or parents were not encouraging at-home academic pursuits. Also according to Shapley et al. (2010), 71% of schools reported only partial parental and community support after 4 years of implementation. In another one-to-one study at a middle school, however, a sizeable percentage of students (81.4%) reported using laptops for homework (Lei & Zhao, 2008).

Parental support is important, as they share equipment responsibility and can encourage or guide their children to use computers appropriately. Community support is important from businesses that might contribute additional funding and volunteers to support one-to-one projects, and from global partners (experts, collaborating schools) that might contribute to shared projects with students.

Changing Relations between School and Pedagogy

In explaining "the case for ubiquitous computing," the Abell Foundation (2008) notes that one-to-one computing programs are ultimately intended

to improve academic achievement by changing instructional methods to be more student-centered, to require higher-order thinking, and to teach 21st century skills such as "information-gathering, communication, and problem-solving" (p. 2). The potential changes that one-to-one computing brings to pedagogy is significant, but not necessarily consistent across schools or initiatives.

Teachers report increased access to teaching materials (Bebell & Kay, 2010), but this also presents new demands, as teachers must locate and evaluate new online tools and resources that constantly change in terms of features, structures, and possibly fees (Drayton et al., 2010). Drayton et al. (2010) lists a number of resources teachers can leverage when students have regular access to computers. For example, online images, video, and animations are more visual and can be more engaging than traditional texts. Students can access more interactive applets, apps, and simulations, and such tools can be beneficial to an understanding of processes in subjects such as science. Students can also access virtual labs for an interactive experience that might otherwise be unavailable due to concerns over lab safety, expense, or difficulty in setting up, although science teachers in their one-to-one computing study used such tools sparingly.

Across numerous studies, students report increased access to information sources and increased use of the Internet to research and look up information (Bebell & Kay, 2010; Drayton et al., 2008; Lei & Zhao, 2008; Shapley et al., 2010; Suhr, Hernandez, Grimes, & Warschauer 2010). In some studies, students use secondary tools such as Inspiration to organize their research findings into conceptual structures such as concept maps (Mouza, 2008).

In one-to-one computing studies, students and teachers report increased student use of software tools for creating products (e.g., webpages, multimedia, storybooks, timelines) (Bebell & Kay, 2010; Lei & Zhao, 2008; Mouza, 2008; Suhr et al., 2010). Mouza (2008) compared two elementary teachers who used

laptops to two elementary teachers who did not use laptops in the classroom. She noted that the laptop classrooms were better able to sustain extended project-based learning, whereas the nonlaptop classrooms spent most of their computer time doing word processing.

In a one-to-one computing study at the fourth and fifth grade levels, Suhr et al. (2010) reported students were frequently seen writing and reviewing papers with word processing tools. Mouza (2008) reported students preferred to write with word processing tools, thus access to laptops might increase student enthusiasm for writing-based activities.

With laptops, Drayton et al. (2010) notes that students have increased access to extended data sets they can use in math, science, and other studies, and they have access to software tools to analyze and visualize the data, although science teachers in their study rarely assigned analysis activities with tools such as spreadsheets. Mouza (2008) reported that the laptop-based activities were designed by two elementary teachers, who had students conduct polls, analyze data with spreadsheets, and graph results.

Studies show teachers with access to the same technology resources and tools integrate technology in very different ways, and the differences may have less to do with subject areas than with individual teachers. For example, math and science teachers used technology less than other subject-area teachers in one study (Bebell & Kay, 2010), but math and science teachers used technology more than other subject-area teachers in another study (Oliver, Corn, & Holcomb, 2008). In some studies that focus on one subject area, such as science, results show significant differences in teacher use of technology (Drayton et al., 2010). Donovan, Green, and Hartley (2010) developed innovation configurations to describe technology uses and student-teacher relations across 12 seventh grade classrooms implementing one-to-one computing. Three configurations emerged that suggested varied uses of the technology across the school day, depending on who is teaching and/or who is being taught. In the fourth

year of the Technology Immersion Pilot in 21 Texas middle schools, 76% of teachers “reported only partial levels of classroom immersion,” with 5% reporting minimal immersion (Shapley et al., 2010, p. 27).

Perhaps owing to these differences in integration, it is not surprising that achievement gains are also sporadic across studies. The Abell Foundation (2008) summarizes findings from state- and county-based one-to-one computing initiatives that report increased writing scores in Maine but no increases in other assessment areas; increased math scores in Texas but no increases in reading with inconclusive results in other subjects; and increased scores on world history, biology, reading, and chemistry state tests in Virginia, but only among students “who used laptops the most frequently” (p. 12).

Weston and Bain (2010) reference Larry Cuban’s view that it is not the one-to-one technology that will make a difference in student learning, but rather teacher pedagogy and informed usage of cognitive tools. Although there is the potential to integrate the new pedagogy described in this section in support of increased student learning, individual teachers will make that decision, given varied constraints such as time, preparation, and curricular demands. For ideal levels of integration, teachers will require systematic support from the multiple levels depicted in Figure 2 (e.g., professional development and technical support from the context level, proper management and teacher–teacher support structures from the school level). As noted by Silvernail and Buffington (2009), providing access to one-to-one computing technology is really just the first step toward transformed instruction and learning. The changing interactions described in the next section have a lot to do with the type of pedagogy that teachers take up in one-to-one computing programs.

Changing Relations between School and Context

Several contextual considerations must be taken into account when planning

one-to-one computing initiatives, including professional development, software and hardware purchases, peripheral and secondary purchases, and technical support. Research has shown that failure to tend to any of these contextual variables can subdue an entire laptop initiative.

Clearly challenges in keeping up with the rapid pace of technological change exist, as “technology resources often have a particularly short shelf life compared to traditional educational resources” (Bebell & Kay, 2010, p. 53). Teachers likely require ongoing professional development to learn both the technical aspects and pedagogical benefits of emerging tools. Teachers report that professional development works best when it focuses not only on how to use the functions of new tools, but also how to integrate new tools into the curriculum (Bebell & Kay, 2010). Cox and Hanson (2009) recommend teachers design lesson plans before laptops ever arrive, focusing first on their curricular standards that allow for a technical approach.

Teachers in a study by Drayton et al. (2010) desired professional development that included interaction with other teachers, both inside and outside of their own school, to learn from other teachers’ experiences. Mentoring from peer teachers, technology facilitators, or professional trainers, however, occurred rarely or never among teachers in 21 Texas middle schools piloting one-to-one computing (Shapley et al., 2010). In contrast, Dexter and Seashore (n.d.) describe six exemplary school cases where professional community was sustained over time, resulting in effective technology integration. Schools adopted various training models, including district-level technology trainers and school-based technology facilitators who co-planned with teachers, grade level teams who attended training and co-planned lessons together, and peer coaches who were trained in integration and then paired with another teacher to co-plan technology activities.

In some cases, school leaders have provided for incentives, such as extra pay or a teacher laptop, for time spent

after school in professional development courses (Dexter & Seashore, n.d.). At least some one-to-one laptop schools have paid teachers to attend professional development courses at universities (Lei & Zhao, 2008). To ensure that motivated teachers used the computer equipment well, Dexter and Seashore (n.d.) describe one district where teachers had to complete a program of unpaid training before they were awarded a two-to-one student-to-computer classroom.

Beyond professional development, school leaders in charge of purchase decisions for software and hardware must ensure that their new purchases can fundamentally change educational practices; otherwise, new technology will just require further training and time expense for teachers and students and replace existing practices with only more technologically advanced equivalents:

... books replaced by webpages, paper report cards with student information systems, chalkboards with interactive whiteboards, and filing cabinets with electronic databases. None of these equivalents addresses the core activity of teaching and learning. Each merely automates the practices of the prevailing paradigm. (Weston & Bain, 2010, p. 10)

A study of one-to-one computing in a middle school illustrates this point, as the most commonly reported use of laptops was electronic note-taking in place of handwritten note-taking: “Instead of carrying a pile of paper notebooks for the different subjects, students now carry their laptop ‘notebook’ from one classroom to the next and use programs such as Microsoft Word, Word Perfect, Notepad, and even PowerPoint to take notes” (Lei & Zhao, 2008, pp. 106–107). Although this switch reportedly helped students with organization and basic technology skills, the pedagogy was not fundamentally changed.

Bebell and Kay (2010) reported widespread differences in peripheral devices, such as projectors and printers, across multiple schools

implementing one-to-one computing, and these differences were obstacles to changes in teaching. Drayton et al. (2010) also reported differences across three schools implementing one-to-one computing in the use of classroom interactive whiteboards. Also noted were differences in school intranets that impacted teaching capabilities, with one school providing an elaborate intranet for teachers, students, and parents, to present content and resources and to communicate student records. Another school provided teachers only with drop boxes on a server to store resources, leaving teachers to set up their own external websites and students to e-mail themselves files for retrieval at home.

Drayton et al. (2010) reports that technical problems in a one-to-one computing environment can “in some cases have substantial impact on teachers’ attitudes and actions about the innovation” (p. 40). Computing problems that may seem minimal may in fact sway some teachers to abandon technology adoption efforts (e.g., limited battery life, frequent crashes, unreliable wireless connection). Shapley et al. (2010) likewise noted a relationship between schools with only partial one-to-one implementation and technical issues (e.g., technical problems not resolved quickly, Internet connectivity inadequate, computers not kept operational).

A final contextual consideration is the availability and distribution of the laptops themselves. One commonly reported barrier to technology use was students not bringing laptops to class or not having laptops to use in class if their equipment was out for repair or not functioning. In such cases, teachers had to improvise and/or provide individual students with separate classroom activities. Shapley et al. (2010) indicates that some schools in that pilot study took laptops out of students’ hands and put them on carts for more consistent distribution, but the authors indicate that this revised model of distribution did not lead to increases in using laptops in the classroom and most certainly took away any opportunities to use laptops in the home for learning.

Implications for Teacher Preparation

As reviewed in this article, there is evidence that in one-to-one environments, changes take place at the school level, between school and community, between school and pedagogy, and between school and context, each with implications for teacher preparation.

At the school level, as teacher and student relations begin to shift in one-to-one environments, it appears that overall communication tends to increase. One key implication on teacher preparation is the need to understand how to effectively leverage a range of student–student and student–teacher communication modes enabled by one-to-one computing for peer learning and instructor support. Professional development on communication strategies supported in one-to-one programs, as well as tools available to enable the strategies, will help introduce teachers to new possibilities and technical requirements to carry them out. For example, teachers might be shown strategies to increase student–student communication, such as cooperative or project-based learning, and introduced to tools such as small-group discussion boards, private chat rooms, group concept maps, and file sharing to support requisite interactions and collaborations. Teachers might also be shown strategies to increase student-to-instructor feedback, such as classroom assessment techniques gathered at the beginning or end of class (e.g., background knowledge probe, one-sentence summary, muddiest point) (Angelo & Cross, 1993). A variety of Web tools are now available to quickly gauge student comprehension and adjust teaching, such as Wallwisher and Lino, for students to post notes/thoughts on a virtual bulletin board, or Socrative and Poll Everywhere for students to respond to teacher questions via their laptops.

In the new one-to-one ecology, teachers should be prepared not only to foster communication among and with students, but also with school leaders as part of shared decision-making. Shared decision-making could involve: using online research tools or networks to identify software, hardware, and

professional development to supplement an initiative; conducting onsite research at more advanced one-to-one schools to determine best practices for orientation and deployment, appropriate policy statements, adequately protective laptop bags, and infrastructure requirements; using polling and survey tools to gather stakeholder input or evaluate the initiative; or employing presentation tools to share or disseminate a program vision (e.g., a teacher wiki, a community webpage). Nearly every one-to-one school we have visited involves teachers on planning teams or committees to help administrators make key program decisions. Teachers who are prepared through professional development to employ a range of research and dissemination tools will be more efficient in these roles that are supplemental to their teaching. Overall, when teacher–administration communication and collaboration is lacking, inefficient implementation of one-to-one computing can result.

Between school and community, the most prevalent changes have resulted in increased e-mail communication between teacher and parents and increased responsibility on the part of parents in terms of protecting equipment. The primary implication on teacher preparation is the need to understand how to move beyond mere grade reporting to parents or parental underwriting of equipment to more actively involving parents and the community in promoting student learning activities and defining a vision for using computers. Creating community bonds must be thoughtfully planned and not left to chance (Addison & McGee, 2010). School planning committees can be trained to employ a number of research-based community engagement strategies. For example, asset mapping is a process of listing community resources that could potentially support a program on three levels: individuals, civic organizations, and institutions such as local community colleges and small businesses (Griffin & Farris, 2010). Asset mapping has been shown to help organizations identify and strengthen partnerships to benefit youth (Crane & Skinner, 2003).

To foster community ties, teachers may also benefit from professional development on curricular models that tap local and global partners for rich interactions with students. For example, Bouillion and Gomez (2001) describe a school-community model called Mutual Benefit Partnerships with four design features: (a) “real-world” community-based problems, (b) a school-community or school-business partnership, (c) problem-based learning, and (d) student-developed products that are beneficial to partners. The use of real local problems of shared interest and mutual benefit contribute to an active exchange between students and experts in the field. Teachers can also be introduced to a range of Internet projects that are available to connect students with peers and experts, such as the popular GLOBE program, in which students collect scientific information, contribute to a shared global database, and collaborate on analytical projects (Ou & Zhang, 2006). Further, teachers can be trained to leverage social media tools such as Twitter for e-mentoring of students through posted messages, shared resources, and discussions around educational topics (Whiteman, 2009). Engaging with partners via Web tools supports the need for access to mentors while accommodating the skills and comfort of youth with technology (McArthur, 2010).

Between school and pedagogy, the research results have been inconsistent, indicating benefits (i.e., increased and more rapid access to information, improvement in the ability to interact with others, opportunities to visualize and interact with information in new ways), but also presenting increased challenges (i.e., time investment in learning new technologies, high costs, technical difficulties, access to all students). Teacher pedagogy appears to be the most critical factor in ensuring that one-to-one initiatives are implemented in effective ways, yet teachers tend to integrate computers differently based on available time and preparation with likewise sporadic gains in achievement. The primary implication for teacher preparation is encouraging

all teachers to effectively integrate new technologies without damaging buy-in under challenging conditions. In our evaluation work with school districts implementing one-to-one computing in North Carolina, administrative staff recommend not pressuring teachers to integrate technology where it doesn't fit or changing at an uncomfortable pace by requiring the integration of a dozen new tools at program implementation. They do, however, recommend a few “non-negotiables” such as requiring teachers to post lessons, content, and assignments in a course management system for student/parent access, and describing how they use technology in their lessons with a goal of adding a few new resources or tools to their repertoire each term. Initial teacher training on a few “core” tools, such as a course management system, will ensure that each teacher has a platform on which to build his or her expertise. Another strategy that one-to-one schools in North Carolina have employed to bring along less tech-savvy teachers involves “tech buddies” or advanced teachers paired with struggling peers to resolve questions quickly and relatively confidentially without damaging teacher buy-in. Schools we work with also recommend training on classroom management to promote more consistent integration. Often one of the biggest teacher concerns in one-to-one schools is the ability to manage a more open classroom environment. Teachers with management concerns tend to integrate laptops less or not at all, so initial professional development on management strategies (e.g., asking students to shut their laptops or turn them away when the teacher is giving a presentation, using monitoring software) can help promote teacher confidence.

In terms of changing relations between school and contextual variables, such as new instructional software, new supplemental hardware (e.g., interactive whiteboards, projection systems), and updated school infrastructure (e.g., Internet access, file storage, filtering), the primary implication for teacher preparation is the need for targeted professional development on specific systems

and tools. Clearly the biggest contextual impact on teachers in one-to-one environments is an increase in professional development needs in general. As already noted in this section, teachers in one-to-one environments may benefit from training on strategies and tools to enhance communication with students, collaborate and plan with peers, better engage with their community and global resources, manage and distribute course materials online, and effectively manage an open classroom. Time available to teachers for learning new strategies and tools is clearly limited, so diversifying the sources of professional development may help teachers find sources of information that fit their learning conditions and comfort levels (e.g., live/recorded, online/print, self-paced/group, expert/peer). Sources of teacher knowledge are plentiful, including: books and periodicals; online tutorials and webinars; online courses; formal workshops led by lead teachers, technology facilitators, or guests from other one-to-one schools; professional learning communities where subject-area teams co-plan and learn together; and informal tips picked up from peers. Administrators in one-to-one schools we have visited note that peer-to-peer sharing is one of the most effective sources of teacher ideas.

Another key change in context that teachers in one-to-one environments must be prepared to manage relates to increased technical problems. Not every one-to-one school can afford a full-time technical assistant, so unfortunately responsibilities often get passed to teachers, technology facilitators, and media coordinators. One-to-one schools we have evaluated in North Carolina help teachers manage increased technical challenges through varied solutions: using synchronous tools such as Skype to call on peer teachers for immediate help, using asynchronous tools such as a shared Google Doc or wiki to post a question and wait on a response from a technical assistant or peer teachers, or setting up a physical help desk in the school staffed by a technology assistant and/or tech-savvy students to field teacher questions. It may also be helpful to take one school's approach and establish a chain

of response, so teachers and students know where to take their questions and any broken equipment, with these technical problems passed up a chain until it reaches a person who can resolve it.

Conclusion

The purpose of this article was twofold: (a) to use a theoretical lens, namely a new learning ecology, to frame the dynamic changes as well as challenges that a one-to-one laptop computing initiative introduces; and (b) to highlight the shifting dynamics and relationships in the new learning ecology that emerging research has shown have implications for better preparing teachers and students to manage change.

The new learning ecology (1.0 and 2.0) is an evolving attempt to create a robust theoretical frame that takes into account the complexity and fluidity of a one-to-one teaching and learning environment. New learning ecology 1.0 provided an initial view that one-to-one environments prompt new conditions that enable immediate and constant access to information; intense, relevant, personalized learning; highly developed learner dispositions; and highly developed teacher capacities. New learning ecology 2.0 includes the conditions found in 1.0, but the emphasis shifts solely from teaching and learning in the classroom to a broader view of the ecological system in which a one-to-one initiative abides. New learning ecology 2.0 widens the lens to include additional factors that comprise and affect the one-to-one environment.

The National Educational Technology Plan (2010) asserted that “all students and educators will have access to a comprehensive infrastructure for learning when and where they need it” (p. 21). The authors of the plan refer to infrastructure as people, processes, and technologies for learning. Most educators believe that the challenge for our education system is to leverage technology to design learning experiences that mirror students’ current and future lives, or, as Bransford et al. (2006) asserts, learning should be lifelong, lifewide, and available on demand.

New learning ecology 1.0 and 2.0 provide a lens for educators to begin understanding the complex conditions and dynamics that take place in one-to-one learning environments with implications for better preparing teachers and students to manage these demands. Current research supports some elements of the diagram depicted in Figure 2. Additional research is needed to further articulate the relationships and changes that take place over time so that educators can embrace the necessary changes for teaching and learning to thrive in this ecology.

Author Notes

Hiller A. Spires is a professor and senior research fellow at the Friday Institute for Educational Innovation in the College of Education at North Carolina State University. She teaches in the New Literacies & Global Learning graduate program and co-directs the New Literacies Collaborate (<http://newlit.org>). Her research focuses on the effects of digital literacies on learning, including emerging literacies associated with gaming environments and Web 2.0 applications. She is a co-principal investigator on the National Science Foundation-funded projects *Crystal Island* (<http://www.intellimedia.ncsu.edu/videos/CI5-yearTwo-video.html>) and *Narrative Theatre*, which focus on game-based learning. Please address correspondence regarding this article to Hiller Spires, Friday Institute for Educational Innovation, College of Education, North Carolina State University, Raleigh, NC 27695. E-mail: hiller_spires@ncsu.edu

Kevin Oliver is program coordinator and associate professor of instructional technology at North Carolina State University, where he teaches graduate courses on technology integration, multimedia, videography, and instructional design. His primary research interests include Web-based learning environments, distance education/virtual schooling, and digital history. He earned a PhD in instructional technology from the University of Georgia and a MEd in educational media and instructional design from University of North Carolina—Chapel Hill. He serves on the editorial board of the *Journal of Digital Learning in Teacher Education* and as a consulting editor for *Educational Technology Research and Development*. Please address correspondence regarding this article to Kevin Oliver, College of Education, 602K Poe Hall; Box 7801; Department of Curriculum, Instruction, and Counselor Education; North Carolina State University; Raleigh, NC 27695-7801. E-mail: kevin_oliver@ncsu.edu

Jenifer O. Corn, PhD, is the director of evaluation programs at the Friday Institute for Educational Innovation at North Carolina State University and serves as principal investigator of several large, statewide evaluation and research studies of innovations in K–12 schools and districts, including leading the evaluation of initiatives funded under North Carolina’s *Race to the*

Top grant. Her research interests focus on leadership, professional development, teaching and learning, infrastructure, and evaluation for technology-enhanced innovations in public school settings. Please address correspondence regarding this article to Jenifer O. Corn, Director of Evaluation Programs, Friday Institute for Educational Innovation, College of Education, North Carolina State University, Raleigh, NC 27695. E-mail: jocorn@ncsu.edu

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