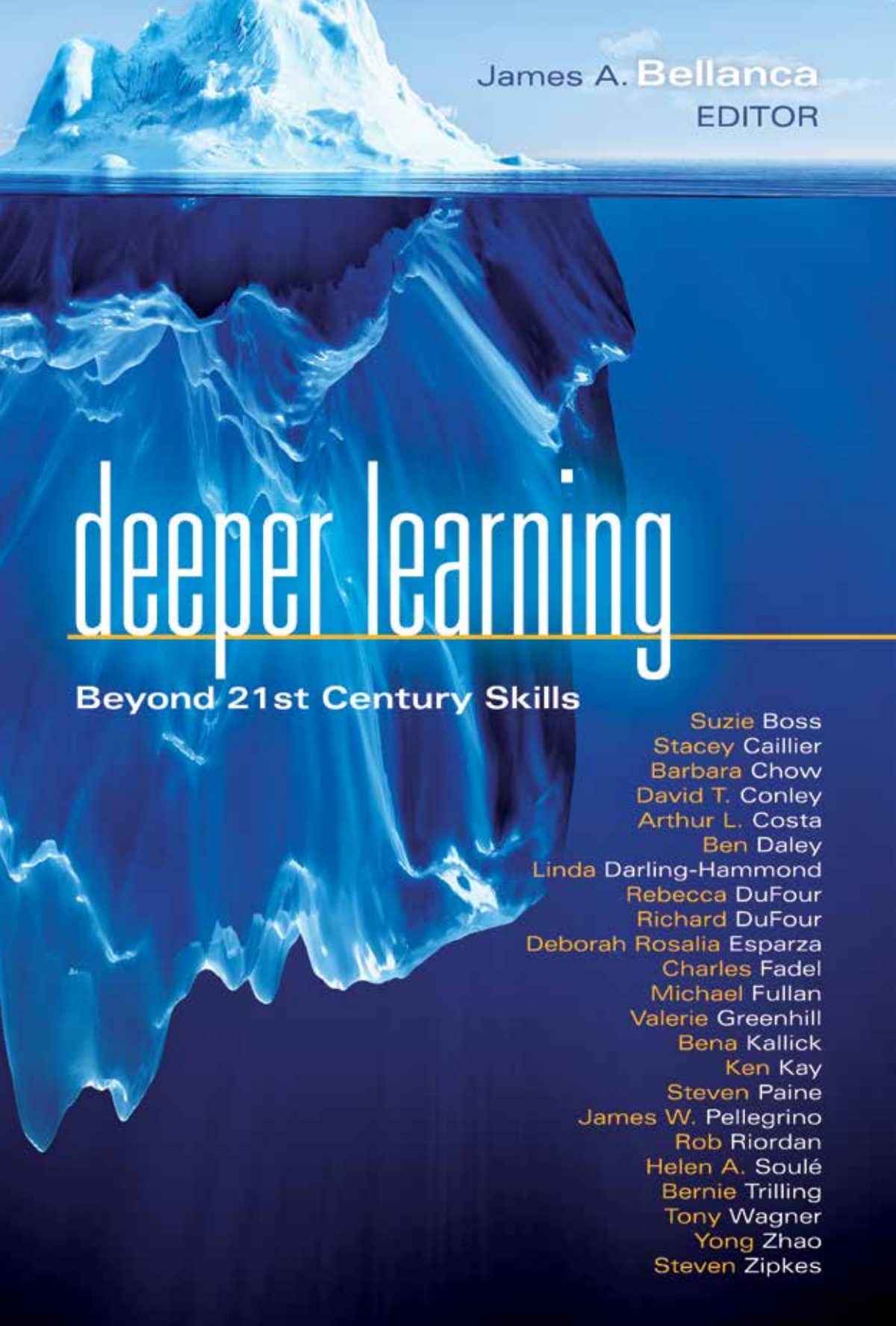
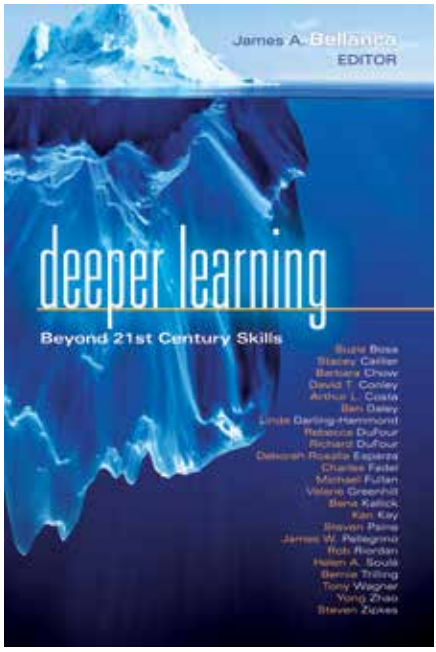

James A. Bellanca
EDITOR
deeper learning
Beyond 21st Century Skills
Suzie Boss
Stacey Caillier
Barbara Chow
David T. Conley
Arthur L. Costa
Ben Daley
Linda Darling-Hammond
Rebecca DuFour
Richard DuFour
Deborah Rosalia Esparza
Charles Fadel
Michael Fullan
Valerie Greenhill
Bena Kallick
Ken Kay
Steven Paine
James W. Pellegrino
Rob Riordan
Helen A. Soulé
Bernie Trilling
Tony Wagner
Yong Zhao
Steven Zipkes



Order now

James A. Bellanca

Available for PD

Chapter 4

Powering Up Learning With PBL Plus Technology

Suzie Boss

A creative agency headquartered in the Atlanta area has no trouble recruiting professional talent to work on award-winning films, animations, and other projects for the entertainment industry. For a 2013 PBS documentary about a global health issue, the agency outsourced 3-D modeling work to a team of local high school students. Risky?

Not according to the agency's creative director. Before enlisting "the kids," as he calls them, Walter Biscardi Jr. toured the Center for Design and Technology (CDAT), a project-based learning program at Lanier High School in Sugar Hill, Georgia. He was impressed not only by the professional-grade tools that students were using to produce high-quality work but also by their passion for tackling challenging projects. Students' contributions to the documentary—ninety seconds of scientifically accurate 3-D animations that help explain the spread of a disease known as river blindness—"have simply blown away all expectations," says Biscardi (as cited in Reilly, 2013).

For CDAT teacher Mike Reilly, this is the kind of real-world learning experience that he strives to offer his students on a regular basis. By incorporating technology into project-based learning, he is able to address rigorous academic standards while also encouraging

what he calls *digital creativity*. The ability to solve problems creatively—while using digital tools and collaborating with others—has value in today's economy and will be an asset for tomorrow's job creators and engaged citizens (Wagner, 2012; Zhao, 2012).

Project-Based Learning Plus Technology: A Digital-Age Combination

The combination of project-based learning plus technology (PBLT) brings a proven instructional strategy into the digital age. Across diverse contexts—from elementary through high school—PBLT provides teachers and students with a framework for in-depth inquiry and tools for authentic problem solving. This powerful combination also reflects how important work gets accomplished in the world outside the classroom.

Project-based learning has a long track record as a strategy to prepare students for college, careers, and citizenship. When students take on meaningful projects and share their work with authentic audiences, they find learning more relevant and school more engaging (Thomas, 2000). Along with producing academic gains, well-designed projects help students develop problem-solving skills (Finkelstein, Hanson, Huang, Hirschman, & Huang, 2010; Mergendoller, Maxwell, & Bellisimo, 2006). PBL also gives students expanded opportunities to practice and hone 21st century skills, such as collaboration, effective communication, and critical thinking (Ravitz, Hixson, English, & Mergendoller, 2012).

Infusing projects with technology has the potential to amplify and even transform the learning. Consider what happens when students have access to collaborative tools while engaged in a project: using Skype, they can consult with remote content experts as part of their research. They can team up with peers—from their own school or from halfway around the world—on a wiki to brainstorm possible solutions and consider diverse perspectives. Using Google Docs, they can get real-time feedback to improve their work at the formative stage. When they're ready to share their final products, they can use publishing tools to interact with everyone from local community members to global stakeholders.

Access to technology is a must for this kind of experience, but access alone is no guarantee of deeper learning. What matters is how the tools are used in PBLT to help students accomplish important learning goals.

Learning by Doing and Then Some

Learning by doing is hardly a new idea. A century ago, John Dewey and other progressive thinkers were advocating for experiential education to replace traditional schooling that kept students in a passive role. In the 1950s, medical schools began pioneering a teaching approach intended to transform book-smart students into competent clinicians. Rather than being drilled on medical facts without context, medical students were now challenged to apply their understanding to arrive at a diagnosis and treatment plan for someone role-playing a patient. This shift from knowledge acquisition to problem solving has taken hold in many other disciplines, from engineering to business to K–12 education.

Across content areas and levels, PBL starts with an open-ended question that has many potentially correct answers. (For example: How can we keep pollutants out of the creek at our local park? How might we improve the lunch experience in our school cafeteria? How should we advise the United Nations to meet the U.N. Millennium Development Goals?) Students can't google their way to solutions. Rather, they must engage in extended inquiry to arrive at their own understanding and develop defensible arguments for their positions. Projects typically conclude with student teams applying what they have learned to produce something original, such as a product, demonstration, or exhibition that they share with an authentic audience. As John Mergendoller (2012), executive director of the Buck Institute for Education, writes: "In Project Based Learning, in order for students to *learn something*, they must *do something*."

When done well, PBL delivers a range of benefits for diverse learners. Yet it's not without challenges. Most teachers have never been students themselves in a project-based setting. That means educators may need extensive professional development to get

comfortable teaching in a more student-centered way (Hmelo-Silver, Ravit, & Chinn, 2007).

Incorporating technology—adding the "T" in PBLT—introduces another layer of complexity. Teachers who have limited experience using technology in the classroom may need support to effectively integrate digital tools into projects.

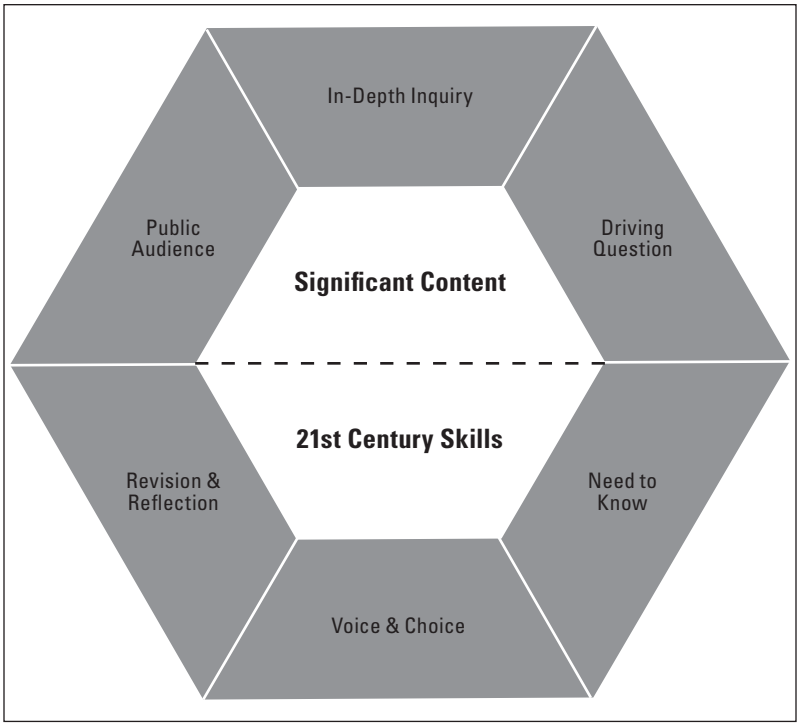
What's Essential in PBLT?

When PBLT works as intended, students meet important learning goals and also develop 21st century skills, such as collaboration and critical thinking. They incorporate technology not as an afterthought to a project, but because specific digital tools are critical to their inquiry experience. To help students stay on track and accomplish meaningful results, teachers need to focus on what's essential for project success.

The Buck Institute for Education (BIE), a nonprofit organization that focuses on project-based learning as a strategy for school reform, has been a driver of PBL expansion, both in the United States and internationally. Through research, professional development, and consultations with thousands of teachers, schools, and districts, BIE has synthesized best practices for PBL into a set of eight essential elements (see figure 4.1).

When teachers incorporate these eight elements across the arc of projects, they set the stage for high-quality PBL experiences in which projects are the "main course" of learning, not the dessert (Mergendoller & Larmer, 2010). Other researchers have reached similar conclusions about the need for careful attention to project design, student collaboration, and comprehensive assessments that support student success in PBL (Darling-Hammond et al., 2008; Vega, 2012).

Technology is not explicitly listed as one of the essential ingredients for project success, although opportunities to integrate technology can be found at all stages of the learning experience. For example, students might use online libraries or collections of primary source documents for in-depth inquiry, digital publishing tools to share work with audiences, and project-management tools to keep team efforts organized.



Source: Buck Institute for Education. Used with permission.

Figure 4.1: Eight essential elements of project-based learning.

In PBLT, teachers and students deliberately leverage these opportunities, using digital tools to accomplish results that might not be achievable otherwise. During the 2012 U.S. election season, for instance, students from several states used YouTube and video-conferencing to debate issues during a virtual political convention. Technology enabled students to produce and publish original videos about the issues they had researched, interact with peers in diverse locations, and find out (via polling) if their arguments had swayed others' opinions.

For teachers who are new to PBLT, it helps to see technology-infused learning in action. Pioneering school models such as High Tech High, Expeditionary Learning, and New Tech Network open their doors to visitors and share project resources. Similarly, websites such as Edutopia (www.edutopia.org) provide video case studies

illustrating PBLT in diverse contexts—charters, independent schools, and traditional public schools spanning the K–12 range.

Despite an explosion of interest in the project approach, only an estimated 1 percent of schools in the United States use PBL as their central approach to instruction (Merrow, 2013). Increasingly, however, individual teachers, schools, and entire districts are incorporating project-based instruction into at least part of the school year. In the Vail (Arizona) School District, teachers are collaborating to design grade-level projects that address Common Core State Standards and incorporate performance assessments. West Virginia has encouraged PBL through a statewide professional development initiative and created an online library of project plans that integrate technology. To encourage projects that have an authentic community focus, Metropolitan Nashville (Tennessee) Public Schools recruit local nonprofits, government agencies, and other organizations to serve as PBL partners for school projects.

Widespread adoption of the Common Core State Standards is adding more urgency to the PBLT movement. The new standards call for students to think critically, solve problems, work collaboratively, use technology to communicate, and be able to apply what they learn. These are natural outcomes of well-designed projects. Michigan teachers Pauline Roberts and Rick Joseph, for example, see their students meeting rigorous, interdisciplinary learning goals through projects that develop what they call *sciracy*, or scientific literacy. In a project that won international honors in the Microsoft Partners in Learning Global Forum in 2012, their fifth- and sixth-graders from Birmingham Covington School conducted an educational campaign to encourage more sustainable business practices among local merchants. They also ranked business according to a "green" scale and published their evidence-based analysis of sustainability practices online.

For PBL practitioners, the higher expectations of the Common Core are nothing new; they align with necessary elements of high-quality project work, including performance-based assessment. Researchers have also long understood the value of learning experiences that call on students to transfer knowledge to new situations

(Bransford, Brown, & Cocking, 2000). Discussions of deeper learning that have been underway since the early 2000s build on this foundation, bringing into sharper focus the strategies that lead to application of knowledge, such as engaging students in challenging tasks. As James Pellegrino and Margaret Hilton (2012) note, "While other types of learning may allow an individual to recall facts, concepts, or procedures, deeper learning allows the individual to transfer what was learned to solve new problems" (p. 6).

Technology as a Turbo-Boost for Learning

The integration of technology sets PBLT apart from experiential learning initiatives of previous eras. With access to digital tools, students can overcome limitations of geography and take inquiry into the wider world. They can also accomplish professional-quality results, using the same tools that experts use to apply the strategies associated with specific disciplines.

Indeed, researchers note that this convergence of interest in PBL use and new technologies has led to many interventions that intentionally incorporate technology as a key component of PBL use (Ravitz & Blazevski, 2010). Some digital tools, such as the following, are uniquely able to open new windows onto student thinking, thus setting the stage for more productive classroom conversations.

- ChronoZoom (www.chronozoom.com), an interactive timeline tool, enables students to zoom in and out of different eras as they explore and discuss the visual history of the cosmos.
- Tuva Labs (https://tuvalabs.com) is a platform that curates open data sets so that students can analyze, visualize, and interpret statistical information about issues relevant to their communities and interests.
- Modeling software like SketchUp (www.sketchup.com) facilitates the process of 3-D drafting and refining. It also supports the rapid prototyping typical of project work.
- QuadBlogging (www.quadblogging.com) is a simple platform for connecting four classrooms of writers—from anywhere in

the world—to comment on each other's blogs, providing students with an authentic audience and real-world feedback.

Many of these online tools allow for instant global connections, redefining the meaning of a learning community (Boss & Krauss, 2014). Of course, simply adding computers, tablets, or other digital devices to classrooms is no guarantee that high-quality PBLT will happen. In many schools, technology is still used primarily for test prep or for an online version of traditional instruction. Harnessing the power of technology to reach deeper learning goals requires a wholesale shift in what students and teachers do with these tools. Tom Vander Ark and Carri Schneider (2013) write that "technology-enabled instruction must be the linchpin of this evolution, and not just casually layered on top of an outdated, industrial-era system" (p. 6).

When fully integrated into projects, technology becomes a powerful tool for accessing, analyzing, and organizing information; connecting learners with peers and experts; personalizing learning; creating new content; and sharing results with authentic audiences. Digital tools, made accessible in a student-centered learning context, can also lead to what researchers have defined as "connected learning" (Ito et al., 2013). Connected learning "draws on the power of today's technology to fuse young people's interests, friendships, and academic achievement through experiences laced with hands-on production, shared purpose, and open networks" (Digital Media and Learning Research Hub, 2012).

Such results can happen from a young age. In a project that connected students with peers around the world, fourth graders in Baltimore, Maryland, took up the issue of girls' right to education. The project was sparked by news reports about Malala Yousafzai, a teenager from Pakistan who was attacked by the Taliban because of her outspoken support for girls' education.

Teacher Heidi Hutchison, in a reflective post about the evolution of the #MalalaProject, cited a number of digital tools that were integrated into the learning experience (Hutchison, 2013). In each instance, specific technologies were used because they were essential for students to extend their learning: a wiki to organize the project

and share content from participating classes in multiple countries, the Internet for research and critical analysis of cultural barriers to girls' education, and digital media to produce advocacy pieces (such as brochures or public service announcements) that were shared at public events. Hutchison herself used Twitter to think through the project with colleagues from her personal learning network as well as a blog to reflect publicly on the outcomes of the project.

In an environment that fosters deeper learning, technology needs to be "like oxygen—ubiquitous, necessary, and invisible" (Lehmann, 2010). That's the oft-repeated mantra of Chris Lehmann, founding principal of the Science Leadership Academy (SLA) in Philadelphia. At SLA, a highly regarded public high school that teaches entirely through PBL, all students have laptops plus access to the social media tools that many other schools routinely block. Ninth graders use these tools for a year-long project called You and the World. Students conduct in-depth research about an issue of personal interest, exploring questions such as, "How can I be a global citizen?" They use blogs and social media to share their passions with others, leveraging their digital fluency to take civic action or lead advocacy efforts to support specific causes.

Technology to Scaffold Instruction

The student-centered learning that is a hallmark of PBLT does not happen without careful teacher planning and facilitation. Across the arc of projects, digital tools can help teachers scaffold instruction, gather formative feedback, and make adjustments to address the needs of diverse learners.

Consider these opportunities to integrate digital tools to support instruction:

- At the project planning stage, online surveys can help identify student interests that may connect with content standards.
- At the launch of projects, compelling videos or immersive online experiences can engage student interest.

- Primary sources and rich data sets help students access, evaluate, and discuss online information throughout the project to answer their own research questions.
- Student blogs, podcasts, and video interviews can encourage reflection throughout a project and provide insights into understanding and opportunities to adjust instructional plans as needed.
- Collaborative tools allow students to cocreate content with team members, connect with content experts, manage the flow of project work, and receive formative feedback throughout the learning process.
- Digital tools allow for rapid prototyping, leading to iterative cycles of feedback, testing, and product improvement.
- Online publishing tools enable students to document and present their work in a compelling way of their choosing, sharing results with authentic audiences.

The instructional strategies essential to PBLT—questioning, formative assessment, and engaging learners in challenging tasks—help put students on the path to deeper learning (Pellegrino & Hilton, 2012). Thoughtful technology use can support all these strategies. Having a backchannel for conversations, via Twitter or TodaysMeet (https://todaysmeet.com), provides a forum for quieter students to pose questions or respond to whole-class discussions. Screenshots of student work in progress allow for quick formative assessments and also create artifacts for deeper discussions. Photo diaries and blogs enable students to document their work over time, encouraging thoughtful reflection when they look back at the completion of a project.

The integration of PBL with technology also helps students take on the role of experts—such as journalists, historians, or scientists—and apply the lenses of these authentic disciplines (Krauss & Boss, 2013). Even projects that require scaffolding to make the work "right sized" for learners can still put students into authentic roles. Middle school students preparing to conduct oral history interviews, for

example, might benefit from having teachers model questions that prompt them to think like historians.

Access to technology means students use the same tools that the pros use—whether for gathering and analyzing scientific data, producing a documentary, or making an infographic to represent information visually. Students at the Science Leadership Academy, for example, worked alongside scientists from the Franklin Institute in Philadelphia to locate and photograph anomalies on the surface of the sun; they then used photo-editing software to create a composite picture from hundreds of individual shots. When it was time to present their research about solar flares at a scientific conference, co-presenters included the planetarium director and a high school student (Schachter, 2013).

Trends to Watch for in PBLT

Digital tools that offer promise in the context of PBL are in almost constant flux. As new tools emerge in beta versions and yesterday's favorites fall by the wayside, teachers may find it challenging to settle on an ideal tech toolkit for the PBL classroom. Rather than gravitating to the latest shiny object, teachers are wise to focus first on the essential learning goals they seek to accomplish in a project and then integrate digital tools that support those goals (Boss & Krauss, 2007).

Four trends are worth watching because of their potential for deeper learning in PBLT: (1) PBLT anywhere, anytime; (2) personalization of PBLT; (3) blended and online learning; and (4) maker spaces, rapid prototyping, and PBL.

PBLT Anywhere, Anytime

The latest *Horizon Report*, an annual forecast of emerging technologies and their effects on education globally, predicts that cloud computing and mobile learning will be key drivers of K–12 education change. Indeed, the report notes that both trends have already gained traction; earlier barriers to adoption are being quickly overcome (Johnson et al., 2013). In the PBLT context, both trends have potential to help students go deeper with collaboration, inquiry, and creativity.

The ability to store and access information in the cloud rather than on a single computer expands opportunities for collaboration. With access to cloud-based platforms such as Google Apps for Education and Microsoft Office 365, students can team up on projects with classmates or remote collaborators from anywhere in the world.

Cloud-based computing also enables formative assessment throughout a project. The iterative nature of project work means that a product will likely go through several cycles of review and revision en route to a final version. With 24-7 access to project materials, team members are able to work simultaneously (rather than waiting for a handoff from a peer). They also benefit from faster feedback. For example, a teacher who has her students use Google Docs for journalism projects says being able to see their work at the early draft stage allows her to offer more timely feedback, which leads to faster revisions and more polished work when it's time to publish. The teacher is not the only one who offers critiques—as part of their project work, peers are expected to give each other critical feedback. The teacher also can look at document history to see students' comments and revisions.

Mobile devices, including mobile phones and tablets, also enable users to gather data and create content, anywhere, anytime, at a fraction of the cost of yesterday's computers. Increasingly, schools are adopting bring-your-own-device (BYOD) policies that allow students to use their own technology tools at school. Essentially, mobile devices put tools for inquiry and creativity into students' hands, equipping them to be more self-directed learners. In PBLT, students often need to leave the physical setting of school to conduct real-world research, and mobile devices allow them to take their digital toolkit with them. On a science project about water quality, for example, students might use mobile devices to analyze test samples in the field, take photos of stream conditions, and add precise GPS location information. This makes their learning environment more like the world beyond the classroom, where access to information and digital tools is ubiquitous.

To appreciate how online collaboration can be the springboard for global learning, consider the Flat Classroom Project. Cofounded

by educators Vicki Davis and Julie Lindsay in 2006, their project model used Web 2.0 tools to connect students and teachers from schools around the world. Middle and high school students from different cultures studied and discussed topics raised in Thomas Friedman's (2005) bestseller, *The World Is Flat*. These geographically dispersed teams then collaborated to create digital stories and other multimedia products that represented what they learned.

A similar project was underway in 2012 when Superstorm Sandy hit the East Coast, knocking out power to some households for weeks. Students from the affected region used their mobile phones to update their project partners. Davis says,

> In the middle of the storm, these kids were worried about their partners' depending on them. When a kid cares enough to get on a smart phone and leave a message for a partner halfway around the world, then you have fundamentally transformed that student. (as cited in Boss & Krauss, 2014)

Online content management systems are a related trend with specific benefits for PBLT. For instance, the New Tech Network, which includes more than 120 schools using PBLT as a core instructional strategy, has built its own proprietary learning management system, called Echo. The system gives students, teachers, and parents a real-time window into PBLT (including ongoing project work, upcoming assignments, and grades). It's a walled garden, accessible only to those within the network. Other platforms, such as fee-based Project Foundry (www.projectfoundry.org) and Edmodo (www.edmodo.com), which is a free social network for educators, incorporate content management and assessment tools that help teachers and students organize the moving parts of PBLT and keep learning on track.

Personalization of PBLT

Personalizing education is a goal that cuts across camps, according to Justin Reich, a fellow at Harvard's Berkman Center for Internet and Society. Reich (2012) states,

> Whether you are a market-based reformer, an open education advocate, or a 21st-century Dewey partisan, everyone agrees

that learning should be personalized: learning experiences should be tailored to each individual student. We also agree that personalization is made feasible by new technologies.

Heightened student engagement has long been identified as a key benefit of project-based learning (Thomas, 2000). Not surprisingly, engagement increases when projects have personal significance for students. Driving questions that frame the inquiry experience in PBLT are intentionally open ended, so that students can direct their own learning and decide how they will demonstrate their understanding. BIE calls this essential element "student voice and choice."

What do student voice and choice look like in action? Consider a project about heroism that begins with students reading literature or analyzing films that introduce the hero's journey theme. From there, the teacher has students form teams based on the hero they choose to celebrate—real or fictional, contemporary or historic, well known or unsung. Similarly, students are offered a wide range of options for how to honor their selected heroes, such as video documentary, museum-style exhibit, or community presentation. At this stage in the project, students are likely to have different needs for instructional support. To personalize the learning experience, the teacher provides a range of resources, such as curated content for deeper research, mini-lessons about nonfiction narrative writing, or YouTube videos about using specific technology applications. Based on formative assessment and the questions students are asking, the teacher matches students with instructional supports that meet their immediate needs.

At CDAT, the PBL program described at the start of this chapter, teacher Mike Reilly uses a version of the flipped classroom approach to personalize instruction for his digital media students. The flipped classroom idea is deceptively simple: instead of delivering lectures in class, a teacher records them, using video or screen-capture software, then posts lessons online for students to watch as homework (Bergmann & Sams, 2012). Reilly's approach offers a good illustration of how the flipped classroom concept can mesh with PBLT. Many projects in his program involve using the same software or editing equipment that the pros use. Rather than teaching the

whole class about software that only one or two students may be using; however, Reilly directs individual students to online tutorials to learn new applications. He checks in informally to assess their proficiency. For some students, the just-in-time tutorials provide all they need to get going. Others need more instruction from Reilly or perhaps help from peers who are already proficient with a particular tool or software. By differentiating instruction and inviting his students to share their expertise, Reilly helps all learners make progress at the speed that makes sense to them.

Content from other sources can be added to the flipped classroom approach, as well, such as Khan Academy lectures or, in Reilly's case, technical tutorials. In the PBLT classroom, such content is not necessarily assigned as homework; it's available "just in time"—whenever students need it to deepen or expand their inquiry.

Blended and Online Learning

Blended and online learning is another trend on the fast track to influence not only PBLT but education globally, according to the *Horizon Report* (Johnson et al., 2013). Early efforts are underway to combine project-based learning with online learning. Even for teachers who use projects often, bringing this approach to virtual spaces raises new challenges along with the opportunities.

For the New Tech Network, the initial motivation to consider online learning was to expand course offerings beyond what students might find on their own campuses, without jettisoning the PBLT approach used in face-to-face courses across the network. Lydia Dobyns, CEO of New Tech Network, explains, "It seemed that students were taking online courses [from other providers] more for expedience than for the learning experience. We didn't think students were being served as well when it came to learning to learn" (L. Dobyns, personal communication, March 5, 2013).

Convinced that online or blended learning "is the way of the future," Dobyns said, New Tech moved ahead with its first two pilot courses in 2012–2013. The first courses attracted students from across the United States, and online offerings are expected to expand in the future.

What's the potential for deeper learning with PBL online? Consider the design of an online statistics class. In a project called "The 'Mean' Truth About Unemployment," students used the concepts of mean, median, and mode to analyze monthly unemployment rates in their respective regions and then worked together (virtually) to produce a 20/20-style news segment in which they presented their analysis to a public audience (New Tech Network, 2013). The project launched with a video introduction from a real broadcast journalist, challenging students to produce video content to document their own investigations of local unemployment trends.

Having students collaborate on a project like this from different parts of the country set the stage for critical thinking as they compared and contrasted local information and observations. "What's more," Dobyns said, "students are building relationships with people from different backgrounds, people they would not have had opportunities to meet otherwise. The student feedback has been phenomenal. They're looking honestly at how much they have had to grow to learn this way" (L. Dobyns, personal communication, March 5, 2013).

Similarly, students who enroll in an advanced placement U.S. government class through the Online School for Girls, a virtual institution created by a consortium of independent schools, are navigating their first online PBL experience. In an interview, social studies teacher Mike Gwaltney explained the challenges and opportunities of combining online learning with the project approach (M. Gwaltney, personal communication, October 19, 2013):

- A significant challenge with online PBL seems to be that the nature of online education allows learners the ability (right?) to do work on their own pace and at the times that they prefer. Since PBL is naturally (or at least in my class, intentionally) collaborative, that presents a challenge for students: they have to at least think about their online work as being at the same pace and time as their project partners.
- To facilitate this, and in part to create a willingness to collaborate, I spend a good amount of time putting students

in situations where they have to share back-and-forth and collaborate in smaller ways. Examples are online discussions and small collaborative presentations on some piece of content. That helps all of them build rapport and a desire to work together.

- From there, students have to get good at using digital tools. Because my students are in every American time zone, digital collaborating requires they are good with Google Docs, Hangouts, VoiceThread, as well as email. Students have to determine for themselves how to use all these tools to bridge the time and space challenges. We've done quite a bit with PBL and VoiceThread, resulting in online presentations for our classes and for public use. As well, students have made short videos by sharing clips in Google Drive that they have recorded individually, then one student does some editing, and they share the files back around for further editing before a final version is made.

Within this digital context, Gwaltney also thinks hard about the relationship side of the learning experience. He describes what it means to get to know students online:

> Do I think I get to know the students well? I get to know them *differently.* With my face-to-face students, I learn plenty about them through non-verbal communication, and by just being around them. With the online students, I only ever see their intentional participation in class activities. But since their participation is so much more robust—they have to be constantly using their "voice" in class for daily discussions—I learn more about what they think than in the traditional brick-and-mortar classes. (M. Gwaltney, personal communication, October 19, 2013)

One student post on the class blog underscores the importance of feedback—in this case, delivered virtually—to promote deeper learning in PBLT:

> The discussion activities seemed to me less like assignments that we had to do, but rather a platform for each of us to raise our opinions and view what others hold as their thoughts on

> an issue. Whenever I saw people commenting on my post, no matter if the comment is agreeing or disagreeing with my opinion, I always found it beneficial to me. (chanchan0207, 2013)

Clearly, this new way of learning requires both students and teachers to hone their communication, collaboration, and problem-solving skills.

Maker Spaces, Rapid Prototyping, and PBL

Maker spaces are reinvented workshops that are equipped with both old-school construction tools and digital fabrication tools, such as 3-D printers, useful for producing prototypes or scale models. In school settings, maker spaces are gaining popularity, in part because they foster the creative thinking and innovation strategies that go hand in hand with PBLT.

The maker movement began outside of education, with people of all ages using a range of tools (from jigsaws and soldering irons to laser cutters and 3-D printers) to unleash grassroots creativity and collaborative problem solving. The make-to-learn idea is rapidly making its way into K–12 settings as a strategy to build students' creative confidence, encourage collaboration, and spark interest in the science, technology, engineering, and mathematics (STEM) fields. In 2012, the first ten pilot sites of an anticipated one thousand high school maker spaces opened in California. Funding is coming from the Defense Advanced Research Projects Agency.

Recognition of the potential of making to learn goes far beyond STEM fields. Make-to-learn environments include not only workshops, but also libraries and community recording studios that foster digital creativity.

The make-to-learn movement also has implications for the teaching of writing. As Elyse Eidman-Aadahl of the National Writing Project explains (Boss, 2013):

> Every writer is trying to make something—some new knowledge with language, some new framing or understanding. We write to inquire about something we don't fully know at the beginning, and we use making (with text and sometimes

> images) as a way to push that inquiry forward. Then we share it with the world . . . Now we have colleagues saying this is what engineering is, this is what the arts are, this is what civic engagement and the design of communities can be. We're seeing a common belief about the kind of learning environments where people do serious and creative work.

Sylvia Martinez and Gary Stager (2013), coauthors of *Invent to Learn*, see maker spaces as ideal settings for student-driven learning in the constructivist tradition: "This 'maker movement' overlaps with the natural inclinations of children and the power of learning by doing. The active learner is at the center of the learning process, amplifying the best traditions of progressive education" (Kindle loc. 172 of 5629). Having a dedicated workspace in a school that puts tools and materials into students' hands, they note, offers a strategy to "reinvigorate project-based learning" (Kindle loc. 191 of 5629).

To imagine the benefits of maker spaces, picture a class of ninth graders in an interdisciplinary class that combines environmental science and geography. These students tackled an engineering question that could have far-reaching benefits: How can we design the most efficient, solar-powered mango dehydrator for Haiti? Their question was not theoretical. They were developing a design that would actually be tested in Haiti. It's a poor country where new sources of revenue from agriculture, such as producing dried mangoes, could help lift farming families out of poverty.

Science teacher Leah Penniman designs such real-world projects at Tech Valley High School in Rensselaer, New York, to give her students opportunities to apply their understanding of engineering and environmental science. A previous class of ninth graders developed a comprehensive reforestation plan for an environmentally distressed region of Haiti, and a team of Tech Valley students traveled to the country to work alongside Haitians to implement the plan.

A variety of supports are in place to set the stage for such ambitious projects, including schoolwide use of PBLT for instruction and a culture that encourages teacher collaboration. For instance, Penniman has developed working relationships with professional

engineers who consult at the project design stage and also give students critical feedback at key times throughout the project.

The school is one of a growing number that are introducing design workshops or maker spaces to complement PBLT. Students have access to high- and low-tech tools and materials that allow for rapid prototyping and collaborative problem solving. Along with laptops, they have a workspace adjacent to the science classroom equipped with tools and materials for building prototypes. Students use the workspace to make their thinking visible, improving solutions through iterative cycles of rapid prototyping, testing, feedback, and revision. "Until students get their hands on materials, sometimes they don't understand how to design," Penniman observes in an interview (L. Penniman, personal communication, September 5, 2012).

During a project, students will typically cycle through multiple learning experiences: workshop-style lessons or mini-lectures to explain concepts, online research and analysis with project teams, sketching and online modeling, hands-on exploration of materials, and building, testing, and improving prototypes. "It's not necessarily linear," Penniman said. Student teams may cycle through the workshop several times as they test and fine-tune prototype designs. Teams collaborate on end-of-project presentations to formally present their findings.

Technology to Support PBL Teachers

The shift from traditional teaching to project-based learning is challenging and requires teachers, students, and administrators to develop new ways of working together. In shifting to PBL, teachers must reconsider how they design curriculum, how they scaffold instruction, and how they assess learning outcomes. Through project experiences, students are expected to acquire deep understanding of content while also applying 21st century skills that may be new to them. Incorporating technology into this mix can add more confusion, especially if there is no coherent vision of why the shift to a new pedagogy, with new tools, is worth all the effort (Park & Ertmer, 2008). Administrators need to encourage this shared vision through their leadership and also remove systemic barriers—such as poor

technology access or inadequate teacher planning time—that can interfere with PBLT.

Yet technology can also provide a lifeline for teachers who might otherwise be struggling alone with the shift to PBL. Teachers who make progress with PBL use technology to build their understanding of this instructional approach (Ravitz & Blazevski, 2010). They access online resources such as project libraries to help with project design. They also use technology tools to connect with peers for feedback, mirroring in their professional networks the collaboration that they want to see students practicing during projects (Ravitz & Blazevski, 2010).

During project implementation, PBLT teachers may use digital tools to scaffold instruction, encourage collaboration, provide students with feedback, and manage the flow of project work. Indeed, the more teachers use online features, the better prepared they feel to handle project challenges. As Jason Ravitz and Juliane Blazevski (2010) note, "online tools may provide an important way for teachers and schools to help address the challenges of PBL use" (p. 9).

Schools doing PBLT wall to wall, such as those that are part of the Deeper Learning Network, allow generous time for collaborative professional development as part of their models. For teachers who do not have that sustained support on site, online communities of practice may help fill at least some of the gaps. Connected educator activities, such as #PBLChat on Twitter or Google Hangouts to discuss PBL best practices, make use of social media tools to support ongoing professional learning and foster peer collaboration.

Implications for Practice

A number of factors are aligning to encourage the wider acceptance of PBLT. Digital tools are becoming more affordable, powerful, and accessible. Educators are gaining appreciation for project-based learning as an effective, engaging instructional strategy. Expectations for what learners need to know and be able to do are becoming increasingly rigorous. Together, these factors have four implications for practice:

1. Consider technology integration and PBL goals together as part of an overall vision of deeper learning through PBLT.

2. Focus on deeper learning goals first; then consider appropriate technology tools to help meet them.
3. Be authentic—as students take on the roles of professionals, have them use the tools of the discipline (scaffolding the experiences as needed to be right-sized to fit the learning needs and abilities of students).
4. Leverage technology to support teachers as they build confidence and competence with PBLT, and provide professional development that champions their continued learning and collaboration with peers.

If PBLT continues its rapid expansion, we may finally realize the vision of more authentic, student-centered learning that has been on the horizon for decades. Twenty years ago, researchers identified a then-promising school reform model calling for

> lengthy multidisciplinary projects, cooperative learning groups, flexible scheduling, and authentic assessments. In such a setting, technology is a valuable tool. It has the power to support students and teachers in obtaining, organizing, manipulating, and displaying information. These uses of technology will, we believe, become an integral feature of schooling. (Means & Olson, 1994)

That model was rare in the 1990s. It's still far from the norm for most U.S. students. But when the right pieces are in place, we see benefits for both students and teachers. We need to watch, learn from, and celebrate pioneers who are leading the way with deeper learning through PBLT. Their results show what is possible when technology is ubiquitous and pedagogy is student centered.

References and Resources

Bergmann, J., & Sams, A. (2012). *Flip your classroom: Reach every student in every class every day*. Eugene, OR: International Society for Technology in Education.

Boss, S. (2013, May 15). Gearing up for a summer of making, connecting and learning by doing [Web log post]. Accessed at http://learning.blogs.nytimes.com/2013/05/15/guest-lesson-gearing-up-for-a-summer-of-making-connect ing-and-learning-by-doing/?_r=0 on May 20, 2014.

Boss, S., & Krauss, J. (2007). *Reinventing project-based learning: Your field guide to real-world projects in the digital age*. Eugene, OR: International Society for Technology in Education.

Boss, S., & Krauss, J. (2014). *Reinventing project-based learning: Your field guide to real-world projects in the digital age* (2nd ed.). Eugene, OR: International Society for Technology in Education.

Bransford, J. D., Brown, A. L., & Cocking, R. R. (2000). *How people learn: Brain, mind, experience, and school*. Washington, DC: National Academy Press.

chanchan0207. (2013, October 7). Together or not together? That is a question [Web log post]. Accessed at http://osgapusgov.wordpress.com/2013/10/07/together-or-not-together-that-is-a-question/ on May 20, 2014.

Darling-Hammond, L., Barron, B., Pearson, P. D., Schoenfeld, A. H., Stage, E. K., Zimmerman, T. D., et al. (2008). *Powerful learning: What we know about teaching for understanding*. San Francisco: Jossey-Bass.

Digital Media and Learning Research Hub. (2012). *The essence of connected learning*. Accessed at http://dmlcentral.net/resources/5000 on October 19, 2013.

Finkelstein, N., Hanson, T., Huang, C.-W., Hirschman, B., & Huang, M. (2010). *Effects of problem based economics on high school instruction* (NCEE 2010–4002). Washington, DC: National Center for Education Evaluation and Regional Assistance, Institute of Education Sciences, U.S. Department of Education.

Friedman, T. L. (2005). *The world is flat: A brief history of the twenty-first century*. New York: Picador.

Hmelo-Silver, C., Ravit, D., & Chinn, C. (2007). Scaffolding achievement in problem-based and inquiry learning: A response to Kirshner, Sweller, and Clark (2006). *Educational Psychologist*, *42*(2), 99–107.

Hutchison, H. (2013, April 1). Project based learning . . . I think we really did it! [Web log post]. Accessed at http://communicateconnectsupport.com/2013 /04/01/project-based-learning-i-think-we-really-did-it/ on March 27, 2014.

Ito, M., Gutiérrez, K., Livingstone, S., Penuel, B., Rhodes, J., Salen, K., et al. (2013). *Connected learning: An agenda for research and design*. Irvine, CA: Digital Media and Learning Research Hub.

Johnson, L., Becker, S. A., Cummins, M., Estrada, V., Freeman, A., & Ludgate, H. (2013). *NMC Horizon report: 2013 K–12 edition*. Austin, TX: The New Media Consortium.

Krauss, J., & Boss, S. (2013). *Thinking through project-based learning: Taking inquiry deeper*. Thousand Oaks, CA: Corwin.

Lehmann, C. (2010). *TEDxNYED* [Video file]. Accessed at www.youtube.com/watch?v=6FEMCyHYTyQ on May 20, 2014.

Martinez, S., & Stager, G. (2013). *Invent to learn: Making, tinkering, and engineering the classroom*. Torrance, CA: Constructing Modern Knowledge Press.

Means, B., & Olson, K. (1994, April). The link between technology and authentic learning. *Educational Leadership*, *51*(7), 15–18. Accessed at www.ascd.org/publications/educational-leadership/apr94/vol51/num07/The-Link-Between -Technology-and-Authentic-Learning.aspx on October 17, 2013.

Mergendoller, J. (2012). Teaching critical thinking skills through project based learning [Web log post]. Accessed at www.p21.org/news-events/p21blog/1097-teaching-critical-thinking-skills-through-project-based-learning on December 29, 2013.

Mergendoller, J. (2013, April 11). Does project based learning teach critical thinking? [Web log post]. Accessed at http://biepbl.blogspot.com/2013/04/does-project-based-learning-teach-critical-thinking.html?spref=tw on October 17, 2013.

Mergendoller, J., & Larmer, J. (2010). Seven essentials for project-based learning. *Educational Leadership*, *68*(1), 34–37.

Mergendoller, J. R., Maxwell, N. L., & Bellisimo, Y. (2006). The effectiveness of problem-based instruction: A comparative study of instructional methods and student characteristics. *Interdisciplinary Journal of Problem-Based Learning*, *1*(2), 49–69.

Merrow, J. (2013, April 3). *School district uses project based learning over testing* [Video file]. Accessed at http://video.pbs.org/video/2364990349/ on March 27, 2013.

New Tech Network. (2013). Digital learning @ New Tech Network: A glimpse into a project [Web log post]. Accessed at www.newtechnetwork.org/about/video/digital-learning-new-tech-network-glimpse-project on December 29, 2013.

Park, S. H., & Ertmer, P. A. (2008). Impact of problem-based learning (PBL) on teachers' beliefs regarding technology use. *Journal of Research on Technology in Education*, *40*(2), 247–267.

Pellegrino, J. W., & Hilton, M. L. (Eds.). (2012). *Education for life and work: Developing transferable knowledge and skills in the 21st century*. Washington, DC: The National Academies Press.

Ravitz, J., & Blazevski, J. (2010, October 28). *Assessing the impact of online technologies on PBL use in US high schools*. Paper presented at Annual Meetings of the Association for Educational Communications and Technology, Anaheim, CA. Accessed at www.bie.org/research/study/online_supports_for_pbl_use on October 17, 2013.

Ravitz, J., Hixson, N., English, M., & Mergendoller, J. (2012, April 16). *Using project based learning to teach 21st century skills: Findings from a statewide initiative*. Paper presented at Annual Meetings of the American Educational Research Association, Vancouver, BC. Accessed at www.bie.org/research/study/PBL_21CS_WV on October 17, 2013.

Reich, J. (2012, June 25). Battling over the meaning of personalization [Web log post]. Accessed at http://blogs.edweek.org/edweek/edtechresearcher/2012/06/battling_over_the_meaning_of_personalization.html on October 17, 2013.

Reilly, M. (2013). Creating animation for PBS—in high school [Web log post]. Accessed at http://library.creativecow.net/reilly_michael/CDAT-History-Videos/1 on December 29, 2013.

Schachter, R. (2013, December). Schools embrace project-based learning 2.0. *District Administration*. Accessed at www.districtadministration.com/article/schools-embrace-project-based-learning-20 on December 29, 2013.

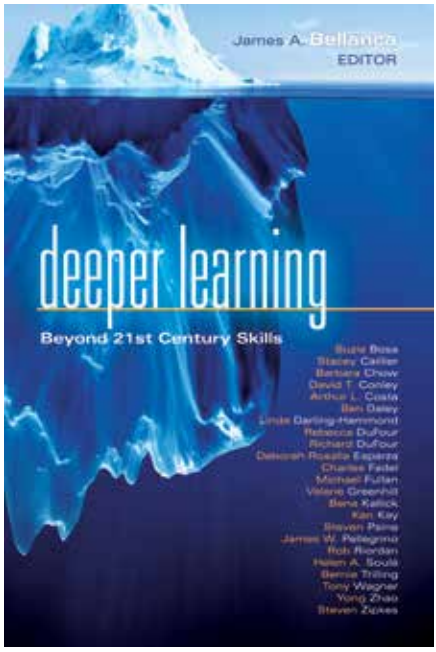
Thomas, J. W. (2000). A *review of research on project-based learning*. San Rafael, CA: Autodesk Foundation. Accessed at www.bobpearlman.org/BestPractices/PBL_Research.pdf on April 4, 2014.

Vander Ark, T., & Schneider, C. (2013). *How digital learning contributes to deeper learning*. Seattle, WA: Getting Smart. Accessed at http://gettingsmart.com/2012/12/how-digital-learning-contributes-to-deeper-learning/ on April 4, 2014.

Vega, V. (2012). *Project-based learning research review*. Accessed at www.edutopia.org/pbl-research-learning-outcomes on December 29, 2013.

Wagner, T. (2012). C*reating innovators: The making of young people who will change the world*. New York: Scribner.

Zhao, Y. (2012). *World class learners: Educating creative and entrepreneurial students*. Thousand Oaks, CA: Corwin.



Order now

James A. Bellanca

Available for PD