



Toward a *New Learning Ecology*: Teaching and Learning in 1:1 Environments

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The mission of the Friday Institute is to advance education through innovation in teaching, learning, and leadership. Bringing together students, teachers, researchers, policy-makers, educational professionals, and other community members, the Friday Institute is a center for fostering collaboration to improve education.

As we progress into the 21st century, our work focuses on preparing students for success in work, life, and citizenry in the global, knowledge-based, technology-rich, culturally-diverse, rapidly-changing world in which they will live. This task requires helping schools become future-oriented organizations that build upon their traditional strengths while updating curriculum content, teaching practices, management approaches, and technology tools to best serve the students of today and tomorrow. For more information, visit www.fi.ncsu.edu.

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Executive Summary

As the nation's economy continues its irrevocable shift from manufacturing toward idea-driven, creative industries, our schools—and the teaching and learning enterprise at the heart of our schools—need to undergo a transformation as well. The result of such a transformation needs to be a type of educational experience and expertise that will not only support but also ignite participation in—and leadership for—an idea-driven, creative economy. Equally important as supporting a new economy is educational experience and expertise that supports a global citizenry.

Our work begins with three foundational assumptions. We believe that the teacher is the single most important factor in determining student success; that professional development needs to be an integral, ongoing part of teachers' lives; and that our educational system must be transformed to support and ignite both an idea-driven economy and a global citizenry. Given this foundation, we see professional development as key to producing teacher leaders who will not only continue to impact student achievement, but also help to transform classrooms and schools for the 21st century.

Considerable research has focused on professional development models, which, in turn, has led to agreement on a number of key principles of successful practices for K-12 educators (Darling-Hammond, Wei, Andree, Richardson, and Orphanos, 2009; Saato and Darling-Hammond, 2008). These principles provide a broad design for how to conduct professional development for teachers. However, they do not address directly the 1:1 learning context, that is, the classroom in which every student and teacher has a mobile learning technology device with access to the Internet. With this focus in mind, the two specific purposes of this white paper are to articulate the unique conditions—that is, a *new learning ecology*—prompted by 1:1 environments, and to propose five key strategies that leverage the new learning ecology within 1:1 environments that can then be included in professional development systems for 1:1 teachers.

We believe the 1:1 environment is prompting a new learning ecology, which we describe through four unique conditions:

- Immediate and constant access to information and a global community;
- Intensity, relevance and personalization of learning;
- Highly developed teacher capacities; and
- Highly developed student dispositions.

As a result of these conditions, we have proposed five strategies for consideration to be included in 1:1 teacher professional development. These strategies are:

- Technological pedagogical content knowledge (TPACK);
- Project-based inquiry;
- A global skill set;
- Performance-based assessment; and
- Professional learning communities and networks.

These strategies take into account the new learning ecology of the 1:1 environment. Equally important, they can help create a new learning ecology for teachers' professional development—one that supports teaching and learning for our increasingly interdependent global age. Technological tools and information are not always educationally productive. Educators must provide leadership in creating new models for the teacher to act as facilitator, coach, mentor, and even improvisational artist within the new learning ecology—always with an eye on the larger aims and purposes of education. President Obama has boldly stated that we must “transform our schools . . . to meet the demands of a new age.” We believe that a critical aspect of educational transformation is ongoing teacher professional development aligned with an evolving learning ecology that is prompted by 1:1 learning technologies.

Toward a *New Learning Ecology*: Teaching and Learning in 1:1 Environments

***“We will transform our schools...
to meet the demands of a new age.”***

*President Obama’s Inaugural Speech
January 20, 2009*

These words are not new; many have said them before. As we experienced the historical significance of President Obama’s inauguration, however, we have renewed hope and sense of purpose that school change and transformation are within reach. North Carolina State University’s Friday Institute for Educational Innovation is uniquely positioned to play a pivotal role in the creation of the next generation of schools through the *North Carolina 1:1 Learning Technology Initiative*.

The ideas in this white paper are set forth within the context of 1:1 learning environments, that is, classrooms in which every student and teacher has a mobile learning technology device and access to the Internet. We developed the ideas within North Carolina’s dynamic environment for educational change.¹ In North Carolina, 1:1 teacher professional development systems are being designed in light of the NC State Board of Education’s dual goals of producing students who are globally competitive and ensuring that all students are led by 21st century professionals. The work of the *North Carolina 1:1 Learning Technology Initiative* (Corn and Osborne, 2009) supports North Carolina’s educational goals by emphasizing the need for every student to have ready access to a mobile learning technology device and the Internet.

Our work begins with three foundational assumptions:

- The teacher is the single, most important factor in determining student success.
- Professional development needs to be an integral, ongoing part of teachers’ lives.
- Our educational system must be transformed to support and ignite both an idea-driven economy and a global citizenry.

Professional development is key in producing teacher leaders who will continue not only to impact student achievement, but also help transform classrooms and schools for the 21st century.

Considerable research has been conducted on professional development models, which, in turn, has led to agreement on a number of key principles of successful practices for K-12 educators (Darling-Hammond, Wei, Andree, Richardson, and Orphanos, 2009; Saato and Darling-Hammond, 2008). These principles provide a broad design for how to conduct professional development for teachers but do not address directly the 1:1 learning context.

With this focus in mind, the two-fold purposes of this white paper are to articulate the unique conditions—that is, *a new learning ecology*—prompted by 1:1 environments, and to propose five key strategies that leverage the new learning ecology within 1:1 environments that can then be included in professional development systems for 1:1 teachers. If we are to understand the challenges and possibilities for contemporary professional development, we must first understand the changing nature of learning for today’s students. Therefore, the next section paints a picture of a new learning ecology prompted by 1:1 environments.

¹ This white paper was written within the context of the NC 1:1 Learning Technology Initiative, North Carolina’s Response to the Framework for Change (2008) and E-Learning Commission Report (2009), and the broader national and global demand for educational transformation. Specifically, the American Recovery and Reinvestment Act of 2009 provides unprecedented opportunity for educational systems to change by providing important funding for schools. It ushers in a new era of innovation in American education.

A New Learning Ecology Prompted by 1:1 Environments

The key feature of 1:1 instructional contexts is that *each* student and teacher has access to a mobile learning technology device² and the Internet. As a result of this initial access, students and teachers have ready access to vast amounts of information and tools for communication, such as instant messaging, email, desktop video conferencing, wikis, and blogs. They can be more productive, using computer applications for word processing, spreadsheets, and the like. They gain more outlets for creativity, including generating multimedia presentations, producing digital videos, and utilizing design software. They also benefit from various types of teaching and learning that these resources make possible.

We qualify the word *access* here, because we know that simply having access to information and tools does not necessarily mean that the access will result in productive teaching and learning outcomes. Nevertheless, if each student has a mobile learning technology device and access to the Internet, the conditions for learning are fundamentally altered.

As Zucker and Light (2009) point out, computers are different than other technologies used in schools because they are “all-purpose machines” (p. 84). They can be used as a library, a museum, or a production studio to create knowledge artifacts in a variety of modes and media types. They can also be combined with other technologies (e.g., cameras, probes, digital calculators, telescopes, microscopes) to engage in focused educational endeavors. There is some evidence that allowing students to work with laptops can be effective in urban, under-privileged schools (Mouza, 2008). Given the effects that computers have in the classroom, high quality and well-designed teacher professional development initiatives become even more crucial for 1:1 learning environments.

Constant access to tools and rich information in the 1:1 classroom creates *a new learning ecology*, in which information and ideas are abundant, in flux, and constantly evolving. Destabilization of information and knowledge is a critical factor within the contemporary learning environment, creating opportunities for new ways for students to be engaged and educated. John Seeley Brown, who has written eloquently on the concept of knowledge ecologies (1999), defined an ecology as “an open system, dynamic and interdependent, diverse, partially self-organizing, and adaptive” (p. 3). More recently, Barron (2006) defined a learning ecology as the “set of contexts found in physical or virtual spaces that provide opportunities for learning,” which may include formal, informal, and non-formal settings (p. 195). Building on these definitions, we offer a perspective for a new learning ecology that takes into account the unique contributions of a 1:1 setting—a learning-forward environment that takes on organic attributes with evolving interdependence among participants.

We visualize a new learning ecology in which learning is multi-directional and multi-modal. Learning, idea exchanges, and inquiry all take place within a dynamic system among *students, teachers, and a global community*. The system becomes open and dynamic as a direct result of 1:1 computing and access to the Internet. Because the teacher is no longer the gatekeeper or proprietor of classroom information and knowledge, student dispositions and skills are challenged to evolve in order for students to take advantage of the human interdependence within the learning ecology. Interdependence among teachers and students is amplified, since they must rely on each other for critical information and perspective. No one person possesses all the skills and knowledge—including knowledge about the technology or the content—needed to function within the new ecology. Instead, a collective intelligence, one that results from individuals and communities working with ideas and information, is leveraged (O’Reilly, 2006). Not unlike the way flora and fauna rely on each other to grow and thrive within an ecosystem, students, teachers, and members of the larger global community rely on each other within the ecology to support learning, and most notably *processes and products of inquiry*. Learners negotiate the inquiry process and draw on the unique conditions of the learning ecology for support as they consider ideas and pose questions, analyze and synthesize information, evaluate

Learners negotiate the inquiry process and draw on the unique conditions of the learning ecology for support as they consider ideas and pose questions, analyze and synthesize information, evaluate and revise, and ultimately share, publish, and act on new knowledge.

² 1:1 learning environments refer to a 1:1 ratio of mobile learning technology devices with Internet access for teachers and students. While the laptop computer currently is the most prevalent device for achieving this type of environment, we recognize that there are many different types of devices that can constitute a 1:1 environment. For the purposes of this paper, however, our emphasis is on the 1:1 ratio of student and teacher to device rather than the type of device.

and revise, and ultimately share, publish, and act on new knowledge.

Figure 1 illustrates four unique conditions, albeit tacit, that are prompted by the new learning ecology of the 1:1 environment:

- Immediate and constant access to information and a global community;
- Intensity, relevance and personalization of learning;
- Highly developed teacher capacities; and
- Highly developed student dispositions.

We discuss each of these conditions and demonstrate how they are applied within a classroom context.

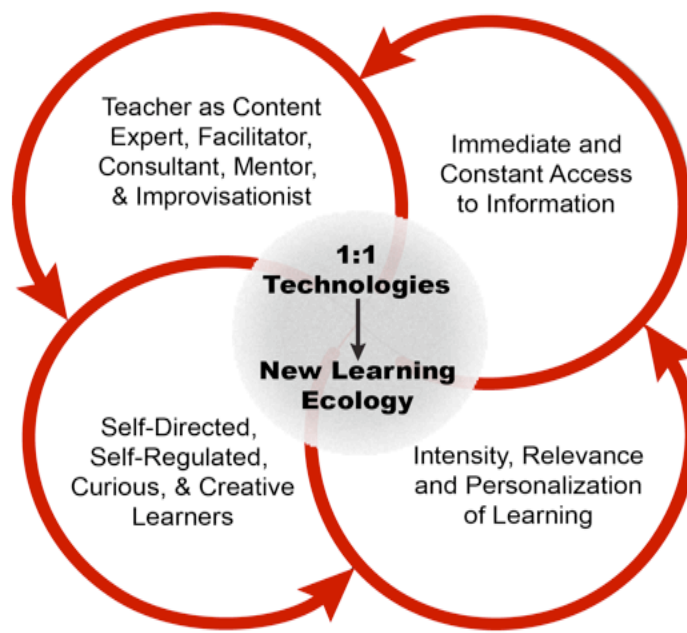


Figure 1. Four unique conditions prompted by the *new learning ecology* in the 1:1 classroom.

Immediate and Constant Access to Information and a Global Community

Teachers and students alike stand to benefit from such 21st century standards and skills as innovation, creativity, problem-solving, and collaboration promoted by the Partnership for 21st Century Skills (P21, 2004), the International Society for Technology in Education (ISTE, 2008), and many other organizations, including the NC State Board of Education (2008; Dede, 2009b). Teachers and students in 1:1 classrooms have the distinct advantage of *immediate and constant access to information and a global community*—including communication, productivity and creativity tools. In a 1:1 environment, teachers do not have to wait to schedule the computer lab or have students take turns using a few computers in the classroom.

Obviously, the addition of ubiquity within the classroom does not in and of itself add value; rather, it is how the ubiquity is applied in the overall design for learning.

For example, in a 1:1 math class, students have constant access to technology tools for gathering and sharing information, visually and interactively exploring mathematical objects and relations, formulating conjectures, creating justifications or proofs, and presenting findings to peers. Imagine the following scenario: The bell rings, students walk into the classroom, start up their computers, go to the course wiki to see what conjectures were posted by peers last evening related to an investigation about the medians of a triangle. Some of the conjectures posted include: 1) The medians intersect in a single point; 2) The point of intersection is always in the interior of the triangle; 3) The medians divide the triangle into six smaller congruent triangles of equal area; and 4) The point of intersection divides a median in a ratio of 1:2. Students begin placing their names next to particular conjectures on the wiki, form subgroups in class, move their desks and huddle with their teams to gather data using a dynamic geometry program to confirm or refute the selected conjecture. Some conjectures are easy to disprove by finding contradictory evidence; others seem to be true, but it is not clear why. Another is true in some types of triangles but not others, so the conjecture needs to be refined to be true.

The teacher circulates around the classroom, listens to students' conversations, and interjects key questions for students to consider so they are looking at all relevant cases. As she notices students reaching conclusions, she focuses their attention back to the front of the room where she displays a student's computer screen from one of the groups working on the first conjecture. The group members use the smart board to demonstrate different triangles they considered and note that the medians will always intersect. Another group member says she searched the Internet and found several sources that named this point the "centroid." A third group member uses coordinate geometry to demonstrate that the medians of any triangle will always intersect in a single point. Some students are unclear about this aspect of the proof, and group members offer explanations.

In this situation, students are clearly engaged in learning. They have tools that enable them to develop conjectures, and in this community they are encouraged to refine, prove, or disprove the conjectures created by classmates. This activity mirrors the activity of mathematicians, who often begin by exploring a problem and then create conjectures, seek evidence that confirms or disproves those conjectures, and build formal justifications that they communicate to peers.

The new wave of Web 2.0 tools gives students constant and immediate access to information. It also provides them with authoring capabilities to create, mash up, comment on, and edit content, and allows them to communicate with people globally. We know that when students are out of school, their digital connectedness and production is pervasive; this has been documented nationally (Lenhart, Madden, Macgill, and Smith, 2007) as well as locally in North Carolina, including students from low-income families (Spires, Lee, Turner, and Johnson, 2008). It is well established that more than one billion people use the Internet globally, and more than half of them live outside the United States and Europe. More than 2.7 billion people use mobile phones. Social networking sites are expected to grow beyond 90 million within the next year. These trends are staggering. Perhaps more staggering, however, is that our schools are typically among the last places to take advantage of what these digital opportunities afford for learning.

Intensity, Relevance, and Personalization of Learning

The second condition of the new learning ecology within a 1:1 setting is the potential value of increased *intensity*, *relevancy*, and *personalization of learning*. These new variables come into play as education shifts to a more learner-centric dynamic—with potentially higher levels of student performance and achievement. If teachers in 1:1 classrooms teach with the explicit assumption of access, what do they do differently? There are many answers to this question; however, central to the pedagogical shift in the 1:1 class is that teachers empower students to rely on the ubiquitous availability of technology to search and acquire information, critically evaluate information,

creatively synthesize information, and generate innovative ideas and products as well as craft solutions to problems.

In the new learning ecology, students engage in what John Dewey referred to as *productive inquiry*, which is to “actively pursue a problem, puzzle, point of fascination, object of wonder, or the like” (Little and Ray, 2005). We would argue that the new learning ecology is not simply conducive to productive inquiry, but indeed, demands it. For example, if class time is no longer spent on receiving content solely from the teacher and, if content is readily available and idiosyncratic to each learner, then inquiry becomes the necessary catalyst to transform the learning process so that information found is converted into new knowledge. Likewise, since information is abundant and often provisional until validated, inquiry again becomes essential as the learner sifts, sorts, and critiques information en route to new ways of knowing and of solving problems.

If every student has a computer and access to the Internet—and an effective teacher—the intensity, relevance, and personalization of the intellectual work becomes more palpable.

Technology tools can actually serve as an extension of student thinking and learning, with students literally tapping into endless *networks of imagination* (Senges, Brown and Rheingold, 2008). 1:1 environments provide a place to explore ideas, pursue research questions, test hypotheses, compose thoughts, and draw conclusions. In addition, there is a much more varied and robust discursive community—facilitated by the technology—in which these ideas, conjectures, solutions, and questions can be presented and cogitated. Students are not engaging in activities in which their singular goal is to build up a repertoire of static knowledge and skills to be used later; rather students become part of an extended participatory community of learners in which the focus is on authentic and productive inquiry and active meaning-making. Active learning in these terms results in significance for students.

Michael Wesch (2008) defines learning as the ability to create significance and distinguishes between *semantic* and *personal significance*. Semantic significance means understanding that “a word, concept or idea is not just meaningful for what it is, but also for how it relates, connects, and contrasts with other words, concepts, and ideas” (2008, video lecture). Personal significance, Wesch claims, connotes that meaningful connections are created in the social interaction with others and through the individual’s process of learning to become a successful, contributing member of a community. Although there is a nuanced difference between the two types of significance, both relate to creating significance with information for the individual learner and, in the 1:1 environment, both provide the terms for enhancing community.

The 1:1 environment has the potential to promote authentic learning, enabling students to create both semantic and personal significance with academic concepts in the context of the world around them.

For example, in an English Language Arts class, rather than lecturing about Alan Paton’s Cry, the Beloved Country, teachers can engage their students in organizing a global book club with students in South Africa and India. Based on personalized interests, students can collaborate virtually to create a multimedia inquiry project prompted by themes in the book and the ways in which the themes relate to students’ respective lives and cultures. Students focus on different parts of the project based on their interests, existing skill sets, and academic goals. For example, several students across countries may collaborate and generate an analysis of societal structures that led to apartheid in South Africa and colonization in India. Other students may focus on Paton’s unique use of literary devices and explore how they support the themes of the book. Yet another group might compare and contrast the themes and events in the novel to the film, The Power of One. The teacher’s role becomes one of facilitator, coach, and consultant. She may make resources available, including literary-related content, technology tools, and outside experts) for the students’ inquiry project. She could teach students how to set up a Ning for their project to promote worldwide visibility. Or she might challenge students’ assumptions about racial prejudice and encourage them to take an activist stance for tolerance in their community as well as on the global stage.

In this English Language Arts learning scenario, the lesson could have been accomplished in a computer lab or with two or three classroom computers. However, if every student has a

computer and access to the Internet—and an effective teacher—the intensity, relevance, and personalization of the intellectual work becomes more palpable. In English Language Arts, the use of the technology to support participatory learning illustrates a paradigm shift from knowledge as didactically transferable content to knowledge as socially processed and constructed. It also reflects a shift emphasizing the importance of “being multi-literate across a range of various dialects, cultural spaces, and semiotic forms” as students engage in learning in which they “communicate across cultures (and sometimes across languages), largely in spaces mediated by technology” (Young, Hicks, and Kajder, 2009, p. 71).

The 1:1 classroom environment inspires an intensity derived from the spontaneous nature of active learning, collaborative problem solving, and innovative thinking. The classroom becomes an imaginative marketplace of ideas and one node in a dynamic network that will motivate and energize students to be curious, productive, and innovative.

Highly-Developed Teacher Capacities

Within the new learning ecology, teachers must have *highly-developed capacities for facilitation, improvisation, coaching, and consultation*. Teachers must make a pedagogical shift to accommodate learning that is continuous, changing, and—above all—exponential. Before the onset of the knowledge society, the teacher’s role was to transmit a relatively stable body of knowledge and skills to students who would then use it for predictable academic and professional careers. Tom Carroll (2007) asserts that “Teaching 2.0” is emerging in response to a 21st century convergence of forces that includes a knowledge-based global workforce, an evolving understanding of how people learn, and a widespread adoption of collaborative teamwork in the workplace. Teaching in the modern era is customized to individual learning needs, where teachers and students co-create meaning and significance out of a wide range of possible learning experiences. They pursue these experiences within a new learning ecology that is dynamic and fluid. One role of the teacher is to navigate the learning terrain by engaging students in worthy, time-honored concepts and ideas while simultaneously valuing the individual nature of each learner.

As a discipline, science demands highly-developed teacher knowledge, including knowledge associated with high-level concepts, and the tools and processes that will allow students to develop scientific ways of thinking.

For example, a science teacher may design a lesson to teach the concept of deforestation. Deforestation is a major issue in many of the tropical and subtropical parts of the world where forests are being cut down for the value of their trees, for agricultural uses, and for housing development. Deforestation contributes to greenhouse gas emissions and, therefore, to the problem of global warming. While the teacher may not recall all the detailed facts related to deforestation, she knows this is a topical issue directly related to certain key science content standards and likely to engage her students. She establishes highly functioning teams based on her knowledge of her students’ dispositions. She makes them responsible for collecting data on a forested region of the world. They are to determine the nature of the deforestation over the last 20 years: How much land was cleared? Where was it cleared? How is the land being used now? They also need to determine the contribution of deforestation to greenhouse gases.

Prior preparation allows the teacher to provide her students with an initial set of resource links, to make the students responsible for finding additional sources of information, and to enable them to justify the quality and relevance of the information they find. She coaches and guides students to likely locations of useful resources in the form of text, numbers, photos, video, and people. She helps them apply and continue to develop their abilities to make sound judgments in evaluating and synthesizing this information. In addition to the Web browser, the teacher suggests the students use image processing software such as Image/J to make measurements on satellite photos, spreadsheets for organizing and graphing data, and various presentation software tools. While she does not know the latest versions of all these software tools inside and out, she has a sense for their general capabilities and usefulness. She also has a strategy for helping students help each other (and her) learn the necessary techniques in a “just in time” fashion. As part of

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their culminating presentations, students report on what alternatives governments and non-governmental organizations are pursuing to slow the rate of deforestation. Carefully reading the dynamics of the discussion, the teacher decides to extend the time for presentations when it becomes clear that her students have brought together an exciting mix of data and alternative interpretations worthy of an additional day of deliberations.

Highly-Developed Learner Dispositions

A final condition for the new learning ecology prompted by the 1:1 environment is *highly-developed learner dispositions*. Increasingly, learners are described in terms of their dispositions and worldviews, rather than as people who are experts in a particular content area. Additionally, personalized learning takes place outside the classroom in a variety of settings and dynamic modes (Bull, Thompson, Searson, Garofalo, Park, Young, and Lee, 2008). The recognition of learning as a social practice that evolves around peoples' interests (Jenkins, Clinton, Purushotma, Robinson, and Weigel, 2006) suggests the need to be intentional about how we situate students in a learning environment. Ideally, in a 1:1 classroom, the learner will be disposed to the learning process in ways that leverage the ecology of the environment. Learning is viewed not simply as obtaining information from an authority figure, but rather "more as a self-directed process with increasingly greater levels of responsibility and commitment" being generated from the learner (Dede, 2009b; P21, 2009). Obviously, all students do not enter the classroom with highly developed monitoring skills and academic self-direction intact, so teachers must take on the role of coach and mentor to help develop these learner dispositions.

A critical stance toward evaluating information and the credibility of online sources is one essential learner disposition in the 1:1 classroom.

For example, the mere availability of Wikipedia in the social studies classroom in some ways turns upside down generations of assumptions about authority and information. With access to Wikipedia, answers to simple and uncontested questions are likely to never be left unanswered. Wikipedia extends the range of possibilities for students who are seeking information on common topics, but also raises questions about knowledge authority in the classroom. Wikipedia is at root a socially-constructed resource and a knowledge community, but in most academic circles it is often devalued and afforded little privilege (Davidson, 2007). When students have access to Wikipedia, the teacher loses some control over which interpretations about the past are valued and over which messages are injected into the classroom culture. But on a simpler level, Wikipedia's open authoring platform results in uneven content quality and requires that students using the resource be more critical in their considerations of content.

Given the conditions that frame Wikipedia as a source of information in the social studies classroom, students need critical dispositions to enable them to make effective use of the information. Although some Wikipedia articles are trustworthy, there are no obvious signs on a Wikipedia article to signal for students when the content should be trusted. Students need to approach using resources such as Wikipedia with a critical eye and an overriding desire to first determine the trustworthiness of the information. Such an approach to using information in the classroom is quite different than traditional uses of information where students are told that the information they receive is correct and not subject to challenge.

Being disposed toward self-direction and monitoring will enable students to critically engage information from not only Wikipedia, but also virtually any online resource. These skills include understanding bias, evaluating reliability, and determining the accuracy of information (Leu, Corio, Castek, Hartman, Henry, and Reinking, 2008). Such skills can be taught in the classroom, but students need self-direction and motivation to apply them. When students use Wikipedia, they cannot rely on the teacher or some other source of authority to vet the materials. Instead, students must take the initiative and apply the critical filters they have learned in the classroom. Furthermore, students will come to school with a wide range of dispositions already in place. Teachers must assess their students' dispositions and provide targeted support for further development in order for the student to fully take advantage of the new learning ecology of the 1:1 learning environment.

Learning is viewed not simply as obtaining information from an authority figure, but rather "more as a self-directed process with increasingly greater levels of responsibility and commitment" being generated from the learner.

In this section, we presented the idea of a new learning ecology that is being prompted by 1:1 learning environments. In an attempt to describe the new learning ecology, we proposed four unique conditions that include:

- Immediate and constant access to information and a global community;
- Intensity, relevance and personalization of learning;
- Highly-developed teacher capacities; and
- Highly-developed student dispositions.

We illustrated each condition with a discipline-based learning scenario to provide concrete examples of how it is applied within a classroom context. Building on the theoretical and practical conditions of the new learning ecology, we now present implications for teacher professional development.

1:1 Teacher Professional Development: Five Strategies for Consideration

In this section, we first review the most current literature on teacher professional development. Next, we propose five promising strategies to be included in 1:1 teacher professional development. These five strategies take into account the new learning ecology that is evolving as a result of the 1:1 learning environment. We argue that these strategies can contribute to a new learning ecology for professional development for teachers.

Review of Research-Based Principles for Professional Development

Teachers need the same types of intellectual challenges and encounters with complex problem-solving scenarios that we want them to design for students.

Educators and policy-makers alike have long recognized the necessity for providing high-quality and challenging learning opportunities that enable teachers to transform teaching and learning in the classroom. In a recent report, *Professional Learning in the Learning Profession* (2009), Linda Darling-Hammond and her colleagues assert that we need to place a greater priority on strengthening the capacity of educators and on building learning communities to deliver higher standards for all students. Specifically, they cited countries like Finland and Sweden as models, where ongoing teacher education is a top priority with impressive results. The report states that in these countries, students achieve more, teachers are retained in the profession longer, and educators are given more freedom and responsibility for what happens in their schools. Analyzing and synthesizing research results from over the past decade, the authors set forth four principles of effective professional development (PD). According to Darling-Hammond, et al. (2009, pp. 9-11), it should:

- Be intensive, ongoing, and connected to practice;
- Focus on student learning and address the teaching of specific curriculum content;
- Align with school improvement priorities and goals; and
- Build strong working relationships among teachers.

Research on PD has demonstrated time and again that occasional workshops do not support substantive change in the way a teacher teaches. Interestingly, Yoon, Duncan, Lee, Scarloss, and Shapley (2007) found that it takes as much as 30 to 100 hours of PD spread over six to 12 months in order to demonstrate a significant positive effect on student performance. Perhaps even more important than the duration of PD sessions is the quality of the learning experiences within those sessions. Teachers need the same types of intellectual challenges and encounters with complex problem-solving scenarios that we want them to design for students. In fact, one well-known study demonstrated that having teachers experience the same content and learning cycle they expected of their students led to higher student performance (Merek and Methven, 1991).

In 1:1 settings, professional development and ongoing support is critical for teachers as they redesign, recontextualize, and contemporize their instructional practices to take full advantage of available technologies. Those who design PD for teachers in a 1:1 environment should carefully consider the five unique conditions of a new learning ecology previously discussed as well as the four major principles that Darling-Hammond and her colleagues derived from a substantial body of research.

Teacher professional development comes in many forms. School systems often offer professional development that is aligned with curricular goals being advocated by the system. Innovative educational programs in North Carolina, like the New Schools Project,³ the IMPACT Project,⁴ and SAS Curriculum Pathways⁵ offer customized professional development that directly supports the types of change processes and related instruction being implemented by the program. Graduate programs for teachers increasingly are being aligned with state curricular goals so these contexts can also be considered professional development for teachers. For example, NC

³ <http://newschoolsproject.org>

⁴ <http://www.ncwiseowl.org/impact>

⁵ <http://www.sascurriculumpathways.com>

State University's College of Education has created a graduate concentration, *New Literacies and Global Learning*.⁶ In-service teachers enter the program with a compelling question that they address through a project-based inquiry process for the duration of the program. The teachers create a final product of learning which they share as a multimedia project in a Design Studio Virtual Showcase. Teachers continue to share their professional insights and challenges after they graduate through an online Ning environment.

Regardless of what group hosts the PD or whether PD is delivered as individualized, self-paced online instruction, online video instruction, cohort-based instruction, or face-to-face instruction, five promising strategies need to be considered when working with teachers in 1:1 environments. Although these strategies can be applied in other learning settings, they hold particular promise for 1:1 settings, since they directly leverage the conditions of the new learning ecology.

Five Strategies for Professional Development for Teachers in 1:1 Environments

Within the context of the research-based principles of effective professional development proposed by Darling-Hammond and her colleagues, we offer five promising strategies to be used with teachers in 1:1 classrooms. These strategies have emerged from our professional development work with teachers participating in the NC 1:1 Learning Initiative. All five strategies leverage the new learning ecology prompted by 1:1 environments:

- Technological pedagogical content knowledge (TPACK);
- Project-based inquiry;
- A new global skill set;
- Performance-based assessment; and
- Professional learning communities.

The strategies intersect at different levels within a PD experience. The first strategy is conceptual and is used heuristically. The second, third, and fourth strategies relate to curricular content and pedagogies. The fifth strategy relates to ongoing support systems for PD. We argue that the concept of the new learning ecology also applies to how teachers need to be engaged in professional development through professional learning communities and networks. We will discuss each of these five strategies and explain how they support the new learning ecology of the 1:1 classroom.

Strategy One: Engaging Teachers' TPACK

The Technological Pedagogical Content Knowledge (TPACK) model can be used as a theory-to-practice heuristic during professional development sessions with teachers as they make necessary pedagogical shifts to take advantage of the new learning ecology in the 1:1 classroom. Koehler and Mishra (2008) claim that effective teaching with technology requires TPACK, or an ability to integrate content, pedagogy, and technology flexibly during the act of teaching. (See Figure 2.) They argue that teaching with technology is a "wicked problem" with solutions being difficult to realize because of "complex interdependencies among a large number of contextually bound variables" (Koehler and Mishra, 2008, p.9). Central to understanding Mishra and Koehler's TPACK framework is the capacity to separate the three components (i.e., content, pedagogy, and technology) while at the same time understanding that the components co-exist in a dynamic transactional relationship. For example, when a new technology is introduced, teachers are forced to "reconstruct the dynamic equilibrium among all three elements" (p.18). Often teachers begin with their disciplinary content as they make TPACK transactional exchanges. As specific pedagogical approaches and technologies enter the equation, teachers must balance competing demands and carefully consider what is lost and gained. Ultimately, the pedagogies and technologies should complement one another and intensify students' opportunities to construct content knowledge.

⁶ <http://www.cednlg.wikispaces.com>

...pedagogical growth should be a primary goal and student learning should be a consistent outcome.

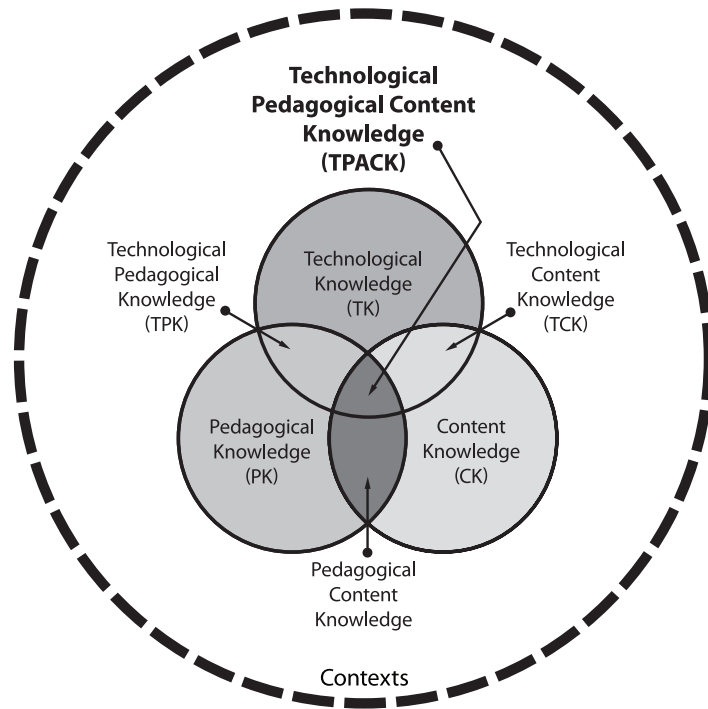


Figure 2. Technological Pedagogical Content Knowledge (TPACK) from Koehler & Mishra (2006).

As Harris et al. (2009) reveal, there has been comparatively little research that helps to put TPACK into practice for teachers and teacher educators. However, the 1:1 environment provides the optimal context for professional development of this kind. In 1:1 environments, teachers often seek professional development related to new technologies. As 1:1 programs mature and teachers acquire more experience in the new environments, the entry points might be content or pedagogy. The current reality is, however, that for most teachers, the act of receiving the computers causes a pedagogical disruption. For example, in situations where all students have computers, teachers may initially ask simple questions: What can I do in my social studies class now that students have continual access to Google maps? What can I do in my math class now that all students have access to Excel and can create a scatter plot? It is important to note that with such examples, content or pedagogy could easily drive the use of technology, but realistically, most teachers will begin with the technology.

Within the environment of TPACK-informed professional development, teachers can work thoughtfully in concert with their colleagues and PD facilitators to devise powerful strategies for classroom instruction. As Mishra and Koehler encourage, TPACK-framed professional development can lead to teacher-centered design experiments. Much as with engineering design problems, teachers are working within a bounded solution space where they can learn to assess the capabilities and constraints of a technology and how it furthers a teaching goal. This design process should be overt and a key goal for PD and can take a number of forms. A design experiment can take the form of a series of iterative mini lessons within the context of a single PD session facilitated by PD instructors. A design experiment can also take the form of extended action research projects in the classroom led by teachers and supported by PD instructors. In all design experiment activities, pedagogical growth should be a primary goal and student learning should be a consistent outcome.

In addition to addressing TPACK as an integrated theory, different combinations of the key elements of technological, pedagogical, and content knowledge reveal details as to how TPACK might inform PD. For example, pedagogical content knowledge (PCK) focuses on illustration and formulation of concepts to be taught and learned. The pedagogical techniques required include an understanding of what makes concepts easy or difficult to learn combined with an

understanding of students' prior knowledge. Technological content knowledge (TCK) represents the reciprocal relationship between technology and content. Emerging technologies make possible accommodating ways to navigate content. Educators need to be aware of their content as well as the ways technology can improve the delivery of that content. TCK will often be more discipline specific, looking at how technology shapes information venues and representation types that will be particularly useful for concept exploration and elaboration. Another way to think about TCK is to consider how it can be applied when looking at how various technology tools might shape the discourse patterns facilitated by these representations. In standard PCK, teachers learn to create, select, and modify tasks that build on students' current understandings. TCK adds the dimension of identifying where and how to apply technology to particular tasks to further these same goals.

Technological pedagogical knowledge (TPK) often addresses larger influences of technology on teaching and learning that cuts across disciplines. TPK primarily entails a deep knowledge of the components and capabilities of various technologies for use in teaching and learning settings, as well as understanding how teaching might change as a result of using a specific technology. Instructors should be familiar with a variety of tools that are appropriate for particular tasks, able to choose a tool that is well suited for the task, and capable of enacting strategies that illuminate the unique benefits inherent in the tool.

One particularly powerful benefit technology offers in education is the ability to expand communities of learners through communicative and participatory media. These technologies enable a richer, more dynamic, democratic life for students. By connecting to people, information, and ideas in other places and on a global scale, students are able to enrich their learning experiences. They are also better prepared to live in emerging and increasingly energetic global contexts. To access the richness of these global contexts, teachers must be able to negotiate the tensions that emerge when teaching with various enabling communication technologies. Teachers' knowledge of how to interweave communication technologies in their planning and their abilities to act on this knowledge in the classroom—which is at the heart of TPACK—can open avenues for participation that result in more democratic experiences for students. Teachers can use technology to promote democratic life, what Dewey (1927) called “associative and continually changing collective experiences, in support of critical and active student learning” (Lee, p. 140).

Acquiring integrated technology pedagogical content knowledge within a 1:1 environment requires a fundamental conceptual change on the part of the teacher. Generally, we think of conceptual change as a process that involves a shift in a person's worldview that fundamentally alters how that person develops new knowledge. For teachers, conceptual change may result from formal learning; for example, when a teacher investigates a new theory on cognition. The teacher's knowledge of this theory changes the way the teacher encounters new information and activities such as planning a lesson on language differences. Posner, Strike, Hewson, and Gertzog (1982) described the process of conceptual change as challenging central assumptions and paradigms framing an individual's worldview. These worldviews are deeply encoded into mental structures and are often resistant to change. Posner et al. (1982) offered four conditions that can facilitate conceptual change: dissatisfaction, intelligibility, plausibility, and fruitfulness. Other scholars have proposed a host of additional factors that may influence conceptual change: Pintrich, Marx, and Boyle's (1993) focus on learning contexts, individual goals, and motivational beliefs; Dole and Sinatra's (1998) concern with cognitive and motivational issues; and Gregoire's (2003) emphasis on affective factors, among others.

We see the new learning ecology that emerges in 1:1 computing environments as a context for conceptual change. Likewise, TPACK is a useful tool to accelerate teacher conceptual change related to technology in the 1:1 classroom. Although they did not measure conceptual change, Spires, Hervey and Watson (2009) found that TPACK can be scaffolded through an inquiry learning process with English Language Arts teachers. The researchers concluded that at a minimum, TPACK represents a powerful heuristic for teachers as they negotiate the rich and complex landscape of new literacies with their students. By having teachers routinely reflect on their evolving TPACK and how their pedagogy is changing as a result of technology, the PD goal is for teachers' TPACK to become increasingly sophisticated in support of student learning. Furthermore, the PD experience should yield more of the “grounded models” (Harris et al., 2009) called for by leaders in the field to help other teachers develop their TPACK as well.

Educators need to be knowledgeable about their content as well as the ways technology can transform the delivery of that content.

Strategy Two: Engaging Teachers in Project-Based Inquiry

Project-based inquiry is particularly suited to the new learning ecology of the 1:1 classroom since teachers are challenged to create tasks in which complexity and openness approximate problems in the real world. Students can see the interdisciplinary nature of these tasks, and realize that each task may have more than one solution. When students have the freedom to choose different strategies and approaches, they become more engaged in learning. Problems that have depth, duration, and complexity challenge students and motivate them toward knowledge creation. When engaged in project-based inquiry, students acquire problem-solving, communication, collaboration, planning, and self-evaluation skills. Likewise, when project-based inquiry is integrated into teachers' professional development, teachers can implement this dynamic process more successfully with their students.

Teachers must develop facilitation skills to challenge students to engage in complex thinking and to pose creative and innovative solutions during project-based inquiry.

Numerous models outline project-based inquiry, and vary according to specific disciplines. However, these are the essential elements of the process, as shown in Figure 3:

- Consider ideas and pose questions;
- Gather and analyze information;
- Creatively synthesize information and solve problems;
- Evaluate and revise results; and
- Share, publish, and/or act.

As noted earlier, project-based inquiry possesses elements of what Dewey referred to as productive inquiry, which "is that aspect of any activity where we are deliberately (although not always consciously) seeking what we need in order to do what we want to do" (Cook and Brown, 2005, p. 62). Teachers must develop facilitation skills to challenge students to engage in complex thinking and to pose creative and innovative solutions during project-based inquiry.

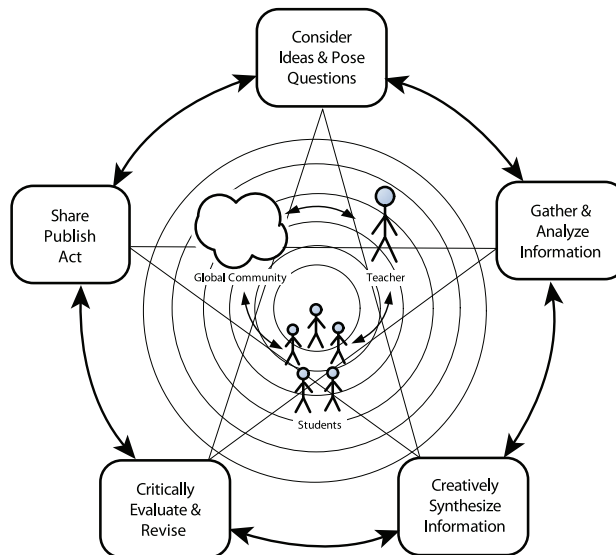


Figure 3. Project-based inquiry in the new learning ecology of the 1:1 classroom.

As professionals and as citizens, adults face very different intellectual challenges from what is typically demanded of students in school. Project-based inquiry within the 1:1 environment provides the opportunity for students to engage in what Newman, Bryck, and Nagaoka (2001) describe as *authentic intellectual work*. They describe the distinctive characteristics of authentic intellectual work as “construction of knowledge through disciplined inquiry in order to produce products that have value beyond school” (p. 14). Newman et al. found that students who received assignments requiring more challenging intellectual work also achieved greater than average gains on the Iowa Tests of Basic Skills in reading and mathematics, and demonstrated higher performance in reading, mathematics, and writing on the Illinois Goals Assessment Program. They concluded that assignments calling for more authentic intellectual work improve scores on conventional tests.

During professional development, teachers must immerse themselves in the project-based inquiry process in order to understand how to develop the skill set that involves facilitation, coaching, improvisation, and consultation. Likewise, teachers must engage in authentic intellectual work in order to grasp the multi-layered facets of what is involved in creating comparable learning conditions for their students.

Strategy Three: Engaging Teachers in a New Global Skill Set

As teachers engage in project-based inquiry as part of their PD, they must also develop a *new global skill set*. Since today’s students will be working in a global marketplace and living in a globalized society, they must acquire a far different set of knowledge, skills, and perspectives than previous generations. They must be able to compete—but also to cooperate—with their international peers. Educational leaders convened by the Asia Society agreed that the new global environment requires students to master knowledge and skills vastly different from those that were adequate for earlier generations (Asia Society, 2007). This group called for a new global skill set that includes a deeper understanding of academic content, and a set of strategies that enable students to learn how to learn, to be creative, and to control their own learning. This set of skills is similar to what the Partnership for 21st Century Skills advocates. The group also called for global literacy, which includes knowledge of other nations and cultures, learning other languages, and exposure to cross-cultural experiences. The best educators around the world encourage students to work in teams to solve problems, deepen their understanding of complex concepts, and increase and share their knowledge. This focus, in turn, helps to generate the skills and dispositions that 21st century employers demand: adaptive expertise, strong communication skills, creativity, interdisciplinary thinking, and team-based problem solving. The ultimate goal, of course, is to imbue professionals and citizens with these valued skills in order to bolster an innovative workforce and stimulate economic development.

Fadel, Honey, and Pasnik (2007) claim that since we are moving from an information-based economy to an innovation-based economy, it is essential that we promote what Robert Sternberg refers to as “successful intelligence,” which includes a combination of analytical, practical, and creative skills. An innovation-based environment places a premium on using information to imagine new ways to solve problems and create new ways of working. Current results from the Program for International Student Assessment demonstrates that on average, 15-year old students in the United States lag behind industrialized countries in Asia and Europe on problem solving skills in mathematics and science.

The shift toward 21st century skills is grounded in research conducted by Levy and Murnane (2004). Their research suggests that expert thinking and complex communication—two skills computers cannot replace—are essential for contemporary work. Expert problem-solving involves effective pattern matching based on detailed knowledge, metacognition, and the skills to determine when to end one strategy and try the next. Complex communication involves managing multiple information streams, interpreting subtleties, and presenting convincing arguments. In an economy flooded with new concepts and invented language, communicating complex information effectively is an increasingly valued skill. Complex problem-solving, quick and intuitive decision-making abilities, collaboration skills, and resourcefulness are keys to workplace success. The rapid pace of change and the need for continuous learning makes the capacity to learn a highly-valued competency as well.

Since today's students will be working in a global marketplace and living in a globalized society, they must acquire a far different set of knowledge, skills, and perspectives than previous generations.

If teachers are to become highly adept with the new global skill set, they must be immersed in authentic, challenging professional development experiences that support their efforts. For example, if we want students to engage in complex problem-solving tasks while collaborating with other students internationally, then professional development must be designed to engage teachers in similar experiences. Embedding the new global skill set within project-based inquiry enables teachers to focus on authentic intellectual work over time while they gain support from a professional learning community.

Strategy Four: Engaging Teachers in Performance-Based Assessment

The contemporary classroom should provide more time for creative, authentic intellectual work and less time on remembering.

Project-based inquiry that embeds global skills calls for performance-based assessment for students and for teachers. Many educators are using the revised Bloom’s taxonomy as a way to design instruction and assessment tasks. Recently, Anderson and Krathwohl (2001) adapted Bloom’s model to fit the needs of today’s classroom. They employed more outcome-oriented language, provided workable objectives, and changed nouns to active verbs. Most notably, they converted the term “knowledge” to “remember.” In addition, the highest level of development is now “create” rather than “evaluate.”

By replacing “evaluate” with “create” at the top of the model, there is a desired focus on the cognitive processes of creating, generating, and producing, which aligns with 21st century skills. We would argue, however, that the contemporary classroom should provide more time for creative, authentic intellectual work and less time on remembering. (See Figure 4). This is particularly important in the new learning ecology of the 1:1 classroom since information is abundant and accessed quickly. Before the Internet, it was more important to remember information since it was not easily retrievable. The inverted Revised Bloom’s diagram signifies the importance of the student’s intellectual contributions, which occur primarily during analyzing, evaluating, and creating.

Bloom’s Revised Taxonomy

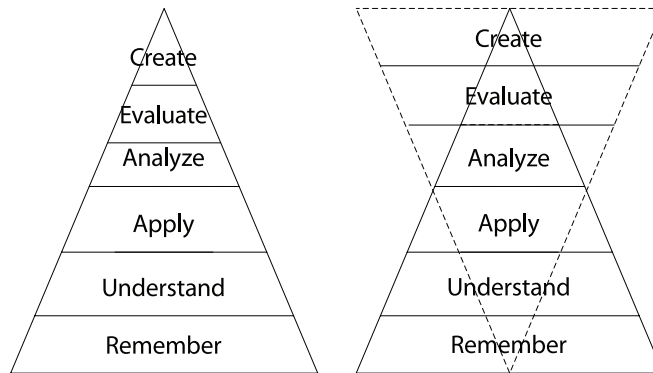


Figure 4. Revised Bloom’s Taxonomy (left) and Inverted Revised Bloom’s Taxonomy (right) signaling the importance of more time and focus on analyze, evaluate, and create—which are important in the new learning ecology.

Performance-based assessment is sometimes characterized as evaluating work in real life, with students assuming responsibility for self-reflection and self-evaluation. The overriding philosophy of performance-based assessment is that teachers should:

- Have access to information that can provide ways to improve achievement;
- Demonstrate exactly what a student does or does not understand;
- Relate learning experiences to instruction; and
- Combine assessment with teaching.

Fadel, Honey, and Pasnik (2007) advocate that assessments should make students' thinking visible so that teachers can see the kinds of conceptual strategies that a student uses to solve problems. Tasks used in performance-based assessment include multimedia products, constructed responses, open-ended problems, real-world simulations and other authentic tasks. Such tasks are concerned with integrating and using knowledge and complex problem solving. The underlying concept is that the student should produce evidence of accomplishing learning goals, which can become part of a learning portfolio that demonstrates achievement.

New forms of performance-based assessment are needed at the classroom level to help teachers monitor and improve student learning and at the large-scale system level for accountability purposes. At the classroom level, teachers have several traditional ways to record the results of performance-based assessments through rubrics (Stiggins, 1994; Hibbard, 1996). The teacher may use a checklist that indicates whether or not certain elements are present in the performances. He may write a narrative report of what was done during each of the performances and then determine to what degree the students met the standards based on the report. Or a teacher may use a numerical rating scale to indicate how well a standard was met.

Additionally, interest in designing standardized performance-based assessments has recently surged, most notably as a result of the national and international call for measuring 21st century skills (Silva, 2008). For example, the recently-developed College Readiness and Work Assessment emphasizes what students can do with knowledge rather than what knowledge they have. The 2009 National Assessment of Educational Progress (NAEP) test will measure how well students apply their knowledge of science in addition to their knowledge of science principles. This is the first time NAEP has tested application-level knowledge. Progress is also being made using virtual environments. For example, River City,⁷ created by Chris Dede and associates teaches and assesses science concepts with middle school students in a virtual world (Dede, 2009a). Students are presented with a problem and must develop a hypothesis and procedure, test it in the virtual space, and then make recommendations based on their findings. Dede and other researchers are exploring whether virtual environments hold promise for advancing performance-based assessments, especially in the area of complex problem-solving.

Strategy Five: Engaging Teachers in Professional Learning Communities and Networks

Key to developing a new skill set is engaging in appropriate tasks over an extended period of time with a professional learning community that provides knowledge, support, and encouragement. Attributes of professional learning communities include:

- Supportive and shared leadership;
- Collective creativity;
- Shared values and vision;
- Supportive conditions; and
- Shared personal practice.

⁷ <http://muve.gse.harvard.edu/rivercityproject>

Social networking technologies (e.g., Facebook, Ning, Twitter) are particularly appropriate as tools for communication, sharing, and just-in-time information within the learning community. Applying the continuous support and feedback of a professional learning community is vital as teachers take on the challenge of acquiring the new global skill set themselves and then being co-learners with their students within the new learning ecology of the 1:1 classroom.

Obviously, professional learning communities have been around for some time and have met with varying levels of success. One might assume that schools inherently are learning organizations, but as we know, they are often structured in ways that inhibit collaboration and innovation. Research suggests that professional learning communities can be effective in supporting teachers to acquire important knowledge and skills that build organizational capacity (Darling-Hammond, et al., 2009). These relationships increasingly are sustained through online interactions (Yang and Lui, 2004; Barab, Kling and Gray, 2004) but are also effective as structured face-to-face interactions (Graham, 2007). Obviously, with emerging technologies come new possibilities for how educators can use virtual environments for professional exchanges and learning experiences. As online professional learning communities become more pervasive, teachers will have increased options to connect with professionals from around the world to enrich their knowledge and teaching expertise. Teachers will create their own personalized interlocking networks as they sample from a variety of resources and become more sophisticated consumers of online learning opportunities. We believe professional learning communities and networks will take on new forms and dimensions, providing additional opportunities for educators to experience continuous learning within their educational organizations.

As online professional learning communities become more pervasive, teachers have increased options to connect with professionals from around the world to enrich their knowledge and teaching expertise.

Conclusion

Richard Florida (2009) notes that in addition to its current economic crisis, the United States is in the midst of a fundamental long-term transformation—one that is similar to the late 19th century shift that occurred when people left farms and moved to cities to acquire manufacturing jobs. Along with numerous others, Florida has observed that today's economy is shifting away from manufacturing toward idea-driven, creative industries. Our schools—and the teaching and learning enterprise at their core—need to undergo a transformation as well. The result of such a transformation needs to be a type of educational experience and expertise that will not only support but also ignite participation in—and leadership for—an idea-driven, creative economy. Equally important as supporting a new economy is educational experience and expertise that supports a global citizenry.

The 1:1 environment is prompting a new learning ecology, which we describe through four unique conditions:

- Immediate and constant access to information and a global community;
- Intensity, relevance and personalization of learning;
- Highly developed teacher capacities; and
- Highly developed student dispositions.

As a result of these conditions, we have proposed five strategies for consideration to be included in 1:1 teacher professional development. These strategies are:

- Technological pedagogical content knowledge (TPACK);
- Project-based inquiry;
- A global skill set;
- Performance-based assessment; and
- Professional learning communities and networks.

These strategies take into account the new learning ecology of the 1:1 environment. Equally important, they can help create a new learning ecology for teacher professional development—one that supports teaching and learning for our increasingly interdependent global age. Technological tools and information are not always educationally productive. Educators must provide leadership in creating new models for the teacher to act as facilitator, coach, mentor, and even improvisational artist within the new learning ecology—always with an eye on the larger aims and purposes of education. President Obama has boldly stated that we must “transform our schools . . . to meet the demands of a new age.” We believe that a critical aspect of educational transformation is ongoing teacher professional development aligned with an evolving learning ecology that is prompted by 1:1 learning technologies.

Educators must provide leadership in creating new models for the teacher to act as facilitator, coach, mentor, and even improvisational artist within the new learning ecology—always with an eye on the larger aims and purposes of education.

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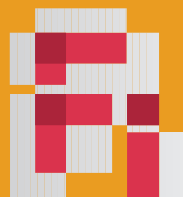
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