Cultivating Digital Literacy

By Heather Pacheco-Guffrey

This issue of *Science and Children* is packed with creative models for building technology into instruction organically, in ways that truly enhance students' learning experiences. Whether you are teaching remotely, hybrid, face-to-face, or in some kind of mashup of these different instructional delivery modes, you are likely still feeling the impact of the increased role of technology in education since the COVID-19 pandemic took hold. It's a great time to consider how your teacher digital literacy has developed, what you want to keep doing, and where you want to turn your attention next.

In this guest editorial, you will find the review of a framework for *teacher* digital literacy, technological pedagogical content knowledge or "TPACK." I hope this framework helps you to think about and reflect upon the tremendously complex and important work you do as an educator. In upcoming issues of *Science and Children*, our "Tech Talk" column will offer more big ideas and resources for digital literacy. Be sure to check it out!

WAYS TECHNOLOGY IS USED IN EDUCATION

Let's take a moment to clarify what is meant by "digital literacy." While not an exhaustive list, here are four different ways technology is used in education:

1. *Digital literacy* is, in essence, knowledge of how to use technology to effectively and safely complete tasks. These tasks vary widely and can include communications, researching information, choosing appropriate technology for tasks, organizing/analyzing data in a spreadsheet, storing/accessing information on the computer, practicing good digital hygiene, digital citizenship and more. Teacher digital literacy also includes skills needed for using technology to manage and support students and deliver instruction; this includes teacher "TPACK," described below.

Today, all American states as well as Guam and Puerto Rico have standards for students' digital literacy that either follow or rely heavily upon the International Society for Technology in Education (ISTE) standards. ISTE should be on your radar. ISTE has put forth three generations of standards (1998, 2007, 2016), with the latest generation including updated standards for students as well as those for educators, educational leaders, computational thinking, and coaches (ISTE 2021). Standards are also available in several languages. Check out the "ISTE Standards Adoption by State" map (ISTE 2021) to see which version of ISTE standards your own state is using. We'll dig into the ISTE standards in an upcoming issue of *Science & Children's* "Tech Talk" column.

2. *Technological Pedagogical Content Knowledge* or *"TPACK,"* provides a framework for understanding everything that goes into a teacher's ability to use technology for effective academic subject-specific instruction (e.g., science, reading) (Koehler and Mishra 2009). TPACK describes the complex interactions between different types of knowledge educators must have to craft and deliver effective learning experiences for their students, including knowledge of content, pedagogy, learners, context, and technologies. This critical facet of educator digital literacy is highlighted in this article.

3. *Computer science education* is about learning to build, test, and troubleshoot computer-based software and hardware products and solutions such as: computer code, robotics, artificial intelligence (AI) systems, virtual / augmented reality (VR/AR) systems, networking, and systems security. Some states include standards for computer science in their digital literacy standards for students. These are rooted in various iterations of the K–12 Computer Science Standards from Computer Science Teachers Association (CSTA 2020).

4. *Vocational/technical education* presents technology use in ways that prepare students for the workforce. These include the wide range of technologies used in skilled technical work such as auto repair, manufacturing, HVAC, engineering, agriculture, and so much more. Today, it is hard to find vocational training that does not require specialized technological proficiencies.

A FRAMEWORK FOR UNDERSTANDING TEACHER DIGITAL LITERACY

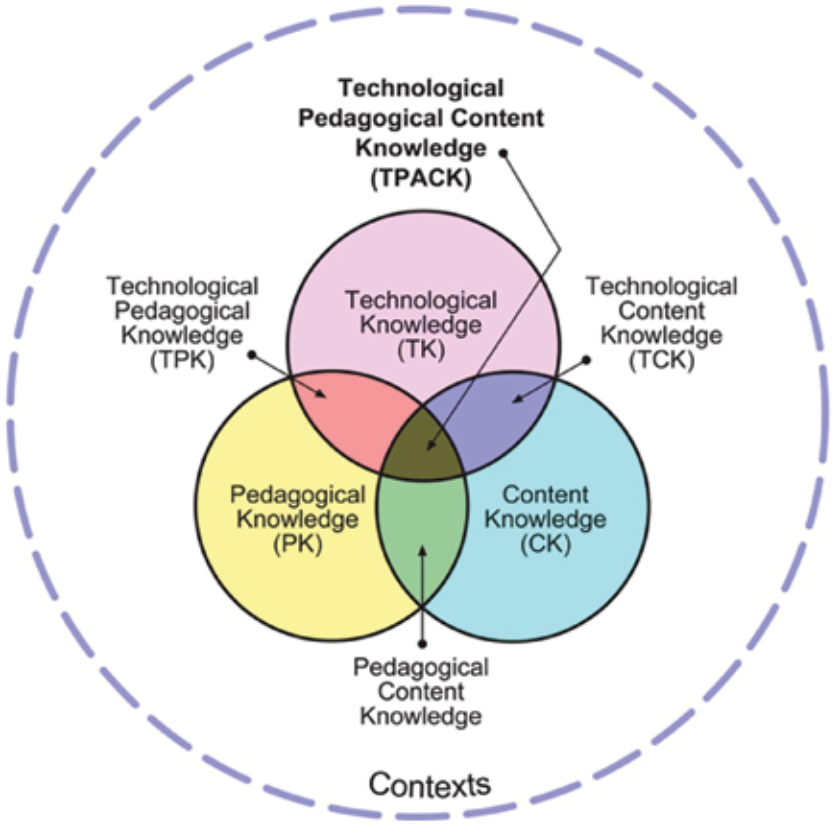
Teachers are incredibly knowledgeable and skilled professionals. Much like the *Next Generation Science Standards'* three dimensions of learning,

teacher digital literacy has different dimensions. TPACK is the dimension of teacher digital literacy focused on the effective use of technology to teach specific academic content (e.g., science, math, engineering). The TPACK framework is useful because it not only describes the types of knowledge that are necessary for effective instruction in academic subjects, but it also clearly articulates the many different kinds of knowledge that educators use in the complex task of teaching.

It wasn't until the mid-1980s that researchers started to really describe the complexity and layers of teacher knowledge. Shulman (1986) sought to distinguish categories of teacher knowledge through his "pedagogical content knowledge" (PCK) conceptual framework. This framework and the many iterations that followed Shulman's initial model were designed to describe the unique knowledge that expert teachers hold. Consider an expert scientist and an expert science teacher. Both will be knowledgeable about science. However, the expert scientist will be more knowledgeable about *science through a research lens* and the expert science teacher will have more knowledge about *science through a teaching lens* (Gudmundsdottir 1987). Over the years, PCK has received much attention from scholars. They have debated, refined and expanded the model. In brief, teacher PCK comprises (1) knowledge of subject matter such as concepts, vocabulary, algorithms, frameworks, theories, etc.; subject matter knowledge is distinct for all subjects and varies by grade level; (2) knowledge of pedagogy, including understandings about how people learn and expertise in instructional strategies/models; (3) knowledge of students including developmental levels, prior knowledge, expected preconceptions, as well as learning strategies that will meet their learning needs and abilities; and (4) knowledge of context such as school culture, setting, politics, and the availability of resources, as well as knowledge of curriculum and assessment (Cochran, DeRuiter, and King 1993; Shulman 1986). The concept of PCK really shaped my thinking about the scope and depth of knowledge required to be an expert teacher. It also helped me to understand why overall teaching performance can be heavily impacted when educators change grades, schools, or academic subjects. A similar impact on teaching can be expected when content standards change for a grade level.

The use of technology in education exploded in the years following Shulmans' landmark work on PCK. Over two decades later, Koehler and Mishra (2009) sought to integrate the specific knowledge teachers have about using technology for instruction into Shulman's PCK framework. They developed the "TPACK" framework to describe teachers' technological pedagogical content knowledge. Figure 1 shows the relationships between TPACK and other types of teacher knowledge (Koehler and Mishra 2009, p 63). The TPACK framework describes the unique types of knowledge teachers must have to engage in effective tech-rich instruction within specific academic subjects. Take a look at these different compo-

FIGURE 1
The TPACK framework and its knowledge components.



nents of teacher knowledge, thinking about your own areas of strength and growth (Figure 1).

Technological Knowledge (TK): knowledge of how to use and interact with technology to accomplish specific tasks. This is teacher digital literacy for educational technology. *Example: A third-grade teacher knows how to create and populate a Google Classroom to manage assignments for his class.*

Pedagogical Knowledge (PK): knowledge of how people learn, also including teaching strategies and instructional methods. This was part of the original PCK model. *Example: A Kindergarten teacher knows about the role the engineering design process plays in fostering important social skills and scaffolding student learning about collaborative problem solving, as well as how it can be an effective way for all students to play an active role in their own learning.*

Content Knowledge (CK): knowledge of academic subject matter such as theories, concepts, vocabulary, frameworks. *Example: A fifth-grade teacher knows how energy is transferred and transformed between the abiotic and biotic components of an ecosystem, appropriate for NGSS standard 5-PS3-1.*

Pedagogical Content Knowledge (PCK): subject-specific knowledge of how to effectively teach specific groups of learners (Cochran et al. 1993; Gudmundsdottir 1987; Shulman 1986). *Example: A first-grade teacher knows how to scaffold a set of learning experiences to facilitate her first-grade students' conceptual development about the pattern of the Sun's path across our sky each day (1-ESS1-1). She chooses specific resources, including flashlights, playground observations, videos, and modeling materials. She then builds upon this to teach them about the seasonal differences of the Sun's path in our sky using modeling and data about changes to our daylight hours (1.MD.C.4). She knows this will support their ability to use evidence to explain that our length of day changes throughout the year (1-ESS1-2).*

Technological Pedagogical Knowledge (TPK): knowledge of how to use technology effectively to facilitate learning for your students in the context of their learning assets and needs. *Example: A third-grade teacher offers students the option of using Wakelet's (2021) Flipgrid video integration or typing in the textbox feature to provide a brief overview of the resources they curated from her larger Wakelet collection "Earth's Animals!" (ISTE 1c & 3c).*

Technological Content Knowledge (TCK): knowledge of how to use and interact with subject-specific technologies. For teachers, this includes knowing which technology tools are best suited for representing content knowledge in different, desired ways. *Example: A fourth-grade teacher uses the interactive web-based USGS Latest Earthquake Maps (USGS 2021) as a data source for his students to analyze, interpret, and draw conclusions about the distribution of earthquakes on our planet (4-ESS2-2).*

Technological Pedagogical Content Knowledge (TPACK): subject-specific knowledge of how to enhance instruction for specific groups of learners through the use of technology. This knowledge considers students' diverse learning assets and needs and how technology can provide targeted and effective learning opportunities; this includes expertise in understandings about how students' digital literacy will impact their ability to engage with technology in the learning experience. *Example: A second-grade teacher engages students in making predictions and testing out hypotheses with the interactive WonderFarm app (First8Studios 2021) in the early days of the class mini-garden project, after children have chosen and planted their seeds but before they start to plan their investigations with the class' mini garden. This app has design and learning features crafted to match students' abilities and needs at ages 4–8 years and is well suited for both independent and guided use with children. The teacher chooses this app because it will give students a good understanding of the concept of testing different variables with their plants as well as some great ideas for what they can investigate in their class mini-garden. Children are offered opportunities to use the app during free-choice time. Later, during the data collection portion of their study, the teacher provides visuals and sentence frames that are similar to those used in the WonderFarm app to support their data collection.*

As a teacher who uses technology in your instruction, I hope you are marveling at all you know and are able to apply in the course of your work. I find TPACK to be an empowering framework that enables teachers to recognize their many areas of expertise and knowledge. It also provides clear pathways for growth in new directions.

We need to find sustainable ways to be limber, nimble, energized, and practical in our tech-rich future in education. Now, each year you teach (even without COVID), you are building your own and your students' digital literacy. However, neither teacher nor student digital literacy is about knowing every technology out there. It is about having a framework for how to approach technologies and how to think about and integrate their use so they enhance the lives and experiences of you and your students. Think: value-added.

Explore the resources in this power-packed issue of *Science and Children* and keep your eye out for our "Tech Talk" column bringing you more about the big ideas in digital literacy in education. Prioritize technol-

ogies that expand the world for you and your students, facilitate growth, energize, and inspire! ●

ONLINE RESOURCES

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Heather Pacheco-Guffrey (*HPACHECOGUFFREY@bridgew.edu*) is an associate professor of STEM education for pre- and inservice teachers at Bridgewater State University in Bridgewater, Massachusetts. She researches TPACK and writes the "Tech Talk" column for *Science and Children*.