Principles for Effective Digital Learning: A Review of Literature

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Executive Summary

While technology has and will continue to change, there are some things that educators can rely on as constants. There are many things that we, as a community of educators, know about how people learn. We know how to implement effective instruction, and we know how to design assessments that actually support learning. There are many decades of research about what does and doesn't work well when it comes to helping students achieve their academic potential, regardless of the resources we use to do so. But along with the introduction of the then-new personal computer into our nation's classrooms, begun in the late 1970s and early 1980s, there began additional research on the effectiveness of these new technologies. While not originally designed for teaching, many educators were excited about the potential for these technologies to take over many educational functions, perhaps even reducing the need for teachers!

> *Were the ancient Greek philosopher Heraclitus to join us today, he might feel affirmed that his belief in change as a fundamental, universal force is still alive and well, especially when it comes to technology. The amount and rate of technological change in our lifetimes are rapid and astounding. Small, powerful, portable devices now pervade every aspect of our lives, including the worlds of work, entertainment, and education, and as those technologies change, so do our worlds. Some educators who once felt that they may have finally gotten a firm command on effectively incorporating one device in their classroom, a device such as a desktop or laptop computer, have then been charged with considering the implications of tablets, then smartphones, next augmented and virtual realities, and on the very near horizon the growing influence of Internet of Things (IoT) devices and artificial intelligence, and… Whether Heraclitus actually wrote "change is the only constant" or not—as opinions have changed even over the translations of his work—the sentiment holds true for technology. Technology is constantly changing.*

Much of the early research, and early practice, on technology in education suffers from methodological flaws. Early educational technology resources tried to focus on technology resources as they would a clinical drug trial, using "traditional" teaching—whatever that is—as the placebo. Do computers work better than teachers or not? In his now famous treatise on reconsidering research on learning from media, Clark (1983) notes that these so-called "media selection" or "media comparison" research design models were asking the wrong question. Media devices available at that time—and still today—by *themselves* have no inherent properties that one should assume will influence learning, positively or negatively. As Clark noted, "media are mere vehicles that deliver instruction but do not influence student

achievement any more than the truck that delivers our groceries cause changes in our nutrition" (p. 445). This is still true today. Instead of asking "is it better than…" more recent research focuses on questions like "when is technology most effective?"

Technology *has* become effective at replacing low-level instructional duties. It can administer and score multiple-choice assessments to dozens, even hundreds of students simultaneously in a fraction of the time it would take any teacher. It can provide up-to-the-minute snapshots of student progress to relevant teachers, their students, and students' families in safe and secure environments with colorful and easy-to-read data reports tracking progress over time. And no teacher has the patience to match technology when it comes to presenting and re-presenting content over and over, whether reading text, watching video, or interacting with animations or other media so students can view and review as much content as often as they need to. But these savings in efficiency for low-level instructional activities provided by technology have actually changed the potential for what teachers can do, when and where learning can occur, and with whom. Technology goes beyond automation and makes it possible for teachers and students to access real-world resources, content, experts, and problems using the same or similar technologies that professionals use. Going far beyond rudimentary drill-and-practice or "read and click" tutorials, teachers can use technology to differentiate instruction to the needs of students as they engage in rigorous learning where they create new knowledge and information relevant to the content being studied, as well as their lives, interests, and experiences. No school currently has access to technology that can do that on its own. As noted time and again throughout the literature on technology integration, "It's more important *how* you use technology than *if* you use it" (Cennamo, Ross & Ertmer, 2018, p. 2; Bundick, Quaglia, Corso & Hawood, 2014; Gurung & Rutledge, 2014), and one of the most important components when using technology is a skillful teacher (Darling-Hammond, Zielezinski & Goldman, 2014; McDonald, 2016).

The topics in this review are based on discussions with district leadership in Seattle Public Schools and a review of relevant documents and artifacts that support the district's mission. Central to teaching and learning in the district are two frameworks: (1) Charlotte Danielson's *A Framework for Teaching* and a pyramid of pedagogical knowledge based on the *Skillful Teacher* from Research for Better Teaching, Inc. Both frameworks address components related to curriculum planning, motivation, instructional strategies, and managing learning. While the two frameworks are important to district leaders in Seattle, the question posed for this review was "how do digital technologies and content resources support best practices in these areas?" This literature provides information and data to explore that question.

Based on a set of principles derived first out of the analysis of the crossover between the two frameworks and major themes in the literature, the following principles are explored in this review of literature. At the end of the review of literature for each principle are questions for consideration that educators at various levels—classroom, school, program, or district—may want to consider and discuss to determine connections between the literature that supports the principle and their own practice and philosophies regarding effective digital learning.

Principle 1: Digital resources promote student achievement for all students, especially historically underserved students, when students use them to produce information rather than passively consume information, but technology use alone is ineffective unless mediated by an effective teacher.

What does this principle mean for schools?

- Digital resources are only effective when used appropriately, as evidenced through decades of research. Technology use alone is ineffective unless mediated by an effective teacher. Technology cannot replace the impact of a highly qualified teacher. Some technology uses, such as drill-and-practice exercises, programmed instruction, using word-processing software for grammar/punctuation practice or checks, and reading activities that rely on drill or tutorials as negatively impacting student achievement.
- Generally, technology will not replace teachers, but it can change what it means to be a teacher, and a learner, and it can replace rudimentary or low-level teaching activities. Technology can be a catalyst for learning that can both be used for helping students develop foundational knowledge and basic skills as well as demonstrate their learning in new ways. New pedagogical models put teachers in the role of activators of learning.
- When used to promote deeper learning through tasks that require students to create content and produce new information, students—especially historically underserved students—show greater gains in achievement than when students use digital resources to consume information.
- Technology is not culturally neutral. Cultural experiences and backgrounds influence both how technology is perceived or received within a culture as well as the role it is expected to play. When used effectively by a culturally responsive teacher, technology can help move students beyond achieving shallow knowledge attributed to dependent learners to deeper learning in environments that promote critical and creative thinking in which students become self-directed, independent learners.

Principle 2: Digital resources help teachers develop authentic learning opportunities that align with the depth of rigor of college-and-career ready standards and are relevant and meaningful to students.

What does this principle mean for schools?

- The best learning occurs when learning is *authentic.* To be authentic, learning should have explicit connections to life outside of school—not only in later college and careers, but to students' current lives outside of school. Authentic intellectual work allows students to construct knowledge within a discipline that has value beyond school.
- The ultimate goal of learning is *transfer*—the application of new knowledge and skills in a novel or unique setting, preferably a real-world setting. Mastering core content is important but insufficient for transfer in most cases. Instead, deep learning tasks help students develop the capacities to learn, create, and implement what they have learned.
- New pedagogies that integrate technology are more complex than ongoing trends and fads. They instead incorporate digital resources so that learners can create and use new knowledge in the real world,

Principle 3: **Digital resources have and continue to change what "literacy" and "being literate" mean and look like.**

What does this principle mean for schools?

- "Being literate" has always depended upon the prevalent technologies of the day. Digital technologies are rapidly expanding what it means to be literate through the generation of New Literacies. Students who have limited opportunities to engage with online resources and develop new literacies demonstrate lower general literacy abilities than their peers. Schools and districts that do not prepare students for these New Literacies are not preparing "literate" students.
- In order to be considered literate, students must not only be able to find and evaluate information but should be able to create verifiable information using relevant media, following accepted standards and practices.

Principle 4: **Digital resources can help but alone are insufficient for helping students authentically engage in learning.**

What does this principle mean for schools?

- Technology can engage students, for a while, but authentic instruction is more likely to yield authentic instruction in learning. Again, technology alone is insufficient for engaging students in authentic learning; it's how it's used that is important. Without authentic learning opportunities, technology can also lead to ritual compliance, retreatism, and even rebellion.
- Students report a wide range of outcomes related to the highest levels of engagement. These go beyond simply using technology and include indicators such as solving real problems, being respected, and making a difference in the world. These align with research that suggest successful, student-engaging classrooms combine relevant, real-world situations or constructs; technology-rich environments; and environments where teachers are co-learners and there is respectful collaboration between students and teachers.

Principle 5: **Digital resources allow students and teachers to connect and collaborate with other students, teachers and other influential adults, and with the content.**

What does this principle mean for schools?

- Students entering college and careers require strong inter- and intrapersonal communication skills and the ability to collaborate effectively. In most industries today, communication and collaboration are either facilitated by or supported by digital technologies and the new literacies they require.
- Students (and adults) are already connecting through various media. Schools may see it as an obligation to support appropriate means for communicating and collaborating with others using digital technologies, whether synchronously or asynchronously, in

order to prepare students for life outside of school. Today, not just later in college and careers.

- Simply providing access to technology alone will not help students become effective communicators and collaborators. They need to be taught these skills in supportive environments using the technologies they do and will use outside of school. Ineffective grouping strategies can negatively impact students. Collaborative groups are more successful when the group members determine goals for the group, and each individual understands their own role in reaching those group goals. Students need to be taught how to communicate and share ideas clearly, listen actively, consider the ideas and perspectives of others, and provide constructive feedback that promotes learning and moving towards the group goals

Principle 6: Digital resources provide opportunities for students to demonstrate mastery of learning goals in a variety of ways.

What does this principle mean for schools?

- A variety of digital tools and resources are available to support a balanced approach to assessment that includes formative, interim, and summative assessment opportunities. These tools can make it easier to present assessment items, sometimes score items, and to collect, analyze, and report data from some of those assessments. Using digital tools to support assessment can improve the efficiency in which students and teachers engage in assessment of and for learning.
- It is difficult to manage all of the data currently made available through a coherent, comprehensive and continuous assessment system without digital technologies. Digital technologies make it easy to track individual and groups of students and how they perform on assessments that can be linked to content standards or other desired learning outcomes, either individual or multiple standards.
- Very little learning can be represented by a dichotomous “got it or didn’t” accounting mindset. Learning progressions are used to describe a well-defined model of how students might be expected to learn. Instruction based on learning progressions can help students achieve transfer, the ultimate goal of learning.
- Using a backwards design approach identifies relevant assessments first that then guide the development of curricula, units, and lessons. Determining assessments first can also determine the types of resources, such as digital technologies, and supporting skills that should also be addressed during instruction.
- Formative assessment strategies are one of the most effective instructional interventions for promoting student achievement.
- While standardized assessments can incorporate technology to capture and report student performance data, these assessments are limited by time and testing formats when trying to assess content standards that require strategic or extended thinking. These standards are often assessed at the classroom level and require multiple and varied representations of concepts and tasks.
- Interim assessments can be used to impact student outcomes on later summative assessments if they are implemented with fidelity. In addition to embedding them within

the learning cycle and the reporting student data from these, teachers and administrators must be prepared to act upon that data to address student learning needs. When used to provide opportunities for problem, project- or performance-based assessments, interim assessments may help teachers restructure teaching in the moment and provide a more comprehensive picture of student achievement. The more closely assessment is linked to and occurs with instruction, the greater opportunity it has to promote student achievement.

- Few assessment experts agree that assessments can be used for multiple purposes. The best assessments are designed to generate data for specific types of purposes and decision making. Trying to use assessments for multiple purposes can erode their validity and reliability.
- Interim and summative assessments can be helpful for making programmatic decisions over long periods of time, and digital technologies make the collection, analysis, and reporting of data more efficient.
- Digital resources are helpful when incorporating problem-, project-, or performance-based tasks, as they often require students to collect, analyze, and create a range of information in a variety of formats.

Principle 7: Digital resources allow teachers and students to monitor progress towards learning goals.

What does this principle mean for schools?

- Formative assessment strategies are one of the most effective instructional interventions for promoting student achievement, especially for students formerly categorized as low achievers. There are a variety of digital resources that can help teachers and students implement formative assessment strategies effectively and efficiently.
- Formative assessment strategies are not an event, like a test, but a process. Formative assessment strategies occur daily during the interactions students have with teachers, with each other, and in self-assessing their own learning. Formative assessment strategies may also be referred to as assessments *for* learning, because they are embedded in the learning process and should result in new learning by students.
- Teachers can predetermine formative assessment opportunities based on their understanding of learning progressions for different content standards or learning outcomes.
- Formative assessment strategies can create a good deal of data for each student. Digital resources are a more efficient method for collecting and sharing this data than print.
- If teachers cannot create learning targets that students understand, it is unlikely they can create valid and reliable assessments for those learning targets.

This review of literature provides evidence to support conversations about effective digital learning. It is not a playbook, but a starting point for conversations and planning. The research supporting the principles for digital integration demonstrate that technology *can* be used effectively to promote student achievement on academic measures and other desired learning

outcomes, such as engaging students in authentic learning opportunities that help make connections between content and the real world; keeping up with the changing meaning of "being literate;" and helping students develop supporting skills important for success in college and careers, skills such as critical and creative thinking, communication, and collaboration. Many of the principles overlap or contribute to each other. Taken as a whole, there is one clear message from the research that undergirds them, **technology is only effective when used appropriately, and that use is mediated by a skillful teacher.**

Literature Sources

An intentional effort was made at the onset to identify scholarly, peer-reviewed literature sources to inform this review. Purposefully, a date range of the last 10 years was used to identify initial sources, however, some notable exceptions do occur based on their prominence and acceptance within the education community and the need to explore primary sources from the initial found set. These include pivotal works by the National Research Council and others who routinely summarize educational research and noted experts in their fields of study, such as Dylan Wiliam and Margaret Heritage, both noted experts in formative assessment, just to name a few. Most sources have been published since 2000. Opinion and theoretical works are not included; however, some readers familiar with education and educational technology literature will note a couple of sources from authors that are well known for promoting theoretical and philosophical positions. In these and all other cases, sources from those authors had to include evidence from practice or research to support their inclusion. A few evaluation studies of technology initiatives are also included. The intent was to identify the best available evidence to support for conversations and decision making in Seattle Public Schools.

About the Author

John Ross has spent much of the past 20 years helping educators understand how technology integration enhances school improvement efforts. He served formerly as the director of the federally funded Institute for the Advancement of Emerging Technologies in Education and the director of technology for the Appalachia Regional Comprehensive Center (ARCC), where he collaborated routinely with multiple federal and state education leaders planning for and implementing statewide and regional educational technology initiatives. He currently works as an educational consultant and coach in school districts across the country.

He is co-author of the first textbook to address the National Educational Technology Standards for Teachers (NETS-T) for the International Society for Educational Technology (ISTE). The third edition of *Technology Integration for Meaningful Classroom Use: A Standards-Based Approach,* co-authored with Dr. Katherine Cennamo from Virginia Tech and Dr. Peg Ertmer from Purdue. The third edition focusing on the release of the new *ISTE Standards for Educators* was released in 2018. His chapter on using technology to support creativity is featured in Mary Kim Schreck's *Transformers, Creative Teachers for the 21st Century.* He has served as consultant and evaluator for numerous projects, such as the Virginia Department of Education's e-Learning Backpack Initiative, Kids' Tech University at Virginia Tech and as an online professional development expert for the Virginia Council on Economic Education and the state education agencies in Alabama, Florida Georgia, North Carolina, Tennessee, and Virginia.

He has extensive experience in developing and delivering online learning for teachers and students. His book, *Online Professional Development: Design, Deliver, Succeed!* (Corwin) was selected as book-of-the-month for July 2011 by Learning Forward and was a publisher's bestseller in its first year of publication. The book is the first "how to" book for designing online professional development and includes case studies of some of the nation's earliest and most successful online professional development programs, including those Ross managed. Because of the book's success, he was invited to contribute the chapter "Online Courses" to the third edition of the popular *Powerful Designs for Professional Learning* co-published by Learning Forward and Corwin in 2015. The online astronomy course he developed for Virtual Virginia with his colleague Anita Deck was selected as one of the "Best of 2014 High School Courses" in iTunes U.

Dr. Ross holds a Ph.D. in curriculum and instruction and instructional technology from Virginia Tech and was a classroom teacher for 10 years. You can find out more about him and his work at TeachLearnTech.com or @TeachLearnTech

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From the Thornburg Computer Services proposal:

> **Suggestions for Success Professional Learning:** In support of Seattle School District 1 goal of focusing on the instructional needs of teachers and the learning needs of students in K-12, Dell is proud to provide Executive Leadership focused professional learning days as a value add that will be tailored to Seattle School District 1 goals and objectives. Upon winning RFP06792 and subsequent purchase, Dell will provide 30 days of customized onsite Professional Learning, market value $78,000. A customized implementation plan will be created in conjunction with district leadership in order to best align the right professional learning offering to best support classroom instruction needs. All consultants are highly skilled educators that hold advanced degrees and have held classroom and district positions across the country.
>
> As educators, we know that simple technology integration is not enough to transform a classroom or school. Instead, an entire learning environment is needed in which students, teachers, administrators, and parents can easily communicate and collaborate with each other, share secure information around the clock, and, ultimately, access a world of knowledge beyond classroom walls. While technology is a tool used by educators, it is not a replacement for the influence that people have on student achievement. To truly enhance education in the digital age, instructional leadership & pedagogy must connect every member of the education system so that each can play a vital role in reshaping education. Dell is proud to provide a professional learning plan that merges innovative technology solutions with enhanced teaching, leading and learning outcomes. These outcomes—developed and implemented through facilitated strategic and implementation planning consulting will provide the Seattle School District with a collaborative framework that informs future steps in the synthesis of a student-centered learning model with enhanced technology access over time.

This research, a foundation for our Professional Development, used seven days of the allocation of the 30 days of work from Advanced Learning Partnerships.

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Introduction

Since the 1980s, there has been an obvious growing presence in our nation's classrooms, and in many schools across the globe. This presence, of course, is the proliferation of small, powerful, portable computing devices that can access high-quality digital content, information, and resources from virtually anywhere learning can occur. Computing devices have been available in classrooms for decades and educators and researchers have been interested in their potential to support teaching and learning from the time the first personal computer (PC) showed up. Even this author started his teaching career in 1986 with one computer in his classroom after writing a master's thesis on evaluating the then-new educational software becoming available for the new PC.

Since then, access to digital devices and content has blossomed and made strides in leveling the playing field for students of all types. This is especially true in schools, which have long provided access to devices and the Internet for students of all backgrounds, including students from historically underserved populations who routinely show lower rates of access to computers or the Internet at home, or who have "handheld-only" access through smartphones. Within 10 years of the launch of the first National Educational Technology Plan (U.S. Department of Commerce, 1999), schools successfully met and exceeded the expectation that schools would achieve a ratio of five students per computer. Within those 10 years, the U.S. Department of Education (Gray, Thomas, & Lewis, 2010) reported that across the nation's schools a computer was either available in the classroom or could be brought into the classroom at a ratio of 1.7 students per computer, and the Education Superhighway (2018) reports that less than 5% of students in Washington state have not met the federal goal for broadband connectivity in their schools. There is and has been no significant difference in terms of access to devices and the Internet at schools across the country for students of different ethnic/racial backgrounds or gender. Since the data was last collected in 2010, schools have continued to add laptops, tablets, and other mobile devices in classrooms, labs, or on mobile carts and even encouraged students to use their own technology in "bring-your-own" programs.

Schools often take some time to catch up to trends in business and industry, and so it should be no surprise that some schools are still grappling with how best to use these ubiquitous computing devices to support their goals, the role of technology and need for skilled technology workers has grown exponentially in business and industry. Recent trends that have changed the demands of work and life can be directly attributed to increasing automation, globalization, workplace changes, and policies increase personal responsibility (Jerald, 2009). Business and government leaders often use the fields of science, technology, engineering, and mathematics and its popular STEM acronym to make the call for an increased number of highly skilled workers to address these trends. Many cite the shifting role of workers in many occupations that now need technology skills and knowledge (Bughin, Hazan, Lund, Dahlström, Wiesinger, Subramaniam, 2018), such as healthcare and medicine which usually comprise the bulk of the

fastest growing occupations in the United States (U.S. Department of Labor, 2018), as well as the growing number of new careers that have been made available through technology innovations.

Authors for the National Academy of Sciences, National Academy of Engineering, and the Institute of Medicine (2011), report that advances in science and engineering are creating a disproportionality in terms of careers available and workers skilled enough to enter them. They reported, in 2011, that only 4% of the nation's workforce is composed of scientists and engineers but that "this group disproportionately creates jobs for the other 96%" (p. 4). They give examples of new opportunities for careers in medicine to archaeology as a result of deciphering the human genome, and improvements in integrated circuits that has now made some tools such as tape recorders, paper maps, pay phones, and two-dimensional X-rays obsolete. They emphasize that it is not simply scientists and engineers that benefit from innovations in technology, it is everyone in the chain of manufacturing, from factory workers, advertisers, delivery personnel, salespeople, people who maintain new products and systems, and of course, those who use them benefit. All along this chain, technology is influencing and changing how workers in these and similar positions work.

The U.S. Bureau of Labor Statistics (Fayer, Lacey & Watson, 2017) confirms the growing number of job openings in STEM occupations as well as a significant gap in available workers. There were nearly 8.6 million STEM jobs in 2015 and STEM occupations had above-average growth, growing by 10.5 percent between May 2009 and May 2015. Computer occupations far outgrew other areas of STEM and are expected to exceedingly outpace growth in other STEM areas through 2024, which will unfortunately leave a projected gap of more than 1 million job openings in computer occupations alone. Racial minorities and women are traditionally underrepresented in STEM fields (Hansen & Gonzalez, 2014), and policies that promote increased participation of these underrepresented groups in STEM fields is one strategy for meeting needs for skilled workers.

Neither technology skills nor academic content knowledge alone will be sufficient to prepare current students for future success in college and careers. In a 2016 survey by PayScale, 44% of managers who responded to the survey reported they feel new graduates lack the important hard skill of writing proficiency. However, similar and larger percentages of managers felt that new graduates were lacking many more soft skills, such as critical thinking/problem solving (60%), attention to detail (56%), communication (46%), ownership (44%), and leadership (44%).

This development—ubiquitous access to high-quality content through powerful, portable computing devices—can, and some might say *should,* shift what learning looks like. But it won't unless teachers are prepared to leverage these materials to help reach both academic and other learning outcomes. Like many things in education, there is no guarantee that simply adding technology to a classroom environment will increase student achievement. As noted time and again throughout the literature on technology integration, "It's more important *how* you use technology than *if* you use it" (Cennamo, Ross & Ertmer, 2018, p. 2; Bundick, Quaglia, Corso & Hawood, 2014; Gurung & Rutledge, 2014).

About this review

The topics in this review are based on discussions with district leadership in Seattle Public Schools and a review of relevant documents and artifacts that support the district's mission. Central to teaching and learning in the district are two frameworks: (1) Charlotte Danielson's *A Framework for Teaching* and pyramid of pedagogical knowledge based on the *Skillful Teacher* from Research for Better Teaching, Inc. Both frameworks address components related to curriculum planning, motivation, instructional strategies, and managing learning. The principles outlined in this document speak to many of the same areas that the *Skillful Teacher* addresses, in particular the areas of instructional strategies, curriculum planning and motivation. A crosswalk between the principles and the key concepts of the *Skillful Teacher* may be of use in the future. While the two frameworks are important to district leaders in Seattle, the question posed was "how do digital technologies and content resources support best practices in these areas?" This literature provides information and data to explore that question.

Based on a set of principles derived first out of the analysis of the crossover between the two frameworks and major themes in the literature, the following principles are explored in this review of literature.

Principle 1: Digital resources promote student achievement for all students, especially historically underserved students, when students use them to produce information rather than passively consume information, but technology use alone is ineffective unless mediated by a skillful teacher.

Principle 2: Digital resources help teachers develop authentic learning opportunities that align with the depth of rigor of college-and-career ready standards and are relevant and meaningful to students.

Principle 3: Digital resources have and continue to change what "literacy" and "being literate" mean and look like.

Principle 4: Digital resources can help but alone are insufficient for helping students authentically engage in learning.

Principle 5: Digital resources allow students and teachers to connect and collaborate with other students, teachers and other influential adults, and with the content.

Principle 6: Digital resources provide opportunities for students to demonstrate mastery of learning goals in a variety of ways.

Principle 7: Digital resources allow teachers and students to monitor progress towards learning goals.

At the end of the review of literature for each principle are questions for consideration that educators at various levels—classroom, school, program, or district—may want to consider and discuss to determine connections between the literature that supports the principle and their own practice and philosophies regarding effective digital learning.

Overarching Principles

Principle 1: Digital resources promote student achievement for all students, especially historically underserved students, when students use them to produce information rather than passively consume information, but technology use alone is ineffective unless mediated by a skillful teacher.

Tasked with uncovering evidence, if it exists, for the use of technology to support student learning, researchers at Stanford (Darling-Hammond, Zielezinski & Goldman, 2014) reviewed recent studies on technology integration, specifically for determining how technology might (or might not) support at-risk students' learning. After reviewing more than 70 recent studies, these researchers *did* find that technology—as one component of what they refer to as a "digital learning ecosystem," can indeed promote student achievement, especially for historically underserved students. They also emphasize the important roles teachers perform in those learning ecosystems. These authors report that research indicates three important variables for success in learning when incorporating technology, especially for students considered at-risk. These three important variables are:

Effective Technology-Enabled Criteria

Three important variables when successfully incorporating technology are:

1. *Interactive learning;*
2. *Use of technology explore and create rather than to "drill and kill"; and*
3. *The right blend of teachers and technology"*

- Darling-Hammond, Zielezinski & Goldman, 2014, p. 6

1. "Interactive learning;
2. Use of technology to explore and create rather than to 'drill and kill'; and
3. The right blend of teachers and technology" (p. 6).

The authors describe **interactive learning** as relying on resources that allow students to manipulate and create information and data, such as the use of animations, simulations, data visualizations, games, 3D models, and the generation of new media-based content. McDonald (2016) concurs, calling modern digital learning environments as ones that "enable students to develop their technological literacy and critical thinking skills through their daily learning activities" (p. 542) and that digital game-based learning and computer simulations are two digital

learning approaches that have been found to be effective in STEM education classrooms. One of the greatest benefits of interactive digital learning resources is that "they can allow students to see and explore concepts from different angles using a variety of representations" (Darling-Hammond, Zielezinski & Goldman, 2014, p. 7). These are contrasted by uses of technology that have actually been demonstrated to be *ineffective.* The researchers at Stanford specifically identify the use of drill-and-practice activities, programmed instruction, using word-processing software for grammar/punctuation practice or checks, and reading activities that rely on drill or tutorials as negatively impacting student achievement. Programmed instruction is described as when students "march through material they learn through rote or algorithm." In these settings, students can be described as passive *consumers* of information, in which they exhibit various levels of interest and enthusiasm while working through screens of text and images and participating in quizzes of low-level conceptual or procedural knowledge. Unfortunately, these ineffective uses of technology predominate in schools with a majority of historically underserved students.

Research on technology integration indicates that "using computers as replacements for teachers in traditional drill-and-practice exercises has not produced greater success for such students, but that more interactive, proactive, and teacher-supported uses have helped students make strong strides in achievement"

- *Darling-Hammond, Zielezinski & Goldman, 2014, p. 14.*

The authors go further to report that research on technology integration indicates that "using computers as replacements for teachers in traditional drill-and-practice exercises has not produced greater success for such students, but that more interactive, proactive, and teacher-supported uses have helped students make strong strides in achievement" (p. 14). They emphasize that the teacher is the critical factor in supporting students beyond the use of digital content, even if that content is adaptive, interactive, and provides feedback to students on their performances. Teachers support students by supplementing their foundational learning, explaining concepts, and coordinating student discussions. These teacher behaviors have been shown to be successful in helping low-achieving students pass state competency tests and master complex new material.

Rather than being passive consumers of content created by others, the research reviewed by these authors (Darling-Hammond et al., 2014) suggest that students learn more when they use technology to create new content themselves. They note that "students demonstrate stronger engagement, self-efficacy, attitudes toward school, and skill development when they are engaged in content creation projects" (p. 9). Thus, it is in the role of becoming *producers* of information that positive student outcomes are most seen. They acknowledge that students require scaffolding when engaging in complex activities that create new content, a finding echoed in research on inquiry-based learning that notes that not all students are able to engage in an open-ended environment all the time (Tieg, Scherer & Nilsen, 2018). Darling-Hammond et

al (2014) report that “a large body of research” has found that well-designed collaborative, problem-based learning activities can have positive impact on inquiry skills, process skills, and building knowledge (p. 14). This finding is corroborated through longitudinal studies on STEM PBL projects (Erdogan, Navruz, Younes & Capraro, 2016; Han, Capraro & Capraro, 2014).

Will computers take my job?

As technology makes its way into most industries and careers, it’s common for professionals to be consider whether their job might be subject to infiltration by automation and other digital processing. This has been an ongoing thread in educational technology literature since personal computers became commonplace in classrooms around the 1980s, and perhaps as far back as the programmed instruction movement in the 1960s.

Will robots take my job? uses information based on a 2013 report by Frey & Osborne that examines the probability of automation for more than 700 occupations. Combined with data from the Bureau of Labor Statistics, the developers of this site estimate that 47% of the U.S. employment market is at risk of being replaced by a computer. Are you?

While a continuing thread in teacher perceptions, history has shown time and again that a teacher’s fear of being replaced by a computer has not come true. However, what computers and computing devices *can* do, is change what it means to be a teacher—and a learner. Ubiquitous access can shift what teachers do in the classroom. Teachers no longer need to take total control for dispensing content and providing opportunities for drill and practice. Instead, digital devices and content can be a catalyst for learning that can both be used for helping students develop foundational knowledge and basic skills as well as demonstrate their learning in new ways (Fullan & Langworthy, 2014). According to these education experts and researchers, this change is not just from “sage on the stage” to “guide on the side” (or teacher-as-facilitator). Instead, they echo the work of noted educational researcher John Hattie (2008) that a guide on the side does not go far enough. Instead, all agree that the most effective teachers are *activators* of learning and the roles they perform require new pedagogical models that leverage ubiquitous access to content and other learners in a way that is much more focused on what many refer to as **deeper learning.** These teachers take a highly proactive role in driving the learning process. They draw from a sophisticated repertoire of strategies and methods to determine appropriate opportunities for the needs of their learners. So, no, computers can’t replace teachers altogether. They can, however, replace those that do not move beyond providing surface level learning to include opportunities for deeper, authentic learning opportunities. They can replace teachers that do not allow students to tackle real-world problems and phenomena or use the same or similar resources that students will later find in college and careers.

To give the notion of activator of learning some context, Hattie's (2008) well known findings from a review of more than 800 meta-analyses (and a subsequent 100+ in later publications) of educational factors that claim to improve student outcomes compare the documented impact from both: teacher-as-facilitator and teacher-as-activator of learning. In reviewing the effect size of both categories, Hattie's team found a significant positive effect for teachers as activators, which is characterized by strong teacher-student relationships, incorporating reciprocal teaching, providing relevant feedback, and promoting metacognition. The category of teacher as facilitator, which includes inductive teaching and student control over learning, had a positive but non-significant impact. (An effect size of .40 or higher is considered significant.)

Table 1. *Hattie's (2008) "Visible Learning" analysis of effect sizes of categories of teaching strategies*

Strategy Category	Effect Size
Teacher as Activator (teacher-student relationship, reciprocal teaching, feedback, metacognition, teacher clarity)	.72
Teacher as Facilitator (inductive teaching, student control over learning)	.19

Hattie (2012) later notes that visible teaching and learning occurs when "learning is the explicit and transparent goal, when it is appropriately challenging, and when the teacher and the student both (in their various ways) seek to ascertain whether and to what degree the challenging goal is attained" (pp. 17-18). In other words, teachers activate learning when they help students develop worthwhile, rigorous goals for learning; when they understand students' past experiences and prior understandings; provide relevant feedback on the progress students are making towards those goals along a progression of learning; and when students and teachers interact together in "active, passionate, and engaging" participation in learning. Hattie further notes that the most effective teachers view their role as seeing themselves as evaluators of their effects on students, and do so based on their knowledge of their learners and knowing enough about the content to provide meaningful learning opportunities at an appropriate level of challenge. Teachers further make learning visible by sharing and helping students understand what the goals for learning (learning intentions) are and how students will know they have mastered those goals (success criteria). Creating an environment that encourages students to become less dependent learners and more independent through strong student-teacher relationships also aligns with promoting culturally relevant learning as described by Hammond (2015).

Hattie's research resulted in six "signposts" of excellence in education that clearly emphasize the valuable role of teachers in the classroom and the importance of students becoming creators of content and producers of information (see signpost 5, specifically). These signposts are:

1. "Teachers are among the most powerful influences in learning.
2. Teachers need to be directive, influential, caring, and actively and passionately engaged in the process of teaching and learning.
3. Teachers need to be aware of what each and every student in their class is thinking and what they know, be able to construct meaning and meaningful experiences in light of this knowledge of the students, and have proficient knowledge and understanding of their subject content so that they can provide meaningful and appropriate feedback such that each student moves progressively through the curriculum levels.
4. Teachers and students need to *know the learning intentions* and the criteria for student success for their lessons, know *how well they are attaining* these criteria for all students, and know *where to go next* in light of the gap between students' current knowledge and understanding and the success criteria of 'Where are you going?', 'How are you going?', and 'Where to next?'
5. Teachers need to move from the single idea to multiple ideas, and to relate and then extend these ideas such that learners construct, and reconstruct, knowledge and ideas. **It is not the knowledge or ideas, but the learner's construction of this knowledge and ideas that is critical.** (emphasis added)
6. School leaders and teachers need to create schools, staffrooms, and classroom environments in which error is welcomed as a learning opportunity, in which discarding incorrect knowledge and understandings is welcomed, and in which teachers can feel safe to learn, re-learn, and explore knowledge and understanding" (p. 22).

In describing new pedagogical models that help support teachers as activators of learning, Fullan and Langworthy (2014) suggests three new roles for teachers that is the foundation for the work of an educational collaborative with which they work. These roles include:

1. **The teacher as designer of powerful learning experiences.** Teachers can use proven instructional design methods to determine learning outcomes that are not only aligned to content goals but that acknowledge the needs and goals of individual students. Within the learning experience, instructors—as content and learning experts—monitor and determine where learners are in their progression of learning and provide individualized feedback (see cognitive vs. outcome feedback later in Principle 4) to motivate learners

towards meeting their goals. The role of teacher as designer, as opposed to simply delivering curricula others have designed, encourages them to engage learners in the co-design of knowledge-based products and learning opportunities, reinforcing the finding that technology use supports student achievement when students use it to produce new content and information. The co-design of learning is a thread that continues throughout this review.

2. **The teacher as a source of human, social, and decisional capital in the learning experience.** All teachers come to a learning setting with human capital, which can be increased by engaging through continuous learning with other educators within and beyond their building to reflect on and hone their craft. Social capital is derived from the relationships teachers have with students, families, other educators, and people outside their organizations. A teacher with high social capital is better equipped to design learning opportunities that are relevant to their students and connects to the resources of a larger social network that brings real-world connections into learning. Decisional capital grows as teachers develop human and social capital. It manifests itself in terms of decisions teachers make with individual students based on their needs.
3. **Teachers as partners in learning with students, accelerated by technology.** Teachers as co-learners or partners in learning is another thread that is woven throughout this review that can support student achievement outcomes when using technology. These authors acknowledge that "strong, supportive, personal" relationships between teachers and students can promote learning for all students. While ubiquitous technologies now help to make and support those relationships by connecting students, teachers, and others within and beyond the classroom to support learning, they also concur that technology alone is insufficient for promoting deeper learning. While technology does provide access to varied learning opportunities, they too caution against technology through digital curricula being used to provide only "surface knowledge," and that supportive relationships are necessary for moving beyond limited, isolated knowledge acquisition.

Hattie (2012) reinforced some of these principles in his "Checklist for Visible Learning" noting that when teachers are planning, implementing, and evaluating their lessons, they need to consider three levels of learning in mind. These three levels are (1) surface knowledge necessary to comprehend basic information, vocabulary, processes, and strategies, (2) deeper understandings of how information, rules, and processes relate to each other that expand their understandings, and (3) the conceptual thinking that "allows surface and deep knowledge to turn into conjectures and concepts upon which to build new surface and deep understandings" (p. 86). He calls for less emphasis on the overwhelming predominance of surface level learning in many classrooms and a balance between surface and deep learning that allows students to more successfully engage in conceptual thinking that becomes the foundation for further learning.

Hammond (2015) provides support for the importance of teachers as activators of learning through the lens of culturally responsive teaching. She encourages teachers to develop a culturally responsive mindset, recognizing how students' cultures influence the ways they learn and making meaning. These teachers use cultural knowledge to co-learn with students who are then encouraged to develop the cognitive skills and habits of mind that move them from being *dependent* learners to *independent* learners in which students develop their intellective capacity,

which she notes is influenced by one's culture. She reports that a disproportionate number of students are dependent learners, meaning that they have not had sufficient access to learning opportunities that allow them "to do complex, school-oriented learning tasks such as synthesizing and analyzing informational text without continuous support" (loc. 389). Hammond emphasizes this is not a deficit on the students' part. Instead, students can become more independent when engaged in instruction that includes "productive struggle." She borrows the phrase "pedagogy of poverty" that describes teaching practices that emphasize lecture and rote memorization that can leave students with outdated skills and "shallow knowledge" in which they can recall facts or concepts but cannot apply their knowledge and skills in new and practical ways, ways embodied the goal of promoting deeper learning. Hammond emphasizes, "to be able to direct their own lives and define success for themselves, they must be able to think critically and creatively" (loc. 419).

Because technology pervades so many aspects of our lives, many may erroneously perceive digital technologies as culturally neutral (Gunawardena, C. N., & McIsaac, M. S., 2004). Just because we may see phones or computers at home, work, school and on television and movies, cultural responses to technology can vary. "Culture interacts with educational technology both in terms of cultural influences on how educational technology is conceptualized and implemented, and in terms of how educational technology is experienced and received" (Bradshaw, p 20). Therefore, technology itself has cultural influences and its use an be influenced by the cultural experiences of students. It should also be viewed through a culturally responsive lens when it is integrated into learning environments, especially when it *is* the learning environment. McLoughlin (in Gunawardena, C. N., & McIsaac, M. S., 2004) has developed a framework based on experiences in online learning that links culturally inclusive technology-enhanced learning with authentic curriculum and assessments. While originally designed for online courses, the pervasive nature of online interactions in both physical and virtual classrooms make these suggestions applicable across a range of learning environments. In the framework, "a goal of culturally inclusive online learning is to ensure that pedagogy and curriculum are flexible, adaptable and relevant to students from a diverse range of cultural and language backgrounds" (p. 384).

Woodley and colleagues (2017) offer these best practices drawn from culturally responsive teaching practices (Gay, 2010) that support the emphasis on helping students move from being dependent to independent learners through learning opportunities that allow them to move beyond acquiring shallow knowledge but to engage in deeper learning in which they think critically and creatively.

1. **Validate the learners' pre-existing knowledge with relevant activities.** When using technology, instructors should take steps to determine the pre-existing knowledge learners possess, whether in terms of the content, technology, or cultural experiences. They suggest incorporating activities that allow instructors and learners to get to know each other better can be helpful, especially when interactions are held online, whether in class or at a distance. They suggest activities such as using the technology-based environment to learn about and introduce someone else to the group, so that a sense of community can better be established when working through collaborative technologies.

2. **Provide comprehensive and multi-dimensional learning opportunities.** These researchers suggest that student engagement can be fostered through the use of high-cognitive demand tasks and to not make assumptions about English language learners or students with learning disabilities being unable to address cognitively complex tasks. Many technologies lend themselves easily to providing scaffolds, various forms of representing or presenting information, and different opportunities for students to work together and share and reflect upon their learning. These researchers suggest providing job aids and scaffolds for collaborative group work online, such as guides for conducting group work, a group activity, and social activities that help the group learn about and support each other.
3. **Transform student learning with synchronous online meetings.** A variety of web-conferencing options are available to help learners connect even when those learners are at a distance. Online connections can occur throughout a course, not just at the beginning, and don't always have to be hosted by an instructor. Student teams can be given the opportunities to use technologies to collaborate, facilitate class discussions, or to report out to the full class regardless of who's in the room.
4. **Empower students through liberatory leadership opportunities.** Liberatory leadership opportunities allow students to provide input into the design and delivery of instructional activities or course components. Students can lead group or class discussions or may be able to provide input as to how they prefer to achieve learning outcomes by choosing or suggesting their own ideas for activities and methods of assessment.

While digital curriculum can play a part in acquiring surface or shallow knowledge, helping students become independent learners that develop deeper understandings and connections to the world outside of the classroom occurs most effectively only when expanded upon or enriched by teachers.

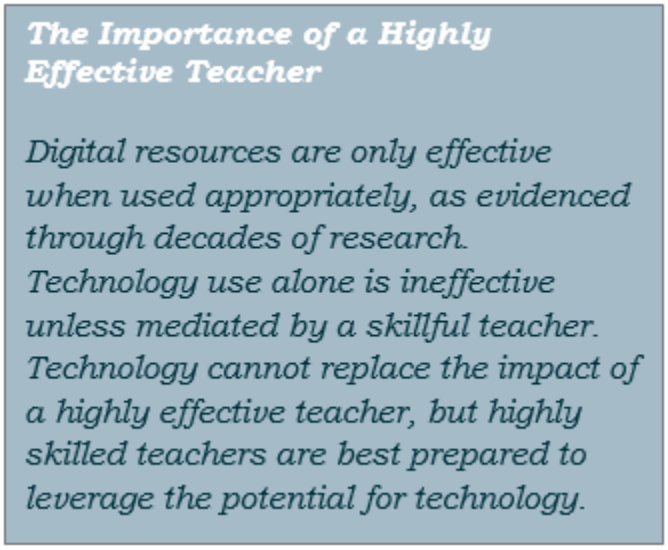
Many digital curriculum resources are now available that provide varied opportunities for students to develop surface knowledge and skills, what Hammond describes as "shallow knowledge." More recent adaptive curricula go beyond static programmed instruction with limited presentation of content and assessment opportunities. Adaptive curricula provide greater flexibility for placing students within a learning progression that is better matched to their current levels of ability, sometimes through the use of a pre-assessment and ongoing monitoring of learning. It is important to note, however, the central finding in this section is that while digital curriculum can play a part in acquiring surface or shallow knowledge, helping students become independent learners that develop deeper understandings and connections to the world outside of the classroom occurs most effectively only when expanded upon or enriched by teachers.

What does good digital curriculum then look like? In summarizing the characteristics of a good digital curriculum, the Center for Digital Education (2014) suggests that digital content and curriculum should be:

- **Personalized.** A confusing term used in many ways, in this case "personalized" references adaptive curricula that provide instructional sequences based on learner input, such as through pre- or embedded tests. Adaptations may also occur more fluidly in response to learner interactions with the content that can help move successful learners forward or require struggling learners to repeat or explore additional learning activities before moving on. These types of curriculum resources are more sophisticated than earlier programmed instruction referenced by Darling-Hammond et al (2014) that can only require students to complete the same sequence over and over, never providing individualized feedback to improve understanding and performance. It's important to emphasize again that even adaptive curricula are best used in conjunction with a knowledgeable teacher who, with the learner, can review data from digital curriculum and determine appropriate extensions beyond the software that promote "collaborative inquiry and knowledge construction" (p. 14).
- **Interactive.** Digital content can be interactive through the interactions between learners, instructors, and the content including: (1) interactions between instructors and learners, (2) interactions between learners, and (3) interactions with the content by learners. One of the most important features of digital content, according to one survey by CDE is its ability to "encourage interaction *among* students and *between* students and teachers," as opposed to assuming the sole role of content provider.
- **Problem- or project-based.** Adhering to principles of good instructional design, as summarized by Merrill (2002) in his "First Principles of Instruction," good digital content provides learners an opportunity to work with real-life problems and projects. Doing so can make learning opportunities more relevant to learners and make connections to their daily lives.
- **Engaging.** While technology can be engaging to learners, for a period, the highest levels of authentic engagement in learning can occur through the incorporation of high-quality content and multimedia. Examples include learning media that provide or support custom feedback to learners, flexibility through sequencing, various media options, elements of gaming, and connecting learners for peer support.

What does this principle mean for schools?

- Digital resources are only effective when used appropriately, as evidenced through decades of research. Technology use alone is ineffective unless mediated by a skillful teacher. Technology cannot replace the impact of a highly effective teacher, but highly skilled teachers are best prepared to leverage the potential for technology. Some technology uses, such as drill-and-practice exercises, programmed instruction, using word-processing software for grammar/punctuation practice or checks, and reading activities that rely on drill or tutorials have been found to negatively impact student achievement.



- Generally, technology will not replace teachers, but it can change what it means to be a teacher, and a learner, and it can replace rudimentary or low-level teaching activities. Technology can be a catalyst for learning that can both be used for helping students develop foundational knowledge and basic skills as well as demonstrate their learning in new ways. New pedagogical models put teachers in the role of activators of learning.
- When used to promote deeper learning through tasks that require students to create content and produce new information, students—especially historically underserved students—show greater gains in achievement than when students use digital resources to consume information.
- Technology is not culturally neutral. Cultural experiences and backgrounds influence both how technology is perceived or received within a culture as well as the role it is expected to play. When used effectively by a culturally responsive teacher, technology can help move students beyond achieving shallow knowledge attributed to dependent learners to deeper learning in environments that promote critical and creative thinking in which students become self-directed, independent learners.

Principle 2: Digital resources help teachers develop authentic learning opportunities that align with the depth of rigor of college-and-career ready standards and are relevant and meaningful to students.

Learning Requires Appropriate Challenge

"Decisions are so often made to engage students in interesting activities, to excite them to participate in learning, and to ensure that, when the bell rings, they have completed the assigned tasks and at least enjoyed the activity. Such dull aspirations for students may entice the willing, the bright, and those with high levels of 'inhibitory control,' but will not continue to challenge students to reinvest in the game of school" (p. 39)

- John Hattie (2012)

Repeatedly found throughout the literature on technology integration is the potential digital resources have to help teachers make connections from content standards and related learning outcomes to real-world applications, what is often referred to as **authentic learning.** Learners of all ages should understand why they are being asked to learn something and how and why it is important in their own lives, either currently or in the future in college or careers.

Cennamo, Ross & Ertmer (2018) suggest that authentic instruction is characterized by a shared set of five characteristics. Authentic instruction may also be referred to as engaged learning, learning by design, or student-centered instruction. The five characteristics that categorize authentic instruction as described by these authors are:

1. **Authentic instruction provides for, and builds on, learner autonomy.** While there are many ways to do this, a key aspect is allowing learners to pursue topics and questions that they are interested in and find relevant. In other words, connecting learning opportunities to the interests, abilities, experiences, and needs of students can promote authentic engagement in learning.
2. **Authentic instruction is based on active, experiential learning.** The most natural form of learning involves active, hands-on, concrete experiences. Active learning implies that learners are *mentally* active, not just physically moving about the room or a learning environment. Learners are mentally active when they are manipulating information, synthesizing data, making interpretations, and reflecting upon and articulating what they are learning and have learned. When learners engage in this metacognitive approach to learning, they achieve a deeper understanding and are more likely to use new knowledge and skills in different situations, which is referred to as *transfer* (see below).
3. **Authentic instruction is holistic.** Authentic instruction engages learners in developing knowledge and skills within the context of meaningful activities. They are meaningful to the content, the learner, and to situations outside of school that they might find in college and careers. Digital resources are especially well suited to providing learners the

opportunity to engage in holistic activities either with a real-world context or in actual real-world settings.

4. **Authentic instruction incorporates real-world and complex problems.** Learning that is situated in real-world situations is not only often more engaging to students but increases the likelihood that learners will be able to transfer their knowledge and skills to new situations. Authentic instruction incorporates learning opportunities that require learners to think, develop deep understandings, and apply new knowledge and skills to realistic, important problems.
5. **Authentic instruction is challenging.** Appropriate challenge varies by individual. Just as with Vygotsky's famous Zone of Proximal Development, authentic instruction provides developmentally appropriate challenges to learners that they can accomplish with effort and supports. Appropriate challenge is the "just right" challenge that is not too hard, which can lead to frustration, yet not too simple for learners, which can result in boredom and disengagement.

Newmann, Bryk & Nagaoka (2007) developed a framework to describe *authentic intellectual work* (AIW) as a means to shape learning opportunities that are meaningful, significant, and worthwhile. The AIW framework consists of three characteristics. They are:

1. **Construction of knowledge.** Authentic settings, such as workplaces, often pose unique and often complex problems that may not have one clear solution. In these settings, skilled adults are required to have a repertoire of knowledge and skills to address these complex or non-routine problems. While grappling with non-routine problems—which *can* be brought into most classrooms—the framework developers propose that people construct new knowledge by working through the problem situation by organizing, interpreting, evaluating, and/or synthesizing prior knowledge. Foundational knowledge and skills are better developed in these contexts rather than isolated.
2. **Disciplined inquiry.** The authors acknowledge it is important that learners have a base of prior knowledge in a content area (e.g., facts, vocabularies, concepts, theories, algorithms and other conventions) from which to draw upon in order to successfully construct knowledge when faced with non-routine problems. The authors suggest prior knowledge is necessary in order to address the complexity in unknown situations and to interpret information, propose hypotheses, and test solutions grounded in what one does know and what one is learning from the situation.
3. **Value beyond school.** Successfully completing a learning or assessment activity should not be in and of itself the primary goal of learning. Instead, successful learning opportunities should be meaningful beyond compliance in the classroom. The AIW Framework suggests that student work should have impact on others.

The term "deep" is often associated with descriptions of authentic instruction. Deep not only refers to academic learning but can also include affective, behavioral, and social-emotional outcomes. The phrase **deeper learning** (Hewlett Foundation, 2013) is one that has been championed by those that encourage the use of authentic learning opportunities that are relevant and meaningful to the interests, experiences, and abilities of learners as well as to the subject matter, and how that subject matter is applied outside of school in college, careers, or our personal lives. Educational researchers and experts writing for the National Research

Council (2012) equate deeper learning with the ultimate goal of learning—**transfer.** Transfer occurs when students can draw upon their learning—from a body of knowledge and repertoire of skills—to know how, why, and when to apply their learning to address questions and solve problems in unique or novel situations. They define it as "the process through which an individual becomes capable of taking what was learned in one situation and applying it to new situations" (p. 5).

According to the Hewlett Foundation (2013), deeper learning encompasses six interrelated competencies:

1. **Mastering core academic content.** Learners develop a foundation of knowledge and skills within a domain by being given multiple opportunities to apply knowledge in a range of challenging tasks. Similar to the AIW framework, deeper learning suggests that learners are able to draw upon and use foundational knowledge and skills to complete meaningful work within a content domain or subject area as they are found in the real world.
2. **Thinking critically and solving complex problems.** Meaningful work is often framed by complex problems within or across domains and requires learners to engage in critical and creative thinking and persist through challenges. Critical and creative thinking are best taught by incorporating the tools and techniques relative to the area of study, meaning that while doctors, musicians, and game designers all engage in critical thinking and problem solving, the tools and techniques they use are shaped by their areas of expertise.
3. **Working collaboratively.** Learners collaborate with others to address academic, social, vocational and personal challenges and problems. Collaborating requires learners to incorporate multiple points of view to reach consensus and meet individual and group goals.

4. **Communicating effectively.** Learners should be able to organize their ideas, information, and thoughts and communicate them to relevant audiences in ways that their messages are meaningful and understood.
5. **Learning how to learn.** In essence, deeper learning can occur when learners engage in self-directed learning (see Principle 3). Self-directed learning strategies *can* be taught and can be encouraged in situational contexts so learners can use them to persist through challenges.
6. **Developing academic mindsets.** As the work of Carol Dweck (2007) has clearly shown, personal beliefs and attitudes about one's self and how one can be a successful learner are malleable. Learners can develop positive mindsets about learning and use them to reach their own goals and produce high-quality work.

Newman and his colleagues (2007) also use the term “deep” when referring to the level of sophistication learners should be exposed to and construct during learning (see Principle 1). They suggest that knowledge is deep when learners are able to understand and share details, distinctions, nuances, and different applications of the concepts being studied. Their knowledge in this case is holistic rather than superficial or thin. In order to develop deep knowledge, students are engaged in substantive conversations with others, whether other students, educators, or those outside of the classroom. These conversations are a means for students to determine how their learning has value beyond school and to construct knowledge through discourse. The AIW framework encourages making connections between subject matter knowledge and skills to public problems or personal experiences that learners have faced or will face in the future. Making connections to the world beyond the classroom builds on learners’ personal experiences in order to help demonstrate how their learning can have some impact.

Instead of focusing on content mastery, deep learning tasks focus on learners and helping them to develop the capacities to learn, create, and proactively implement what they have learned. Deep learning tasks often leverage the power of digital technologies and resources, and many incorporate the social nature of learning through collaborative work.

- Fullan & Langworthy, 2014

Fullan and Langworthy (2014) describe how teachers can incorporate “deep learning tasks” in order to reach the complex, and multi-faceted outcomes often associated with authentic learning opportunities. A deep learning tasks engages learners in “practicing the process of deep learning through discovering and mastering existing knowledge and then creating and using new knowledge in the world” (p. 21). Deep learning tasks support the research-based outcomes from Darling-Hammond and her colleagues (2014) that indicate that student learning increases when students become producers of information rather than simply consuming information. Deep learning tasks restructure the learning process towards knowledge creation and purposeful use to an audience beyond the classroom.

Instead of focusing on content mastery, deep learning tasks focus on learners and helping them to develop the capacities to learn, create, and proactively implement what they have learned (Fullan & Langworthy, 2014). In reviewing deep learning tasks in action, the authors report that deep learning tasks do result in knowledge construction, similar to how it is defined by the AIW framework. Deep learning tasks often leverage the power of digital technologies and resources, and many incorporate the social nature of learning through collaborative work. These authors suggest that “when pedagogical and deep learning capacities are clearly defined and developed, digital tools and resources enable the: 1) discovery and mastery of new content knowledge; 2) collaborative, connected learning; 3) low-cost creation and iteration of new knowledge; 4) use of new knowledge with authentic audiences for ‘real’ purposes; and 5) enhancement of teachers’ ability to put students in control of the learning process, accelerating learner autonomy” (p. 33).

As noted previously, digital resources have become commonplace for obtaining foundational knowledge and developing basic skills in many content areas. Digital tools can be an effective and efficient means for building on this foundational level of knowledge and skills from which students can then dig deeper. As these authors point out, “new pedagogies are not as simple as ‘flipped’ classrooms or MOOCs (Massive Open Online Courses) where content information and existing knowledge are ‘delivered’ online rather than through textbooks or live in classrooms” (p. 7). They are more complex. Instead, digital resources are used to make it possible for learners to create and use new knowledge in the real world. Digital resources also support learning partnerships between teachers and students where the learning process is the focus of the journey, not just learning content or a new skill. Students develop the ability to lead their own learning.

New Pedagogies

“New pedagogies are not as simple as ‘flipped’ classrooms or MOOCs (Massive Open Online Courses) where content information and existing knowledge are ‘delivered’ online rather than through textbooks or live in classrooms” (Fullan & Langworthy, 2014, p. 7). They are more complex. Instead, digital resources are used to make it possible for learners to create and use new knowledge in the real world.

What does this principle mean for schools?

- The best learning occurs when learning is *authentic.* To be authentic, learning should have explicit connections to life outside of school—not only in later college and careers, but to students’ current lives outside of school. Authentic intellectual work allows students to construct knowledge within a discipline that has value beyond school.
- The ultimate goal of learning is *transfer*—the application of new knowledge and skills in a novel or unique setting, preferably a real-world setting. Mastering core content is important but insufficient for transfer in most cases. Instead, deep learning tasks help students develop the capacities to learn, create, and implement what they have learned.
- New pedagogies that integrate technology are more complex than ongoing trends and fads. They instead incorporate digital resources so that learners can create and use new knowledge in the real world.

Principle 3: Digital resources have and continue to change what "literacy" and "being literate" mean and look like.

What it means to be "literate" continues to evolve yet always has a symbiotic relationship tied to prevalent technologies of the day. Once only the provenance of the wealthy, literacy evolved when people beyond the aristocracy and religious leaders were given the opportunity to interact with the new technologies of paper and pen. The printing press and the ability to mass generate tomes pushed the concept of being literate forward again, along with the generation of a new "middle class" that could use their literacy skills to support their careers and advance their station. Schools in this country were established, in part, to help create a literate population that was able to engage in the democratic ideal of following one's dream and contributing to society. It was during the first half of the 20th century when "being literate" was determined to go beyond reading and writing to encompass the skills of listening and speaking (Hobbs, 2016). Then came radio, and film, television, mass media, and the Internet, and the concept of literacy continued to evolve throughout, but now at a much more rapid pace.

Reading and writing are still foundational literacy skills, but many conclude that they are insufficient for being considered literate any longer. Reading and writing can be accomplished with traditional texts, but even the concept of what constitutes a "text" has expanded, and many acknowledge that text includes a variety of media formats with which people communicate, collaborate, debate, and share ideas. The digital "texts" we all interact with on a daily basis in the 21st century cannot be limited simply to static text and pictures. Hobbs (2011) notes that the term "text" can be expanded to include "any form of expression or communication in fixed and tangible form that uses symbol systems, including language, still and moving images, graphic design, sound, music, and interactivity" (p. 14). The dynamic forms of "text" are especially relevant now as people can create their own texts in which they embody or impart interactive elements to "text" through videos, simulations, applications, and gaming environments. Indeed, the term "literacy" can be expanded to include social interactions and "traces" of social interactions that are recorded, reported, and available for asynchronous analysis.

> *Students who have limited opportunities to engage with online resources often demonstrate lower general reading and writing abilities than their counterparts.*
>
> *- Leu, Forzani, Rhoads, Maykel, Kennedy, & Timbrell, 2014*

Several literacy experts note that digital technologies provide students various approaches to developing and sharing knowledge that are different from more traditional approaches to literacy, even from just a few decades ago. The way that new digital technologies impact our lives, and the way we learn through and with them, are often described as the theory of **New Literacies** (Leu et al., 2014; Sweeney, 2010). There are what some refer to as "lowercase" *new*

literacies that relate to different digital technologies and the ways that they are used (e.g., texting, social networking, using an online search engine). Many of these new literacies are platform dependent. In contrast, "uppercase" *New Literacies* represent skills and knowledge that manifest themselves across a range of technology-specific modalities (e.g., reading and comprehending online information, navigating digital environments, curating information in various media formats). New Literacies acknowledge that the digital technologies we interact with encourage us to develop new knowledge and express ourselves in unique ways when using technology. The same was true with the first papyrus and pencil, and it now continues with social media, web-based interactions, and real-time interactions with people at a distance.

Several researchers have noted that interacting with texts online varies from how we interact with offline texts, and this impacts what it means to be literate. For example, much of the reading and writing we do online is related to finding and sharing information. "Where should we go to dinner?" "What car should I buy?" "How does Western migration in the late 19th Century impact me today?" All of these questions prompt us to interact in an interconnected online environment through computers, tablets, phones and other devices that contain embedded links and connected information across sources. It requires different literacy skills to read, summarize, and share the information we've found. Students need opportunities to express themselves with this variety of media—digital text, images, videos, and others. Restricting or withholding these opportunities for students to interact with and develop New Literacies (and new literacies) can have negative consequences for students, especially those students in schools that are designated as high poverty compared to those in more affluent schools (Leu et al., 2014). Research has shown that students who have limited opportunities to engage with online resources often demonstrate lower general reading and writing abilities than their counterparts.

Literacy in the digital age is multi-faceted. There may be no one metric to determine if one is literate. Hobbs (2016) provides a panoply of interrelated terms, such as visual literacy, information literacy, media literacy, and computer literacy, and news literacy as examples of the range of skills necessary for people in a digital age to access, analyze, evaluate, and create information using a variety of texts, genres, tools, and technologies. Even terms like author, audience, context, and text have also expanded from their earlier formulation focused on writers and writing towards the inclusion of forms of expression and communication that include visual, audiovisual, sound, interactive, and digital formats and modes" (p. 9). New Literacies demand that students demonstrate a combination of cognitive and social competencies, knowledge, and skills needed to understand communication and communicate effectively with others.

In addition to finding, evaluating, and synthesizing information, New Literacies demand that students produce or develop new information that others can access, verify, and use. The Partnership for 21st Century Learning (2016) describes information literacy as having two parts or stages: (1) accessing and evaluating information, and (2) using and managing information. In the first stage, students are consumers of information, and in the second, students use the information they have found to become creators of information. In the current century, we engage in these two stages using a variety of media—often through the use of digital tools.

The inclusion of two stages suggests that evaluating information is not sufficient to be considered literate in an information economy—one in which information can easily be generated and disseminated. In addition to finding and verifying the authority of information, it's important that students also develop the skills to create information that can be verified to increase their own authority. Ironically, one strong model of generating verifiable information comes from a resource that is not universally accepted in classrooms, Wikipedia (Cennamo, Ross, & Ertmer, 2018). The irony is that this popular online encyclopedia is often the first step many people take outside of schools to find information about a topic; whereas, it is often castigated by educators and its use banned outright in many classrooms despite an investigation finding that its error rate is slightly larger but no more significant than that of *Encyclopedia Britannica* online (Giles, 2005). Wikipedia's parent organization, Wikimedia Foundation, has established guidelines for contributors to generate verifiable information. Content on Wikipedia is reviewed for accuracy and information that cannot be verified receives comments to warn the reader. Wikimedia Foundation's guidelines serve as one model that students and teachers can use to generate verifiable information in schools.

Wikimedia's guidelines for posting include:

- All information contributed must adhere to the BY-Attribution Creative Commons license (described later in this chapter).
- Wikimedia accepts only original content. Authors cannot copy and paste from other sources.
- Authors cannot post their original research, like their thesis or dissertation findings. They can refer to their own research if it has been published elsewhere, like in an appropriate peer-reviewed journal.
- Authors have to maintain a neutral point of view, meaning they cannot argue for or against any point, and have to provide information from multiple viewpoints, when available.
- All information must be verifiable from reliable sources. On Wikipedia, that generally means all information must be cited and, preferably, linked to a verifiable resource.

Information Literacy

The Partnership for 21st Century Learning (2016) describes information literacy as having two parts or stages:

1. *accessing and evaluating information, and*
2. *using and managing information.*

The inclusion of two stages suggests that evaluating information is not sufficient to be considered literate in an information economy—one in which information can easily be generated and disseminated. In addition to finding and verifying the authority of information, it's important that students also develop the skills to create information that can be verified to increase their own authority.

What does this principle mean for schools?

- “Being literate” has always depended upon the prevalent technologies of the day. Digital technologies are rapidly expanding what it means to be literate through the generation of New Literacies. Students who have limited opportunities to engage with online resources and develop new literacies demonstrate lower general literacy abilities than their peers. Schools and districts that do not prepare students for these New Literacies are not preparing “literate” students.
- In order to be considered literate, students must not only be able to find and evaluate information but should be able to create verifiable information using relevant media, following accepted standards and practices.

Principle 4: Digital resources can help but alone are insufficient for helping students authentically engage in learning.

An often-stated justification for including technology in teaching and learning is that students are "engaged" by technology. Many may point out that most K-12 students have now grown up digital, with laptops, gaming systems, and later tablets and smartphones being a common part of their lives. Gurung & Rutledge (2014) point out two competing camps when considering students as digital learners simply because they have grown up with technology: enthusiasts and skeptics. *Enthusiasts* promote what these authors refer to as the "hope argument" which suggests that because students have grown up with technology, they are more willing to use it and try new technologies with little fear. Because of this, many new learning opportunities are made possible through digital technologies, such as mobile learning, ubiquitous learning (anytime, anywhere learning), and collaborative learning with social media. On the other hand, *Skeptics* promote the "fear argument" that poses that students use personal technology differently than they would in academic settings, and their basic technology use does not transfer well in learning environments. In their qualitative study comparing student personal (PDE) and educational digital engagement (EDE), these researchers propose a common ground. They reinforce that engagement in learning can be increased through learning opportunities that are intentional, active, constructive, cooperative, and authentic, which are often seen as teacher obligations; however, participants in their (small) sample indicated that digital learners do bring a range of technology skills to the table that allow them to move beyond "basic" use (the authors list drill-and-practice activities as an example of basic technology use) and knowledge and skills students can contribute to more interactive, engaging technology use. Again, it's not the technology alone, but how it is used that's important, and often students learn those uses with support from a teacher.

While many students do find technology interesting, to a point, there's a difference between being behaving compliantly and being authentically engaged in instruction. According to several researchers (Bundick, Quaglia, Corso & Haywood, 2014; Lawson, 2017; Parsons & Taylor, 2011), the interest in observing and promoting student engagement as a construct in education became popular in the 1980s but has shifted over time. It may best now be considered a "metaconstruct." Many educators want students to be "more engaged," but what do they mean? Is that just compliant? Non-disruptive? Or are students authentically engaged in learning because they see it is relevant and important to their lives? As the literature on engagement evolves, one's concept of engagement should be clearly described so that appropriate data can be collected to determine if students are truly engaged, with or without technology.

Early indicators for student engagement included items such as fewer discipline referrals and absences and increased graduation rates. These factors are often ascribed to **Behavioral Engagement,** and early efforts to enhance student engagement were targeted primarily towards at-risk students (Parsons & Taylor, 2011). Measures of Behavioral Engagement often do focus on students complying with desired procedures or rules.

Another early focus of student engagement was to help support better classroom management practices, and teachers were encouraged to use a variety of teaching strategies, many of which relied on using technology to research and present information. Indications of **Emotional Engagement** expanded the construct to include psychological or affective indicators that attempted to measure the value students perceived for school, their sense of belonging or their motivation or interest in school activities in and beyond the classroom. Over time the connection between student engagement and student achievement, sometimes referred to as **Cognitive or Intellectual Engagement**, have become more closely linked (Larson, 2017; Parsons & Taylor, 2011).

In a review of a large-scale implementation of a multidimensional framework of student engagement in 17 school districts in Canada, the *What did you do in school today?* Framework for Student Engagement describes three components of the engagement construct (Dunleavy, Milton & Crawford, 2010; Willms, Friesen, & Milton, 2009):

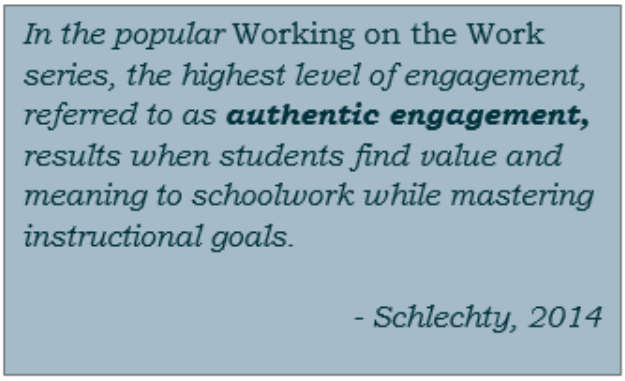
1. **Social Engagement.** Sense of belonging and meaningful participation in school life.
2. **Institutional or Academic Engagement**. Active participation in the formal requirements of school (e.g., attendance and homework completion).
3. **Intellectual Engagement.** Serious emotional and cognitive investment in learning using higher-order thinking skills (such as analysis and evaluation) to increase understanding, solve complex problems, or construct new knowledge.

Using a matrix for low to high challenge versus low to high student skills, researchers propose that different student indicators can be observed to describe different levels of engagement.

- **Apathy.** Students who perceive low challenge and have low or limited skills are likely to feel apathetic towards learning opportunities.
- **Boredom.** Those students who perceive low challenge in school work but have higher proficiencies or skills may find school work boring or of little relevance.
- **Anxiety.** Students with low or limited skills placed in a learning opportunity that they perceive as highly challenging are likely to feel apprehensive or anxious about learning.
- **Flow.** Borrowing a term from Csikszentmihalyi, once students develop sufficient skills and knowledge and are engaged in challenging learning opportunities, they are likely to be interested and feel successful.

When asked to describe what full engagement, or "flow," would look or feel like, students reported they imagined they would (Dunleavy & Milton, 2009):

- Solve real problems.
- Engage with knowledge that matters.
- Make a difference in the world.
- Be respected.
- See how subjects are interconnected.
- Learn from and with each other and people in their community.
- Connect with experts and expertise.
- Have more opportunities for dialogue and conversation (p. 10).



Engagement is a central component of Schlechty's (2002) popular *Working on the Work* series. He acknowledges that students will be engaged in different ways at different times within and across learning opportunities, but that different levels of engagement can be identified based on what students do and report. This framework describes the highest level of engagement, referred to as authentic engagement, results when students find value and meaning to schoolwork while mastering instructional goals—a concept clearly connected to authentic instruction and the AIW framework. These students are attentive, persistent, and committed to reaching learning goals. This is the type of engagement that most educators seek during instruction; however, Schlechty describes additional levels of engagement that can be observed in classrooms. Brief descriptions of these five levels of engagement follow.

Authentic Engagement

- Students are personally interested in topics and see them as relevant.
- Students persist through the work, even when faced with challenges, and the level of challenge is sufficient that the student feels a sense of accomplishment when completing it.
- Students perform at high levels and learning is retained beyond short-term measures of achievement.

Strategic Compliance

- Students are motivated to do the work due to external influences, such as grades, eligibility, pleasing parents or others, or the necessity for acceptance into college or other programs.

- Students work to get the right answer or complete activities rather than working for deeper understanding of content or high level of proficiency of skills.
- Learning is often not transferred to novel settings or not retained beyond intermediary performance opportunities (e.g., quizzes, tests, exams).

Ritual Compliance

- Students find little or no personal relevance to the work nor are they able to see a connection to their own lives and goals.
- The student often behaves or avoids calling attention to themselves by being unresponsive or avoiding contact.
- Student focuses on minimum requirements and works to "get by" or avoid outright failure.

Retreatism

- The student is not connected to the work and disconnects from classroom activities and learning goals.
- Students are not disruptive but attempt to hide or avoid notice.
- The student may feel or state they "can't" do the work or that they don't understand it.

Rebellion

- Students are completely disengaged from the learning activities. They are withdrawn and may put their heads down or sleep.
- Student goals are unrelated to the lesson or instruction.
- Students may call attention to themselves by acting out, disrupting the class, or encouraging others to disengage or even misbehave.

Research on engagement in its many forms has suggestion of benefit for students and schools. Student engagement has been found to predictive of "desirable academic and life outcomes" (Bundick, Quaglia, Corso & Haywood, 2014), including higher grades and higher scores on standardized tests, matriculating to not only attending but graduating from college, and reducing dropout rates.

Several researchers pose characteristics of classrooms and instruction that are considered to engage students in learning and therefore increase student achievement outcomes. In their extensive review of prior research on engagement, Parsons & Taylor (2011) posit that "successful, student-engaging classrooms" often combine:

1. Learning opportunities that are relevant, drawn from real-world situations or constructs, and are interdisciplinary, sometimes extending to learning beyond the classroom into the community.
2. Technology-rich environments that include a range of devices and digital resources, not just computers.

3. “Transparent” learning climates that are positive, challenging, and encourage students to take risks and reach high expectations that are determined through collaboration between teacher and student and are monitored by assessment for and of learning.
4. Respectful collaboration between students, between students and teachers, and between teachers.
5. A culture of learning where teachers are co-learners with students that focus on learning needs and engagement in learning over achievement.

Bundick, Quaglia, Corso, & Hawood (2014) propose the *Student Engagement Core (SEC)* model that consists of three-overlapping components, much like a Venn diagram with three circles pertaining to the students, the teacher, and the content. The four areas of overlap show the greatest evidences for promoting student engagement. These areas are:

1. **Student-teacher intersection (relationships)**. Engagement is increased when students perceive their teacher to be supportive, invested, caring, fair and respectful. Student engagement can, reciprocally, affect teachers instructional and motivational behaviors.
2. **Student-content intersection (relevance).** The more relevant students perceive learning opportunities to be, the more engaged they are likely to be. Relevance include relevance to one’s current interests, one’s future goals, and one’s identity.
3. **Teacher-content intersection (competence).** A teachers’ deep content knowledge alone is insufficient for promoting student engagement. Teachers must also be effective facilitators who incorporate pedagogical and social skills to deliver content.
4. **Student-teacher-content intersection.** Student engagement is greatest at the intersection of relationships, relevance, and teacher competence in delivering instruction.

These same authors specifically note that technology can be used to enhance student engagement but emphasize that simply using more technology may not lead to greater student engagement or learning. As echoed throughout the review, how that technology is used is important. They recall four suggestions (based on Corno and Mandinach, 2004) to consider for integrating technology to promote student engagement, including (a) educational computer games, (b) technological innovations designed to improve classroom teaching and learning (such as interactive whiteboards), (c) computer applications developed specifically for promoting motivation and self-regulation, and (d) use of Internet-based resources in and out of the classroom.

Echoing the work of Windham (2005), Parsons & Taylor (2011) note that much of the more recent research on engagement do fall into categories of "best practices" for increasing engagement in learning. These include:

1. **Interaction.** In order to promote authentic intellectual engagement, students describe a need for a teaching-learning partnership in which they are challenged, develop deep conceptual understanding, and can contribute their own ideas to their learning. Rather than telling students the correct answers, students and teachers explore and discuss content together to co-construct understanding and skills.
2. **Exploration.** Instructional approaches often mentioned to increase student engagement in learning include inquiry-based, problem-based, and exploratory learning.
3. **Relevancy.** Resonating strongly throughout the literature is the finding that students are most engaged when they perceive learning opportunities are relevant, meaningful and authentic as opposed to theoretical and text-based. Work that is relevant immerses students in inquiry within the discipline, requiring deep thinking and intellectual rigor, and is connected to the world outside of the classroom. Willms, Friesen & Milton (2009) also noted that these tasks can involve substantive conversation.
4. **Multimedia and Technology.** Students engage with a variety of digital media on various devices outside of classroom and would like to see a similar range of digital resources in their classrooms and learning opportunities. These best increase student engagement when they are leveraged to provide learning opportunities that meet the other five characteristics, such as relevant and challenging problem-based learning opportunities that connect beyond the classroom.
5. **Engaging and Challenging Instruction.** Numerous researchers studying student engagement report that students prefer appropriately challenging instruction in which they are held to high expectations. Engagement is promoted through engaging pedagogy and engaging curriculum, that requires both teachers and students to take some risk in an environment that supports learning from mistakes and even allowing students to have greater say in designing their own learning.
6. **Authentic Assessment.** As described earlier, engagement is increased when assessment contributes to learning and helps teachers improve learning opportunities rather than being used to summatively audit student knowledge and skills.

What does this principle mean for schools?

- Technology can engage students, for a while, but authentic instruction is more likely to yield authentic engagement in learning. Again, technology alone is insufficient for engaging students in authentic learning; it's how it's used that is important. Without authentic learning opportunities, technology can also lead to ritual compliance, retreatism, and even rebellion.
- Students report a wide range of outcomes related to the highest levels of engagement. These go beyond simply using technology and include indicators such as solving real problems, being respected, and making a difference in the world. These align with research that suggest successful, student-engaging classrooms combine relevant, real-world situations or constructs; technology-rich environments; and environments where teachers are co-learners and there is respectful collaboration between students and teachers.

Principle 5: Digital resources allow students and teachers to connect and collaborate with other students, teachers and other influential adults, and with the content.

Students entering college and careers (and many would correctly argue even before then) require strong inter- and intrapersonal skills that allow them to communicate their ideas at least verbally and in writing. Much current work is also team based, so the ability to effectively work as a part of a team is a key part of collaboration.

Many lists that describe key skills for graduates developed by educators, policymakers, and business and industry leaders usually include the categories of communication and collaboration (Jerald, 2009; National Association of Colleges and Employers, 2017; NRC, 2012; OECD 2017), including those that describe deep learning (Hewlett Foundation, 2013) and a range of soft skills often called 21st Century Skills (Partnership for 21st Century Skills. 2015). Students entering college and careers (and many would correctly argue even before then) require strong inter- and intrapersonal skills that allow them to communicate their ideas at least verbally and in writing. Much current work is also team based, so the ability to effectively work as a part of a team is a key part of collaboration. Because current methods and standards for communication and collaboration are influenced by New Literacies shaped by new and emerging digital resources, schools and districts across the country are making effort to incorporate instruction that allows students to develop these skills using digital resources while also meeting academic learning outcomes.

In terms of some of the instructional interventions related to developing communication and collaboration skills that show significant positive impact on student achievement, Hattie (2012) lists classroom discussion (*d* = .88), self-verbalization and self-questioning (*d* = .64), problem-solving teaching (*d* = .88), cooperative vs individualistic learning (*d* = .59), cooperative vs competitive learning (*d* = .54), and questioning (*d* = .49). Peer influences (*d* = .53) are also high and, Hattie notes, “can be much higher indeed if some of the negative influences of peers is mitigated” (p. 87).

Effective collaboration is not synonymous with “group work.” In fact, ineffective grouping strategies can have negative effects on students who then may try to avoid group work. Others might work independently even when assigned a group while still others might engage in “social loafing,” which refers to students who don’t contribute but expect others in the group to complete assignments for the group. Collaboration that yields effective teamwork must be taught (Lai, DeCerbo, & Foltz, 2017), and communication and collaboration can be taught while addressing content standards.

Collaborative groups are more successful when the group members determine goals for the group, and each individual understands their own role in reaching those group goals. Wiliam

(2011) refers to this as “group goals and individual accountability.” Beyond individual and group goal setting, group members need to understand—and often be taught and supported—effective collaboration. In reviewing definitions and descriptions of effective collaboration, Lai at al. (2017) identified three common elements: (1) interpersonal communication; (2) negotiation or conflict resolution; and (3) task management or team regulation. In other words, for students to collaborate successfully, they have to be taught how to communicate effectively with everyone on the team; negotiate potential solutions when problems arise; and establish processes for managing their work (e.g., setting personal and team goals, determining roles and workloads, and monitoring how well individuals and teams are progressing toward goals) (Cennamo, Ross & Ertmer, 2018).

Johnson and Johnson (1991) described the principles of effective cooperative learning that allows students to reach communication, collaboration, and academic outcomes. It has been used in a range of different subject areas and with students with diverse characteristics including English language learners, students of all ability levels including those with identified learning disabilities, along with students who require enrichment. In order for cooperative learning to be successful, students develop and use inter- and intrapersonal communication skills and group processes that allows them to reach personal academic goals while contributing to the goals of the group.

Collaboration Must Be Taught

Collaborative groups are more successful when the group members determine goals for the group, and each individual understands their own role in reaching those group goals. Beyond individual and group goal setting, group members need to understand—and often be taught and supported—effective collaboration. This requires being able to communicate and share ideas clearly, listen actively, consider the ideas and perspectives of others, and provide constructive feedback that promotes learning and moving towards the group goals.

Effective cooperative learning relies on five key elements:

1. **Positive interdependence.** Students in the group have to work together to accomplish goals for the group. The work of the group should be greater than what individuals can accomplish together, so it is important that students establish their own personal learning goals as well as goals for the group. As noted above, Wiliam (2011) emphasizes the need for group goals and individual accountability to promote effective collaboration in groups. Just as in work groups or teams, students are given or request roles to help the group be successful. Students need to understand their role and how their work contributes to the group. Wiliam (2011) cautions that to help promote individual accountability, no single student should be assigned the role of “reporter.” Instead, every student is responsible for reporting out on the work of the group.
2. **Applying interpersonal and social skills.** Depending on their prior experiences with group work, students may need to be taught communication and social skills that allow the group to work effectively. This requires being able to communicate and share ideas clearly, listen actively, consider the ideas and perspectives of others, and provide constructive feedback that promotes learning and moving towards the group goals.

Simply placing students in groups will not yield these complex interpersonal communication skills. Students may start with structured protocols for taking turns, sentence stems for asking questions of the group, and project plans or structured agendas. Eventually, students can determine the best ways to interact and monitor the effectiveness of their strategies.

3. **Individual accountability.** While the group is working on a larger goal, every student is responsible for specific learning outcomes, often academic outcomes based on content standards, but sometimes affective, behavioral, or social-emotional outcomes. Accountability implies assessment, and students can engage in self- and peer-assessments as well as those administered by the teacher within or outside of the group process to monitor and evaluate student success. While progress on content standards should always be assessed, many educators also assess the effectiveness of the group work and the processes they incorporated. Some teachers may incorporate group contracts that clearly describe the roles each team member is to play and the outcomes they are expected to reach.
4. **Promoting one another's success.** Because success of the group depends on each individual, team members should incorporate methods and strategies that motivate, encourage, acknowledge, and congratulate other members of the team. As with other group strategies, these may need to be modeled and taught, perhaps even drawing from strategies used during whole class instruction.
5. **Group processing.** Work teams have established processes. Managers shape the work and monitor the work of others to determine if the group will meet expected milestones. Other workers have to know how to ask for help, request information from others, and to share their work outcomes appropriately. Some of this can be modeled during whole class instruction. For example, if the whole class has developed norms for how students behave and work in class, group members may choose to bring some of these norms to their group to facilitate interactions with each other. Sometimes, groups may also need to have mediation or conflict resolution skills that allow them to address issues that come up within the group. Conflict resolution may sometimes require an outside mediator (aka the teacher) and, in some models, may result in the "firing" of a group member who cannot meet individual and group responsibilities.

Keeping groups small, from three to five students, is a recommended strategy for effective group work (Johnson & Johnson, 1991). Just as work teams are not randomly generated, there should be a purpose for determining group make up. Mixed groups often work well, but some tasks may require heterogenous grouping based on ability or other factors. Some teachers incorporate frameworks to identify student traits or characteristics (e.g., Gardner's Multiple Intelligences) to generate a mix of students. Others ask students to "apply" for different positions in groups. Teachers should monitor grouping strategies and determine the best strategies for different purposes.

Simply giving students access to technologies will not necessarily result in collaboration. However, just as in the world of work, school work groups can rely on a range of collaborative digital resources to support their work if they are taught how to use them to facilitate effective communication and collaboration. Group work does not always have to occur in class, and team members can still be productive when using asynchronous sharing resources, such as online productivity tools (e.g., Office 365), project or task management software (e.g., Trello), and

communications tools, such as email or social media. Groups can also leverage many of the tools used in many businesses across the globe to support synchronous communication, whether they are in the same room or not. Web conferencing tools, like Skype or Zoom, or ways students can meet, share and collaborate on documents and ideas, and archive their conversations to document their progress.

Simply giving students access to technologies will not necessarily result in collaboration. However, just as in the world of work, school work groups can rely on a range of collaborative digital resources to support their work if they are taught how to use them to facilitate effective communication and collaboration.

What does this principle mean for schools?

- Students entering college and careers require strong inter- and intrapersonal communication skills and the ability to collaborate effectively. In most industries today, communication and collaboration are either facilitated by or supported by digital technologies and the new literacies they require.
- Students (and adults) are already connecting through various media. Schools may see it as an obligation to support appropriate means for communicating and collaborating with others using digital technologies, whether synchronously or asynchronously, in order to prepare students for life outside of school. Today, not just later in college and careers.
- Simply providing access to technology alone will not help students become effective communicators and collaborators. They need to be taught these skills in supportive environments using the technologies they do and will use outside of school. Ineffective grouping strategies can negatively impact students. Collaborative groups are more successful when the group members determine goals for the group, and each individual understands their own role in reaching those group goals. Students need to be taught how to communicate and share ideas clearly, listen actively, consider the ideas and perspectives of others, and provide constructive feedback that promotes learning and moving towards the group goals.

Principle 6: Digital resources provide opportunities for students to demonstrate mastery of learning goals in a variety of ways.

Students demonstrate mastery of learning goals through a variety of formal and informal assessments. It is important to note that assessment here means more than "a test." While the term "assessment" often brings up images of bubble sheets, or now clickable radio buttons, "a test" is only one way to assess student learning. Assessment experts (Heritage, 2010; Herman & Baker, 2005; Herman, Osmundson, & Dietel, 2010; NRC, 2001) suggest that educators take a balanced approach to classroom and school assessment that includes short- (formative), medium- (interim), and long-cycle (summative) assessments. The number and type of digital resources available to support educators along all three cycles of assessment continue to increase. Digital technologies support more effective and efficient monitoring of student learning, along with the collection and reporting of student data that help teachers make decisions to adjust teaching, when necessary, to meet the needs of students. Collecting data from multiple measures of assessment has found its way into national policy with the reauthorization of the *Elementary and Secondary Education Act,* currently referred to as the *Every Student Succeeds Act* (Pub. L. 114-95), that allows states flexibility to develop new assessment designs, such as interim assessments offered throughout the course of the year that lead to a single summative score.

Assessment experts (Heritage, 2010; Herman & Baker, 2005; Herman, Osmundson, & Dietel, 2010; NRC, 2001) suggest that educators take a balanced approach to classroom and school assessment that includes short- (formative), medium- (interim), and long-cycle (summative) assessments. Digital technologies support more effective and efficient monitoring of student learning, along with the collection and reporting of student data that help teachers make decisions to adjust teaching, when necessary, to meet the needs of students.

The National Research Council (2001) describes a quality assessment system as one that is coherent, comprehensive, and continuous. *Coherency* refers to a system that includes assessment opportunities that are appropriately aligned to the demands of content standards and other desired learning outcomes (e.g., affective, behavioral, social-emotional outcomes, or others). A *comprehensive* assessment system is one that covers a range of knowledge, skills, and appropriate applications across the expected progressions of learning. A comprehensive system also provides data to support decision making at the classroom, program, school, and district level. A *continuous* system is, as the term applies, applied continuously throughout the year to monitor learning and adjust teaching and learning opportunities rather than simply auditing learning after the fact. It is difficult to manage all of the data currently made available through a coherent, comprehensive and continuous assessment system without digital technologies. Digital technologies make it easy to track individual and groups of students and

how they perform on assessments that can be linked to content standards or other desired learning outcomes, either individual or multiple standards. Digital systems, such as learning management systems, also make it possible to identify (tag) instructional activities by content standards or learning outcomes so data can be collected on the full teaching/learning cycle.

It is difficult to manage all of the data currently made available through a coherent, comprehensive and continuous assessment system without digital technologies. Digital technologies make it easy to track individual and groups of students and how they perform on assessments that can be linked to content standards or other desired learning outcomes, either individual or multiple standards.

Reporting for the National Research Council (2012), noted educational researchers and experts acknowledge that educators can approach learning from varied theoretical perspectives; however, to design instruction that results in transfer (the ultimate goal of learning), educators should clearly describe the desired learning goals and develop learning opportunities based on a "well-defined model of how learning is expected to develop" (p. 144), or a **learning progression.** Learning progressions can be described at various grain sizes. Macro learning progressions, what some may refer to as "upper-case Learning Progressions," describe common sequences that most learners are likely to follow to achieve significant learning outcomes within a curriculum or series of courses. These learning progressions are often confirmed by empirical studies and have led to the development of national standards that describe learning progressions within and across years of study (Gotwals, 2018).

The Importance of Learning Progressions

To design instruction that results in transfer (the ultimate goal of learning), educators should clearly describe the desired learning goals and develop learning opportunities based on a "well-defined model of how learning is expected to develop" (National Research Council, 2014, p. 144), or a ***learning progression.***

Learning progressions can be constructed at ever finer grain sizes down to the sequence that describes how students are likely to learn a particular skill, set of related skills, or a bank of knowledge. These can be accomplished over a lesson or series of lessons and while teachers make their best-informed decision about how learning progressions unfold, individual students bring their own prior experiences and understandings, misunderstandings, ways of thinking, and abilities that can impact the actual progression they take. Understanding learning progressions is critical because not all learning—in fact *most* learning—can be represented by a dichotomous "got it or didn't" (right or wrong) accounting mindset (Alonzo, 2018; Furtak, Morrison & Kroog, 2014). Sometimes students get *some* of it, or some students

get more than others, and some students got it but don't necessarily have the appropriate language to share that they did (Alonzo, 2011). Ultimately, however, students should reach the desired learning goals regardless of the path they take.

Authors for the National Research Council (2012) suggest best practices encourages teachers to first design measures (assessments) to determine how learners will demonstrate their new knowledge and skills before designing activities within curricula, units, or lessons. In other words, incorporating a "backwards design" instructional design model can help to provide those valuable models and examples that learners require to guide their learning along their progression and can help determine (1) what kinds of assessments are appropriate, and (2) the learning opportunities that are necessary for students to be successful on those assessments. Determining assessments first can also determine the types of resources, such as digital technologies, and supporting skills that should also be addressed during instruction. Using a backwards design approach that first determines appropriate demonstration of learning outcomes rests on what this group describes as "three pillars" (National Research Council, 2001, p. 44) for which evidence of learning can be determined. The connection between the instructional design principles and these three pillars are obvious. The three pillars include

1. A model of what students are to know and do
2. Tasks or situations that allow instructors to observe student behaviors relative to the model
3. An interpretation framework for "drawing inferences" from how students perform, to determine where they are in their learning progression or the degree of mastery they have obtained.

McTighe and O'Connor (2005) describe seven assessment and grading practices that can support learning and enhance teaching, all of which can be more efficient and effective when using digital technologies:

1. **Use summative assessments to frame meaningful performance goals.** Letting students know, at the onset of a unit of study, how they will be assessed helps them set goals and understand what they need to know and be able to do.
2. **Show criteria and models in advance.** Sharing sample work products at varying levels of mastery helps students better understand the expectations for their work and can support them as they monitor their progress toward learning goals.
3. **Assess before teaching.** Pretests are a popular component of digital curricula but can be implemented with a variety of digital resources by any teacher. Pre-assessments help teachers understand the knowledge and skills students already possess and can save them time when data indicates learning outcomes students have already mastered.
4. **Offer appropriate choices.** Digital resources expand the choices students have for demonstrating their learning.
5. **Provide feedback early and often.** While teachers and peers can do this in person, a variety of digital resources including collaborative environments allows students to receive feedback that is specific, helps them identify their strengths and areas for growth, and gives them help in determining the next steps they need to take to meet their learning goals.

6. **Encourage self-assessment and goal setting.** Students benefit from incorporating self-directed learning strategies, and using digital resources such as digital portfolios, calendars and task management software to set goals and monitor their progress towards them.
7. **Allow new evidence of achievement to replace old evidence.** When moving towards a mastery- or competency-based approach when students demonstrate learning outcomes when they are ready requires flexible grading tools that may best be handled by digital grading and reporting tools. Digital tools make it simple to assign weighted grades, partial credit, and replace grades with links to evidence and comments justifying the reason for change.

Of the three types of assessments, formative assessment strategies alone have proven to be effective in supporting student achievement. “Providing formative evaluation” has the fourth largest effect size (*d* - .90) for any intervention identified in Hattie’s (2012) research on visible learning. Only self-reported grades (a formative strategy related to progress monitoring), Piagetian programs (using developmental theories from noted education expert Jean Piaget), and response to intervention have higher effect sizes.

A Balanced Assessment System

Authors for the National Research Council (2012) acknowledge that there is widescale evidence that long-cycle assessments, such as standardized tests, do not adequately represent true measures of student progress towards learning goals, particularly because of the constraints of limited time and testing formats (National Research Council, 2012). In other words, even successful performance on long-cycle assessments may not indicate learning transfer, or may not give students the opportunity to truly demonstrate transfer because they cannot assess students at the depth of rigor required by some content standards, standards at what may be classified as the strategic thinking (DOK 3) or extended thinking Depth of Knowledge (DOK) levels (Webb, 1997). Instead, standards at this depth of rigor must be assessed in classrooms.

Unfortunately, while technology is now often used in long-cycle, summative assessments, the authors for the National Research Council (2012) acknowledge that there is widescale evidence that long-cycle assessments, such as standardized tests, do not adequately represent true measures of student progress towards learning goals, particularly because of the constraints of limited time and testing formats (National Research Council, 2012). In other words, even successful performance on long-cycle assessments may not indicate learning transfer, or may not give students the opportunity to truly demonstrate transfer because they cannot assess students at the depth of rigor required by some content standards, standards at what may be classified as the *strategic thinking* (DOK 3) or *extended thinking* Depth of Knowledge (DOK)

levels (Webb, 1997). Instead, standards at this depth of rigor must be assessed in classrooms. In order to provide learning opportunities that support transfer these authors list the following research-based methods for designing learning that yields transfer of knowledge:

- **Use multiple and varied representations of concepts and tasks.** Building upon the research of multimedia design for learning and the Universal Design for Learning Framework[1], these authors note that multiple representations of content and knowledge can help learners of all ages understand even complex concepts. These authors note that recent research demonstrates that young children, as young as preschool, are capable of quite sophisticated reasoning and thinking in science, math, and other content areas but may require various methods to demonstrate their understandings.
- **Encourage elaboration, questioning, and self-explanation.** Asking learners to justify their answers or to summarize material has been shown to support transfer. Learners can also be taught to incorporate self-generated questions and elaboration (i.e., self-assess) during their own reading so they can better understand materials they have just read or studied.
- **Encourage learners in challenging tasks with supportive guidance and feedback.** Decades of research show that novice learners do not have the skills nor the ability to learn from complex or challenging materials without guidance and feedback. This is similar to Vygotsky's famous premise of the Zone of Proximal Development (ZPD). Feedback that scaffolds learning and helps students progress across the ZPD must be specific in nature. Simply indicating a learner response is correct or not, referred to as **outcome** or **performance feedback**, has little to no value in terms of learning for transfer. Students require **cognitive feedback** that describes what they are doing, how well what they are doing does or doesn't align within the learning progression, and what they can do to try to improve their performance to reach desired learning outcomes.
- **Use examples and cases when teaching.** Examples and modeling can help learners, even very young learners, understand complex ideas and knowledge. Learning scaffolds that are gradually taken away have significant impact on learning.
- **Promote student motivation.** Instruction can be designed that actually motivates students to succeed (see Keller's ARCS Model for Motivational Design as one framework). Identifying the concept of promoting a growth mindset promoted by Dweck (2007) demonstrates that learners reach deeper learning associated with transfer when they: (1) attribute their performance to effort rather than ability, (2) orient their goals towards mastering the material rather than performing well (or not), (3) believe they can be and expect to be successful, (4) believe that intelligence is changeable, not fixed, and (5) are interested in what they are learning.

[1] Originally developed by researchers at the Center for Applied Special Technologies (CAST) (Rose & Meyer, 2002) and using the findings from neuroscience and insights on how people learn, the Universal Design for Learning Framework includes guidelines for educators that remove barriers to learning for all children. Now included in education policy, such as the Individuals with Disabilities in Education Act (IDEA) and the Every Student Succeeds Act (ESSA), UDL principles rely on digital technologies to provide multiple means of engagement, representation, and action & expression. The guidelines can be found online at http://udlguidelines.cast.org/.

- **Use formative assessment strategies.** The NRC reinforces findings from other researchers that transfer can occur as a result of learning when formative assessment strategies are used to (1) make learning goals clear to learners, (2) monitor learner progress, provide cognitive feedback, and help learners understand where they are in a learning progression, and (3) involve learners in self- and peer-assessment. These three characteristics are the acknowledge components of self-directed learners (Ertmer & Newby, 1996).

Many educators believe that interim assessments, also referred to as benchmark assessments or tests, hold great promise to improve student achievement on summative assessments. The theory is that teachers and others that support learning will receive data on student progress during the learning process so that instruction and learning opportunities can be modified based on the medium-cycle assessment data. The key to their success is implementation. For interim assessments to have the desired positive impact on student achievement as they are intended, they must quickly and easily provide clear data within the learning cycle that teachers can act upon in a timely fashion. Interim assessments that are implemented more like their summative counterparts opportunities for learning will not have the desired impact on student achievement (Christman, Neild, Bulkley, Blanc, Liu, Mitchell, & Travers, 2009; Goertz, Oláh, & Riggan, 2009; Konstantopoulosa, Miller, van der Ploeg, & Lia, 2016).

For interim assessments to have a greater impact on promoting positive student outcomes, advocates suggest a wider conception of how they should be implemented, including using multiple formats and methods. They should also be embedded in a culture where assessments are not seen as "a test," but as an opportunity to monitor learning and change the course for learners who need it. Critical to this culture, according to one large-scale study (Christman et al., 2009) are "learning leaders" who can engage all faculty in substantive conversations around teaching, assessment strategies, and the use of assessment data for more formative approaches. Effective learning leaders can facilitate conversations in a supportive environment so teachers can consider how their specific students might learn best, what current instruction and resource have and have not worked, and to identify their own needs either for different methods, resources, or even to learn more about their content. These can be challenging conversations. As these researchers noted, "The most important message from this research is that the success of even a well-designed system of interim assessments is dependent on the knowledge and skills of the school leaders and teachers who are responsible for bringing the system to life in schools" (p. 22).

Those using interim assessments should focus more on how they are implemented and how their data is used for adjusting learning opportunities rather than continuing to engage in practices that have not borne any fruit. Most assessment experts agree that interim assessments can be used for one of three different purposes, which determines when they are administered; what resources are used to administer them; and how the data is collected, reported, and analyzed. When used for *instructional purposes,* interim assessments are used more like formative strategies during instruction to help adjust instruction, as necessary. Interim assessments that are used for *evaluative purposes* occur less often and their data is often used over the span of years to make programmatic decisions about teaching practices, curricula, and other resources. Many school districts incorporate interim assessments for *predictive purposes* to determine how well students will perform on long-cycle summative assessments. Few, perhaps no, assessment experts agree that a valid and reliable assessment—of any type—can be used for multiple purposes. The best assessments are designed to generate data for specific types of purposes and decision making (Perie, Marion, Gong & Wurtzel, 2007). Trying to use assessments for multiple purposes, especially purposes that they were not designed for, can erode their validity and reliability.

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Districts and schools that wish to use interim assessments for instructional purposes may want to expand their conception of what can be assessed and how, such as incorporating problems, projects, and performances that generate a wide range of data to monitor student progress. In a policy brief for the Aspen Institute (Perie et al., 2007), the following eight characteristics are listed for implementing interim assessments for instructional purposes:

1. The assessments should fit as seamlessly as possible with instruction and support student learning during the assessment.
2. The assessment should provide rigorous evidence it has contributed to student learning.
3. The assessment itself and the score reports should facilitate meaningful and useful conversations about instructional effectiveness.
4. Clear guidelines describe how the results can and should be used to inform instruction.
5. The assessment should include only content and skills students have had an opportunity to learn and be situated as closely as possible to that learning opportunity.

6. The assessment addresses a limited number of important instructional goals.
7. Assessment items should include high-quality, open-ended tasks, not just multiple-choice questions in order to thoroughly diagnose student understanding and misconceptions.
8. The assessment should incorporate extended tasks or synthesis works to measure learning goals not easily addressed by long-cycle, large-scale assessments.

Few, perhaps no, assessment experts agree that a valid and reliable assessment—of any type—can be used for multiple purposes. The best assessments are designed to generate data for specific types of purposes and decision making (Perie, Marion, Gong & Wurtzel, 2007). Trying to use assessments for multiple purposes, especially purposes that they were not designed for, can erode their validity and reliability.

The idea that interim assessments should include open-ended and extended tasks that help to gather information about student understanding and misconceptions supports the idea that interim assessments may benefit from being aligned to authentic instruction. Authentic assessments often incorporate problem-, project-, or performance-based tasks that leverage digital resources. Students can use digital resources to research, collect and organize information, and generate products in various formats that demonstrate deep learning that is difficult to measure with a multiple-choice test. Authentic tasks, including performance tasks, are now being incorporated into large-scale, high-stakes testing through access to digital technologies. Although there may be some differences in description, such as whether or not students can collaborate on authentic assessments, some of the more common aspects of authentic assessments are the following:

1. The assessment is realistic or has a realistic context; it reflects the way information or skills would be used in the “real world.”
2. The assessment is cognitively complex and requires judgment and innovation; it is based on solving unstructured problems that could easily have more than one answer and, as such, requires learners to make informed choices and defend their answer(s).
3. The assessment is often performance-based; it asks students to “do” the subject, that is, to go through the procedures that are typical to the discipline under study.
4. The assessment requires students to demonstrate a wide range of skills that are related to the complex problem, including some that involve judgment.
5. The assessment can be formative in nature and allow for practice, feedback, and second chances to solve a problem being addressed.
6. Because the assessment is complex, the scoring criteria can also be complex, sometimes requiring multiple indicators, portfolios, or other means to score student work. (Frey, Schmitt, & Allen, 2012; Wiggins, 1998)

What does this principle mean for schools?

- A variety of digital tools and resources are available to support a balanced approach to assessment that includes formative, interim, and summative assessment opportunities. These tools can make it easier to present assessment items, sometimes score items, and to collect, analyze, and report data from some of those assessments. Using digital tools to support assessment can improve the efficiency in which students and teachers engage in assessment of and for learning.
- It is difficult to manage all of the data currently made available through a coherent, comprehensive and continuous assessment system without digital technologies. Digital technologies make it easy to track individual and groups of students and how they perform on assessments that can be linked to content standards or other desired learning outcomes, either individual or multiple standards.
- Very little learning can be represented by a dichotomous “got it or didn’t” accounting mindset. Learning progressions are used to describe a well-defined model of how students might be expected to learn. Instruction based on learning progressions can help students achieve transfer, the ultimate goal of learning.
- Using a backwards design approach identifies relevant assessments first that then guide the development of curricula, units, and lessons. Determining assessments first can also determine the types of resources, such as digital technologies, and supporting skills that should also be addressed during instruction.
- Formative assessment strategies are one of the most effective instructional interventions for promoting student achievement.
- While standardized assessments can incorporate technology to capture and report student performance data, these assessments are limited by time and testing formats when trying to assess content standards that require strategic or extended thinking. These standards are often assessed at the classroom level and require multiple and varied representations of concepts and tasks.
- Interim assessments can be used to impact student outcomes on later summative assessments if they are implemented with fidelity. In addition to embedding them within the learning cycle and the reporting student data from these assessments, teachers and administrators must be prepared to act upon that data to address student learning needs. When used to provide opportunities for problem, project- or performance-based assessments, interim assessments may help teachers restructure teaching in the moment and provide a more comprehensive picture of student achievement. The more closely assessment is linked to and occurs with instruction, the greater opportunity it has to promote student achievement.
- Few assessment experts agree that assessments can be used for multiple purposes. The best assessments are designed to generate data for specific types of purposes and decision making. Trying to use assessments for multiple purposes can erode their validity and reliability.
- Interim and summative assessments can be helpful for making programmatic decisions over long periods of time, and digital technologies make the collection, analysis, and reporting of data more efficient.
- Digital resources are helpful when incorporating problem-, project-, or performance-based tasks, as they often require students to collect, analyze, and create a range of information in a variety of formats.

Principle 7: Digital resources allow teachers and students to monitor progress towards learning goals.

As noted previously, formative assessment strategies have a significant positive impact on student achievement (Black & Wiliam, 1998; Heritage, 2010, NRC, 2001; Wiliam, 2014), and by Hattie's (2012) calculations, one of the largest significant positive effects over almost any other instructional intervention. Black & Wiliam (1998) reported in their seminal research synthesis that not only were learning gains from formative assessment strategies among the largest reported for educational interventions, the largest student gains were made by those formerly categorized as low achievers. As with other forms of assessment, the data generated when incorporating formative assessment strategies is more efficiently and effectively gathered when using digital tools.

The Value of Formative Assessment Strategies

Formative assessment strategies *have a significant positive impact on student achievement (Black & Wiliam, 1998; Heritage, 2010, NRC, 2001; Wiliam, 2014), and by Hattie's (2012) calculations, one of the largest significant positive effects over almost any other instructional intervention. Black & Wiliam (1998) reported in their seminal research synthesis that not only were learning gains from formative assessment strategies among the largest reported for educational interventions, the largest student gains were made by those formerly categorized as low achievers.*

Formative assessment strategies occur daily during the interactions students have with teachers, with each other, and in self-assessing their own learning. Formative assessment strategies may also be referred to as assessments for learning, because they are embedded in the learning process and should result in new learning by students.

There is some confusion around the term. Some educators and policymakers use the term "formative assessment" as an event, like a test, that is intended to help inform instruction but can often take place long after instruction has occurred and so has minimal impact on day-to-day instruction. In this review, this type of assessment event is referred to as an interim assessment.

Instead, this review refers to **formative assessment strategies,** not an event, which is in line with the definition presented by the major researchers and their findings cited above. Formative assessment strategies occur daily during the interactions students have with teachers, with each other, and in self-assessing their own learning. Formative assessment strategies may also be referred to as assessments *for* learning, because they are embedded in the learning process

and should result in new learning by students. Because formative assessment strategies are a part of the learning process, they are not graded (Heritage, 2010; Wiliam, 2014). They can be informal interactions, such as a series of probing questions a teacher asks a student or group of students during instruction, or a quick exit poll students respond to on their phones or laptops as they leave class. They can also be more structured or formal, such as the use of a rubric or peer-review checklist that students use with each other to monitor their learning. In all cases, formative assessment strategies represent a process, not an event (Alonzo, 2018; Furtak, Morrison & Kroog, 2014; Gotwals, 2018; Heritage, 2010; Linquanti, 2014; Wiliam, 2014).

Formative assessment strategies, according to Heritage (2010), are “aligned to the short-term sub-goals, which are the focus of the lesson, and data from them provide teachers with a steady stream of information to keep learning moving forward” (p. 28). Teachers who implement formative assessment strategies effectively rely on known and evolving understandings of learning progressions, both at a macro and very micro level. These micro learning progressions, as described earlier, may be based on the best-known progression students are likely to make while mastering the learning outcomes for a lesson or unit but can be influenced by their prior knowledge, misconceptions, and skills. These effective teachers modify or update their understanding of micro learning progressions over time as they interact with their students.

One common metaphor for describing progressions is that of using a map. On the map, the teacher and students need to know where they are and where they want to end up. But students in a single class may be at different starting places and may take different routes to get to the final destination (learning transfer). Therefore, students can demonstrate their learning in different ways depending on where they are and the path they took. Using their understanding of learning progressions, teachers can predetermine appropriate formative assessment strategies they can incorporate in their instruction based on their knowledge of students.

One way to do this is by using the Depth of Knowledge (DOK) framework developed by Webb (1997) which also serves as the framework that informed the development of new college-and-career-ready content standards (Gotwals, 2018), including the Washington State K-12 Learning Standards in English Language Arts, Mathematics, and Science. The DOK framework not only describes the knowledge and academic skills students must master in a content area but also how content knowledge and skills are used strategically when addressing real-world problems and to extend one’s own knowledge through reflection and metacognition. Various digital technologies provide ample resources to help both students and teachers monitor and

document learning progress efficiently and effectively, especially when students are in different places and take different routes to learning transfer. Examples follow:

1. **DOK 1.** Students working on comprehending key ideas and processes in a subject may respond to multiple-choice or short-answer questions to share their understanding using online or digital quizzes or surveys using mobile devices or computers (e.g., Pick the letter that corresponds to the hypotenuse in triangle ABC. Explain the difference between a hypothesis and a theory. Highlight the two lines in the poem that incorporate assonance.).
2. **DOK 2.** Students that require feedback on new academic skills may be asked to perform them for each other or the teacher or to capture their performances digitally using collaborative productivity software (e.g., Office 365); screen capture or whiteboard applications; video or audio recordings; or applications tailored to content areas, such as calculators, simulated labs, or coding robots.
3. **DOK 3.** Students engaged in content standards at the level of strategic thinking choose the most appropriate knowledge and skills they have developed through academic exercises and apply them to ill-structured problems that may require finding, evaluating, synthesizing, and reporting a variety of information and data related to a problem or project. Students may capture this information in text, graphic, or other media formats in a digital notebook, journal, project plan, or website, often being asked to support their findings and reasoning, sometimes using a checklist or rubric.
4. **DOK 4.** At this depth of knowledge, students reflect on their performance in ill-structured, real-world problems to determine what they have learned, what misunderstandings they might have clarified, what learning strategies worked well, and how they might approach similar learning in the future. Sometimes referred to as “making thinking visible” (Ritchhart, Church & Morrison, 2011), many digital technologies can help students in these metacognitive activities through the generation of concept maps, flowcharts, and reflections using text, imagery, video, or other media.

Continuing with the map idea, the formative assessment process is usually organized around a series of three or four questions (Hattie, 2012; Heritage, 2010). When you think about traveling with a map, these questions are often presented similar to the following:

1. Where am I going?
2. Where am I now?
3. Where do I go next?
4. How will I get there?

In terms of knowing where students ultimately need to end up, teachers use learning progressions to determine the learning outcomes, often referred to as **learning targets.** Hattie refers to them as “learning intentions.” Usually based on content standards, but sometimes including affective, behavioral, or social-emotional outcomes, students should understand what the desired learning targets are in language that makes sense to them. If teachers cannot create clear learning targets that students understand, it is unlikely they can create valid and reliable assessment opportunities for students (Hattie, 2012). In order for students to know

when they've reached their destination, teachers also provide **success criteria** that clearly describe what the students should know and be able to do. Clarke, Timperly and Hattie (2003) confirm, "A key issue is that students often need to be explicitly taught the learning intentions and the success criteria" (p. 53). Students and teachers should be able to determine whether students have met the success criteria or whether they're still on the road.

Added Value for Learning Progressions

Using their understanding of learning progressions, teachers can predetermine appropriate formative assessment strategies they can incorporate in their instruction based on their knowledge of students. If teachers cannot create clear learning targets that students understand, it is unlikely they can create valid and reliable assessment opportunities for students (Hattie, 2012).

In order for students to understand where they are and where to go next, formative assessment strategies incorporate explicit feedback based on student performance. There is evidence that providing appropriate feedback to advance student understanding may be the most difficult step in the formative assessment process (Alonzo, 2018). Finding out your answer was correct or not (right or wrong), called **performance** or **outcome feedback,** does not meet this type of explicit feedback necessary for students to move forward (Butler & Winne, 1995). This is one reason early programmed instruction held little educational value. While it may have been fun to try and beat your score of the number of questions correct, or sometimes to experience the raucous sounds and visuals for incorrect answers, simply knowing the status of your response gave students no direction of what to do next if they were correct, or what to try differently or not. Feedback that gets to this level of detail, sometimes referred to as **cognitive feedback** (Butler & Winne, 1995), helps students measure their current understanding (where they are), and what they might do to improve their performance or to move towards the final learning target (where to do next).

The final question, 'How will I get there?' often depends on the teacher's content and pedagogical knowledge, but sometimes can be scaffolded by adaptive curricula (or intelligent tutoring systems), rubrics, scoring guidelines, or other curricula material. Teachers make decisions about "responsive action," or the next best action students can take as a key part of the formative assessment process (Heritage, 2010).

Teachers and students can rely on a range of digital and print methods and resources to collect and manage all of the data that is generated through learning with embedded formative assessment strategies, which can be embedded in digital curricula units or posted to a learning management system. Teachers need to create and share learning targets and success criteria for students. Students and teachers need to collect progress along the way that helps students understand where they are in the learning progression towards meeting learning targets. Ultimately, the learning process will end and students will complete some form of summative assessment. Teachers and students can use learning management systems, print or digital data

notebooks, print or digital portfolios or journals, and a range of assessment technologies that collect print, scannable print, or digital responses. While the term print is included often to represent actual practice in my schools, the most efficient teachers and students use a combination of digital systems to capture and manage all of this learning data—data that can be shared with parents and guardians.

What does this principle mean for schools?

- Formative assessment strategies are one of the most effective instructional interventions for promoting student achievement, especially for students formerly categorized as low achievers. There are a variety of digital resources that can help teachers and students implement formative assessment strategies effectively and efficiently.
- Formative assessment strategies are not an event, like a test, but a process. Formative assessment strategies occur daily during the interactions students have with teachers, with each other, and in self-assessing their own learning. Formative assessment strategies may also be referred to as assessments *for* learning, because they are embedded in the learning process and should result in new learning by students.
- Teachers can predetermine formative assessment opportunities based on their understanding of learning progressions for different content standards or learning outcomes.
- Formative assessment strategies can create a good deal of data for each student. Digital resources are a more efficient method for collecting and sharing this data than print.
- If teachers cannot create learning targets that students understand, it is unlikely they can create valid and reliable assessments for those learning targets.

Conclusion: Making the Most of the Principles for Digital Learning

The research supporting the principles for digital integration demonstrate that technology *can* be used effectively to promote student achievement on academic measures and other desired learning outcomes, such as engaging students in authentic learning opportunities that help make connections between content and the real world; keeping up with the changing meaning of "being literate;" and helping students develop supporting skills important for success in college and careers, skills such as critical and creative thinking, communication, and collaboration. Many of the principles overlap or contribute to each other. Taken as a whole, there is one clear message from the research that undergirds them, **technology is only effective when used appropriately, and that use is mediated by a skillful teacher.**

Technology can help teachers and students become more effective and efficient in their corresponding roles, with those roles sometimes overlapping. High-quality digital content is now available that can be reached at any time from anywhere through a variety of devices connected to the Internet. Students and teachers alike have access to the same or similar tools and information that professionals use that can help them move beyond developing shallow knowledge to applying those same resources to learn content more deeply by addressing ill-structured, real-world problems. Technologies are especially helpful for capturing and managing the large amounts of data generated during the teaching and learning process, so teachers and students can monitor student progress and take actions within the learning cycle to reach desired learning goals before it is too late.

Introducing technology alone is insufficient for reaching the outcomes that the research literature shows are possible. Technology proficiency, often embodied by New Literacies, is necessary to make the most of technology resources. Both teachers and students require technology proficiency, but those proficiencies change over time. This does not suggest an emphasis on basic technology skills. Mastering New Literacies requires developing skills in context, and continued opportunities to enhance those skills as technologies change. Having teachers and students participate in decontextualized, low-level programs that teach basic technology skills that may soon be outdated is not the answer. Instead, having teachers and

students develop the skills to become self-directed, independent learners will allow them to integrate and use technology more effectively and to incorporate relevant new and emerging technologies as they become available.

Reaching a point where teachers and students are self-directed, independent learners who leverage technologies to support teaching and learning takes time and support. Yes, the tangible supports of hardware, networking, and content resources are important, but teachers and students also require sufficient time to develop and hone their skills, to monitor what is and isn't working, and to explore new technologies and digital resources. They need time to practice, and sometimes fail, and learn from those experiences so they are better adept at meeting the next challenge.

The suggestion that things can go wrong, that failure is an opportunity for learning, suggests that schools that do not already embody this philosophy may need more substantial supports for changing the culture of the school, or the mindset of those in the school. Changing the culture of schooling can be daunting, as it calls all stakeholders to question their own roles and the purposes of the organization. But schools the retain the mindset that "standards-based" instruction means providing shallow learning opportunities that result in dependent learners through the use of low-level "read and complete" worksheets or drill-and-practice programmed instruction will not truly be reaching the depth of rigor required by content standards in all content areas in all grade levels. Nor will they reach the potential of technology to truly support the generation of self-directed, independent learners who can transfer their learning to authentic settings. Those schools that empower teachers and learners to take risks and to learn from their mistakes are those where technology has the greatest potential for promoting desired student outcomes—whether academic, behavioral, or social-emotional. Schools that help teachers become those that leverage technologies for authentic learning opportunities will see a higher return on their technology investments as yielded through increased student learning.

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