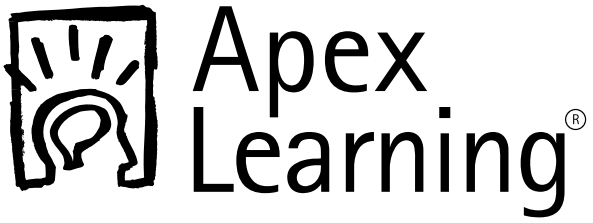

Research Put into Practice:

Apex Learning Curriculum & Pedagogy

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Introduction

Apex Learning® was founded in the late 1990s as one of the world's first providers of fully online, digital curriculum for secondary education, at a time when online learning was beginning to enter the popular lexicon. From the start, Apex Learning has paid close attention to how students learn and how digital curriculum can support learning. The introduction to this white paper begins with a discussion about how learning sciences define learning and the learning experiences students need exposure to in order to be prepared for college, work, and life. The paper then presents how research on learning theory has been put into practice in the development of Apex Learning digital curriculum.

How Learning Sciences Define Learning

The National Research Council's seminal book How People Learn (HPL): Brain, Mind, Experience, and School (Bransford, Brown, & Cocking, 1999) has set one of the most widely used and respected standards for how educators and researchers define learning.

The HPL framework defines successful learning as moving toward adaptive expertise—that is, the ability to apply knowledge creatively in new situations (Hatano & Inagaki, 1986). Student learners are like apprentices who work with experts (teachers and others) and tools (curriculum) in authentic settings (learning communities) to grow from novices to experts. Successful learners develop characteristics that experts possess (Bransford, Brown, & Cocking, 2000, p. 31):

- Experts have accumulated extensive content knowledge that is organized in ways that reflect a deep conceptual understanding of the subject matter in their domain.
- Experts' content knowledge is more than sets of facts and procedures. Experts understand facts and procedures within the contexts and conditions for which they apply.
- Experts' deep, conditionalized knowledge enables them to notice features and meaningful patterns that novices do not notice.
- Experts can fluently access and recall pertinent knowledge with little cognitive effort.
- Experts can flexibly apply their knowledge to routine situations within their domain and may adaptively apply their expertise to unfamiliar situations, including situations outside of their domain.

Students typically begin as novices in education, with varying formal and informal content knowledge and understanding. Through the educational process they move toward formal knowledge.

Apex Learning understands that the goal is for students to become active learners whose pursuit of increasingly adaptive expertise is a lifelong journey.

Learning for College, Work, and Life

Apex Learning is committed to helping students achieve the educational outcomes they need to succeed today and thrive tomorrow. These outcomes are consistent with the characteristics of experts and the goal of adaptive expertise.

Since How People Learn was published, the pace of globalization has increased, and young people now face significantly more competition in a global workforce. Books such as The World Is Flat (Friedman, 2005) have driven home the importance of education in building expertise that supports problem solving, creativity, and lifelong learning.

While developing academic expertise was once a privilege of the few at elite institutions, today we are tasked with empowering all learners everywhere (Davidson & Goldberg, 2009).

With the growing abundance of information available, students need the intellectual tools and learning strategies to seek relevant resources, recognize what is important, and evaluate what is credible (Bransford et al., 2000). They need to understand the fundamental structures in various subject areas well enough to ask pertinent questions, think productively, and communicate effectively.

Students need integrated knowledge of facts, concepts, and strategies that will enable them to make connections and contributions to complex issues such as those related to the environment, health, and the economy (Partnership for 21st Century Skills, 2009). More than ever, education must help learners become innovators—with the ability to apply their knowledge flexibly and creatively to solve problems in new situations.

Research and Apex Learning Practice

The research presented is divided into three sections. Section I focuses on how learners build knowledge modeled on the characteristics of experts and how the multimedia presentation of knowledge can be designed to support this learning. Adhering to these principles, Apex Learning digital curriculum gives students the tools they need to actively build knowledge and thinking skills.

Section II discusses research on improving learning with instruction that elicits students' prior knowledge, makes learning meaningful, and addresses learners' readiness for new content. Apex Learning courses differentiate instruction to meet students where they are and develop their capacities, giving all students access to rigorous content.

Section III focuses on the use of assessment, timely feedback, and effective data management to reveal student understanding and support effective learning throughout the instructional process. The Apex Learning management system seamlessly provides information about learner knowledge to guide teachers in planning instruction, empower learners in monitoring their own progress, and report standards-based outcomes.

Each research summary is followed by detailed discussion of how the research is applied within the Apex Learning digital curriculum.

I. Research on Acquiring Knowledge and Thinking Skills

This section discusses important findings about learning and creating knowledge-centered environments. First, the learning sciences offer a time-tested base of research and practice on how people learn and how to design instruction so that students build knowledge modeled on the characteristics of expert knowledge. Second, students learn more when information in multiple media is presented to them in ways that reduce unnecessary cognitive effort, facilitate processing of essential information, and maximize processing potential. These knowledge-centered elements contribute to learning with understanding and the goal of adaptive expertise.

Actively Building Knowledge and Thinking Skills

The organization of content around central concepts that are supported by selected facts and information is an evidence-based best practice in curriculum design (Bransford et al., 2000; Wiggins & McTighe, 2005). This is a time-tested principle. In 1929, Alfred North Whitehead wrote, "Let the main ideas which are introduced into a child's education be few and important, and let them be thrown into every combination possible. The child should make them his own and should understand their application here and now" (p. 2).

The importance of coherence in the design of curriculum for developing student understanding was advocated by Jerome Bruner in his 1960 classic *The Process of Education:*

> The teaching and learning of structure, rather than simply the mastery of facts and techniques, is at the center of the classic problem of transfer. . . . If earlier learning is to render later learning easier, it must do so by providing a general picture in terms of which the relations between things encountered earlier and later are made as clear as possible. (p. 12)

Students develop understanding of a discipline by engaging in challenging activities that allow them to see how, where, and when the important ideas and facts are relevant (Bransford et al., 2000). Students can acquire more factual knowledge when it is connected to meaningful problem-solving activities. Conversely, problem solving cannot be taught without a base of factual knowledge.

Important ideas need to be presented in increasing depth. They need to be revisited with many examples and built on so that understanding grows over time in ways that increase students' ability to use and apply their factual knowledge (Bransford et al., 2000). Approaches such as problem-based and inquiry-based instruction help students make connections, develop integrated knowledge structures of facts and concepts, and understand conditions of applicability.

Clear understanding of what, why, and how subject matter is taught is important for learners as well as teachers. Instructional goals narrow what students focus their energy on (Marzano, Pickering, & Pollock, 2001). But goals should not be too specific. When students personalize goals, the goals become relevant for them as learners.

Learning improves when students' progress toward instructional goals is made explicit (Bransford et al., 2000; Vye et al., 1998). For instance, students have enhanced opportunities to monitor their own learning when an overview of the learning process remains visible and their attention is directed to it as instructional milestones are reached.

Findings from research synthesized by Marzano et al. (2001) indicate that student learning improves with the use of certain types of instructional strategies and supports. Use of predictions, advance organizers, and questions elicits students' prior knowledge, which is necessary for building new understanding. Summarizing and guided note-taking can aid comprehension by helping students determine what is most important.

It takes considerable time and practice to learn with understanding, and research shows that students must be familiar with the skill being developed in order for practice to be an effective learning support; otherwise, practice may simply reinforce misconceptions (Bransford et al., 2000; Marzano et al., 2001). A key to successful practice is checking for readiness before students practice, and then providing corrective feedback immediately afterward.

While some students master these strategies and supports easily, others benefit from instruction that scaffolds their use until students become independently proficient with them (Marzano et al., 2001). Strategies and supports that can be readily integrated into online instruction include automated concept maps, graphic organizers, and prompts for predicting and summarizing, which can be used online or printed and used manually (Hiebert, Menon, Martin, & Bach, 2009).

Teachers can help students learn new content by designing instruction that takes students' existing understanding and misconceptions into account (Bransford et al., 2000). In order to use what learners know to guide instruction, students' understanding must be made visible. Learners can show what they know by demonstrating understanding according to a taxonomy of cognitive abilities such as explain, apply, and generalize (Anderson & Krathwohl, 2001; International Center for Leadership in Education, 2009; Keene, 2008). These different types of understanding are often presented as a hierarchical progression

through levels, but best practices in instructional design show that they can be used flexibly and simultaneously, depending on learning goals.

Students can share their understanding using multiple modes of expression (e.g., draw, chart, graph, write, speak, present). Using multiple expressions with varying levels of abstraction supports learners' ability to think flexibly about complex domains and transfer knowledge to new situations (Bransford et al., 2000). Students can demonstrate their understanding through projects and performances in addition to discussions, interactive simulations, and tests. Projects and performances also provide motivation for mastering content and opportunities for cycles of revision and feedback (Barron et al., 1998).

Another important reason for making students' thinking visible is to help students develop metacognition, or active monitoring of their own learning (Bransford et al., 2000). Metacognition includes making sense of new content, assessing one's understanding, and reflecting on one's learning—practices that increase students' responsibility for their own learning and increase their ability to apply new knowledge to different situations. Online curriculum increases opportunities for students to engage in learning that integrates important practices like metacognition, while also addressing the need for students to hone media skills (Hiebert et al., 2009).

Multimedia Presentation of Knowledge

Knowledge cannot be acquired from problem solving alone (Bransford et al., 2000). In many subject areas, it is necessary to acquire knowledge from text, lectures, or media presentations. Students are primed to acquire this knowledge when they need it to complete an analytical task or to meet a purpose, such as a problem they need to solve or a question they need to answer (Schwartz & Bransford, 1998).

Mayer (2008) presents evidence-based and theoretically grounded principles for presenting information using multimedia. Instruction that adheres to these principles improves students' learning and ability to transfer knowledge:

- Reducing extraneous processing helps prevent learners from wasting cognitive effort on activity that is not essential to learning the targeted content (Mayer, 2008). For example, extraneous processing can be reduced by good layout—text placed close to related graphics requires less effort to process than text separated from graphics—or by minimizing unnecessary material. Struggling readers especially benefit from coherent and clear presentation of content (Hiebert et al., 2009).
- Managing essential processing facilitates the learning of complex knowledge, once extraneous processing has been minimized (Mayer, 2008). For example, learning improves when complex information is presented in digestible chunks, such as when a narrated animation is presented in learner-paced segments rather than being presented in one continuous stream.
- Fostering generative processing means enabling and improving learners' ability to maximize their processing potential (Mayer, 2008). For example, students learn better when knowledge is presented with a conversational rather than formal narrative style (an engaging voice creates a sense of social relationship, which makes the learner try harder to understand).

Another example of fostering generative processing is presenting knowledge with words and pictures rather than with words alone (Mayer, 2008). Multiple representations of information in online settings similarly assist student learning (Hiebert et al., 2009). These can come in the form of video, animation, audio, and interactive simulations integrated into the lessons and available for the students to access as needed. Using multiple modes of representation supports students' engagement and comprehension by making connections between texts and information explicit and the structure of concepts visible.

Knowledge and Thinking Skills Research Applied to Apex Learning Curriculum

Apex Learning courses align with comprehensive state and national curriculum content standards for rigorous high school courses. With a balanced architecture of direct instruction, constructive practice, and formative feedback, courses are designed to give all students access to rigorous content and to the tools they need to actively build knowledge and thinking skills. The digital curriculum adheres to research-based principles for presenting knowledge using multimedia that result in improved student learning and transfer.

Actively Building Knowledge and Thinking Skills

Apex Learning digital curriculum offers a balanced architecture of direct instruction, constructive practice, and formative feedback. Critical thinking, problem solving, and questioning are integrated into all courses to support engagement and active learning. Students observe, inquire, confirm, connect, and create as they build knowledge in Apex Learning lessons. There are frequent opportunities to check one's own understanding, empowering the learner to look back or ahead and control their own progress.

Each Apex Learning course is carefully crafted with a predictable, consistent, and coherent unit-lesson-activity structure to facilitate use by teachers and support for learners. Clearly presented content is helpful for adolescent learners, and the conversational voice of the instruction stimulates learning.

Objectives are presented in ways that tap the interests of learners and effectively use technology to involve and challenge. Heeding research on goal-setting, anticipatory frames focus students on what they need to know and do in the units and lessons. "Big questions" and conceptual frames trigger students' curiosity and elicit their initial thoughts about the principal ideas. Not only do students anticipate what is coming and what is expected of them, but with the digital platform the objectives also remain transparent, a click away wherever students are in the lessons. Having a window on the overall learning process improves students' progress toward the goals.

The primary direct instruction components in Apex Learning lessons are called Studies. Studies often lead with real-world examples and with challenging questions to make the content inviting and relevant for adolescents.

As students learn academic content with Apex Learning digital curriculum, they are supported with instruction that effectively uses research-based reading and comprehension strategies—including questioning, advance organizers, summarizing, and note taking—with scaffolds available as needed to provide extra support. These active reading strategies deepen connectedness of text both online and in print.

To deepen engagement and understanding, students commonly use processes such as guided inquiry, the scientific method, and reading, writing, and problem-solving processes. Because Apex Learning curriculum is digital, the online platform seamlessly provides these instructional supports and offers benefits for comprehension over traditional instruction.

Once students are familiar with content, they have opportunities to test their understanding of what they have just learned with embedded self-assessments. Self-assessments come in a variety of formats including Checkup activities, self-check games, and interactive assessments. Students get immediate corrective feedback that informs them about their understanding. Metacognition develops as students take control of their progress through the lesson. They can move ahead when content is mastered or revisit the previous instruction, drawing on appropriate embedded supports and requesting teacher guidance as needed.

Knowledge is deepened at strategic points throughout each lesson with Practices, Labs, Journals, Readings, Discussions, Explorations, and Projects. Practices help build fluency and target written communication and analysis. Labs provide practice with scientific methods, lab procedures, science terminology, and data analysis. Discussions offer asynchronous forums for students and teachers to build on one another's understanding and develop communication skills. Explorations are inquiry-based activities that invite students to explore alternative points of view or to go into more depth on a topic, often by searching in vetted websites. Journals encourage reflection, and in some cases, analysis, as students evaluate their personal perspectives and relate them to concepts or apply their original insights to close reading. Projects are individualized extensions of learning.

In Apex Learning digital curriculum the instruction and evaluation is constructed around a taxonomy of knowledge, with which different types of understanding are targeted by specific activities and assessments. Self-checks are designed to allow students to demonstrate understanding across the taxonomy—but focus on recalling, explaining, using, and differentiating. Computer-scored assessments have a similar focus. Checkups are largely about application. Teacher-scored activities and assessments extend across the taxonomy.

Multimedia Presentation of Knowledge

Navigation is consistent throughout all Apex Learning courses. Using the scrollable table of contents present in the navigation to the left of every page, it is easy to select and see the corresponding content on the right. Content is carefully presented so that students have appropriate access to multimodal information without being overwhelmed.

Throughout activities there is a balanced mix of reading, observing, listening, watching, and doing, where effective use of text, pictures, audio, video, and interaction capture and keep learners' interest. Multiple modes of media are used in activities to deepen understanding of complex information and challenging concepts. For example, with digital curriculum students studying biology can learn the concept of population growth by viewing a video on how populations use resources. They can learn about the same concept by reading text on how the human population is expanding. They can also change variables in a simulation of carrying capacity in which the consequences of population growth become immediately visible. And they can listen to audio on how technology is being used to meet population challenges—all while taking notes in a graphic organizer. In this active online learning

environment, deep understanding results from the range and diversity of experiences students have with content. Persistence and resiliency result from encouragement, formative feedback, and steady reminders to use all the resources at hand to solve a problem rather than walk away from it.

II. Research on Learners

This section discusses three important findings about learners and creating learner-centered environments. First, learning improves when instruction takes account of learners' prior knowledge and misconceptions. Second, students engage more and try harder when tasks are meaningful to them. Third, students benefit from differentiated instruction tailored to their readiness. These learner-centered elements contribute to improved student learning.

Prior Knowledge and Misconceptions

A learner's initial knowledge serves as the foundation for all future learning, determining how new experiences and information are interpreted (Alexander & Murphy, 1998; Brandt, 1998). Students come to the classroom with preconceptions—and often misconceptions—about content they will learn in school.

If students' initial conceptions are not made visible and addressed through instruction, students may only learn new facts and concepts superficially, clinging to their original misconceptions (Bransford et al., 2000). These lingering misconceptions form a faulty basis for future learning and can thwart understanding of new content and concepts.

The implication of this for teaching is that there is a need to elicit students' pre-existing knowledge and skills and to build on them in the teaching of new content—at the beginning of instruction and as learning progresses (American Psychological Association [APA], 1997). Instruction that is based on learners' understanding will necessitate offering additional supports for some students and advanced challenges for others. Students' needs will change as instruction proceeds, and learning improves when instruction is continually attuned to these changing conceptions (Bransford et al., 2000).

Building on current knowledge to progress through high school courses in specialized content areas presents special challenges for adolescents who are weak readers. Research on adolescent literacy provides insights on helping struggling readers meet rigorous demands of high school subjects (Kamil, Borman, Dole, Kral, Salinger, & Torgesen, 2008; Lee & Spratley, 2010), each of which has its own technical vocabulary, syntax (way of using language), and ways of using elements like diagrams and charts.

There is strong evidence for the value of providing explicit vocabulary instruction and explicit reading strategy instruction—including the use of predicting, inferring, visualizing, questioning, summarizing, and more (Kamil et al., 2008). Strategies such as these make thinking visible and make both students and teachers aware of misconceptions. While these strategies are important for all readers to learn and use, explicit instruction calls for teacher modeling, explanation, guided practice with feedback, and independent practice with scaffolding as needed.

In addition, struggling readers can benefit from discipline-specific strategy instruction including emphasis on reading comprehension with modeling and guided support for making

sense of text before, during, and after reading (Lee & Spratley, 2010). As important as these supports are for those who need them, it is just as important that students who do not need the supports are not encumbered by them.

Making Learning Meaningful

People are motivated to learn what is meaningful to them (Brandt, 1998). Key factors that contribute to making learning meaningful include the learner's emotional states, beliefs (such as the role of effort in achievement), interests, goals, and intellectual habits (such as persistence through ambiguity) (APA, 1997; Costa & Kallick, 2008; Marzano et al., 2001).

Motivation can be stimulated by difficult but achievable tasks that engage individuals to use their higher-order thinking skills and exert effort over an extended period of time (Brandt, 1998). Problem-based learning and inquiry-based instruction are two practices designed to engage students in challenging activities (Bransford et al., 2000).

Motivation to learn can also be stimulated by personally relevant goals, which can be developed when individuals have personal choice and control (Brandt, 1998). Adolescent learners benefit from activities they perceive as relevant to their lives and from those that build confidence (Kamil et al., 2008; Lee & Spratley, 2010).

For example, a study of high school students found that learners' engagement increased when the perceived challenge of the task and their own skills were high and in balance, the instruction was relevant, and the learning environment was under their control (Shernoff, Csikszenihalyi, Shneider, & Shernoff, 2003). In another study, middle school students' learning improved when the instruction used media effectively to engage a range of readers in complex problem solving, was anchored in a simulated real-world context, involved generating and evaluating multiple feasible solutions, and demanded extended time to complete (Cognition and Technology Group at Vanderbilt, 1997).

Findings from research synthesized by Hiebert et al. (2009) on online learning and engagement echo the findings on engagement relevant for any type of learning. As in any context, adolescents are motivated when they believe they have some control over their learning. For instance, adolescents who believe that their own effort contributes to their ability to read, rather than it being a given ability, are motivated to persevere in a task even when it is difficult. Similarly, students are motivated by online content that is challenging but achievable as well as personally relevant and interesting.

Hiebert et al. (2009) also report that digital learning offers unique motivational benefits, in part because the online environment itself is motivating to students. In addition, student interest and expertise improves with online opportunities for student control (e.g., choice in the pace at which text is presented and in having sections reread) and engagement (e.g., having texts and tasks at the appropriate level). Together this presents a significant opportunity for making learning meaningful through digital curriculum.

Learner Readiness

In their own way, learners progress through various common stages of development. Learning at each stage is most effective when developmental readiness is taken into account (APA, 1997; Vygotsky, 1986). This includes readiness in terms of physical, intellectual,

emotional, and social factors. It also is determined by the understandings, strategies, skills, and habits that learners bring to each new learning task (Bransford et al., 2000). As Costa and Kallick (2008) say, "All kids do learn but not on the same day and not in the same way" (p. 13). Effective learning requires quality curriculum and quality instruction designed to meet students where they are.

As students go through similar stages of development, they can work toward common rigorous goals with individually differing support (Tomlinson & McTighe, 2006). Differing support includes adjusting the content, format, or pacing of lessons to address students' needs, strengths, weaknesses, and interests (APA, 1997; Brenner, 2009). For instance, instruction in a unit may be differentiated by including scaffolds for students weak in reading skills while challenging others to stretch their communication skills to more complex levels.

Online environments afford special opportunities for addressing learner readiness through differentiated instruction. With increased flexibility in when, where, and how learning occurs, online contexts offer a way to break through the scheduling constraints that so often limit school learning time (Cavanaugh, 2009). In online courses, students can control how much time to spend on each activity, choosing to move quickly through tasks to avoid boredom or revisiting previous lessons to bolster understanding. For some students the online environment provides the emotional security needed to overcome social insecurities that hamper ability to focus on academics in traditional classroom environments, allowing students to prosper with digital curriculum (Watson & Gemin, 2009; Hiebert, 2009).

Findings from research synthesized by Hiebert et al. (2009) shed light on ways to differentiate instruction by using adaptive and strategic online scaffolds to support struggling and disengaged adolescents' comprehension. Online scaffolds help readers by increasing their access to grade-level content and texts, which in turn increases their engagement.

Use of adaptive scaffolds (e.g., online help with vocabulary and text-to-speech support) enables readers to learn with content that is above their independent reading level (Hiebert, 2009). Strategic online scaffolds incorporate instruction on effective use of strategies (e.g., predicting, questioning, and summarizing) into grade-level content. With technology such as virtual tutors, responsibility for the use of online scaffolds can be adjusted from mandatory to independent as learners progress.

Learner Research Applied to Apex Learning Curriculum

Apex Learning digital curriculum meets students where they are and develops their capacities. It provides differentiated instruction for all students by taking into account pre-existing conceptions, making learning activities meaningful, and enhancing access to curriculum based on learner readiness.

Prior Knowledge and Misconceptions

In Apex Learning courses, students are asked to respond to instruction in ways that reveal their preconceptions and misconceptions throughout learning. Students' initial thinking is elicited early in lessons with conceptual frames and "big questions." Strategies such as

discovery-confirmation, making observations, questioning, predicting, and using advance organizers before reading, during reading, and after reading make thinking visible and reveal misconceptions. Activities such as Discussions, Practices, and Journals provide additional opportunities in which prior knowledge is taken into account.

Making Learning Meaningful

Apex Learning puts the research on making learning meaningful into practice in its digital curriculum. First, anticipatory frames hook students' interest, eliciting their prior knowledge and piquing their interest in the content to come. Next, a variety of activities offers the right level of challenge to make tasks difficult but achievable, which increases engagement. Engaging tasks involving problem solving, questioning, and critical thinking also foster intellectual habits like persistence, ability to handle ambiguity, and belief in self-efficacy—all important for improving learning as well as providing students with important college- and career-readiness skills.

Third, with 24-hour access, the option to set one's own pace, a choice in use of supports, and the ability to self-monitor through frequent checks on understanding, students increase their control over their learning—another component of making learning personally meaningful. Finally, Apex Learning lessons effectively use media to engage learners with multiple modes of representations, a balanced variety of activities (e.g., guided inquiry and practice, direct instruction, and interactive manipulatives that encourage students to make discoveries), and even the opportunity to develop expertise in using the media.

Learner Readiness

With Apex Learning digital curriculum, learners with varying levels of readiness can obtain the same rigor in different ways. Students are motivated to do better when the bar is higher. Apex Learning courses set the same bar and shared expectations for all, but there is flexibility for each student to reach and exceed the bar in his or her unique way and in his or her own time.

Apex Learning courses that include online scaffolding increase student access to grade-level content. Adaptive text scaffolding includes clickable access to text transcripts for audio, to vocabulary definitions, and to English and Spanish audio corresponding to text. Making text accessible in multiple ways is a technique supported by CAST's Universal Design for Learning Guidelines (2008) for curriculum, which accommodates diverse abilities. Strategic scaffolding is included in lessons to support comprehension while also increasing access to grade-level content and building a capacity for increasingly independent learning. As access to grade-level content increases, so does student control and engagement, leading to improved student learning.

Unlike tracking, there is flexibility for students to shift between paths according to their differing and growing readiness in each subject area. General studies courses are available in multiple pathways, all with the same scope and sequence, that can be differentiated in these ways:

- Courses designed to meet the needs of students seeking to accelerate their learning and deepen their conceptual understanding with many opportunities to apply, extend, and synthesize knowledge.

- Courses that assume student readiness for grade-level academic challenges, but also include targeted scaffolding for students who benefit from additional learning support.

- Courses that meet the needs of students who are reading below proficiency and who are seeking to master required content in math, science, English, and social studies to earn credits toward high school graduation. These courses simultaneously develop students' general and academic literacy skills.

Another pathway consists of College Board–authorized Advanced Placement courses that prepare students to demonstrate college-level achievement through success on the AP exams. Courses in a final pathway provide structured remediation in math, reading, and writing to meet the needs of both high school students and transitioning middle school students who are not prepared for grade-level academic challenges.

III. Research on Assessment and Feedback

This section establishes the importance of using formative assessment and data to reveal student understanding throughout the learning process. First, formative assessment provides information that is essential to teachers guiding learners. Second, learning improves with cycles of revision, assessment, and feedback, especially when the feedback is timely, specific, and explanatory. Third, learning improves when students develop the ability to reflect on their own progress and adjust their behavior accordingly. Finally, the role of summative assessment is reporting student outcomes and grades as well as accounting for progress at the classroom level and beyond. Integrated learning management systems can facilitate the management of student data for formative feedback and summative assessment.

The Effectiveness of Formative Assessment

In education, much attention is given to assessments that report student learning results. However, learning actually improves when assessments are used formatively to guide instruction (Black & Wiliam, 1998). Formative assessments are used during instruction to make students' thinking and understanding visible. Students and teachers then use this feedback to monitor progress toward learning goals, affording opportunities for instruction to be tailored to student needs and readiness as instruction proceeds.

Research discussed earlier emphasizes the importance of revealing information about learners' preconceptions, misconceptions, current depth of understanding, and readiness for learning new concepts. Formative assessment is one of the most effective strategies that can be used to make student understanding visible and improve learning (Bransford et al., 2000).

Formative assessment lies at the heart of effective instruction—this is where the expert knowledge can guide the novice. Student learning improves when the teacher, as the pedagogical and content expert, uses formative assessments to make informed decisions about what students have learned and what instruction is needed (Alexander & Murphy, 1998; Black & Wiliam, 1998; Vygotsky, 1986). This expertise allows the instructor to provide feedback and instruction that guides the students in developing their content expertise. Formative assessment is not only useful for helping students, but also for instructors and curriculum designers who use it to improve their methods.

The key to using activities formatively is turning the information they provide into timely and specific feedback that informs subsequent teaching and learning (Black & Wiliam, 1998). Formative assessment activities can come in many forms (e.g., multiple-choice or constructed-response tests, discussions, observations, performances, portfolios, or projects) and can be designed to reveal varying levels of understanding (e.g., recall, application, or generation) (Anderson & Krathwohl, 2001; International Center for Leadership in Education, 2009; Keene, 2008; Wiggins & McTighe, 2005).

Timely and Specific Formative Feedback

The effectiveness of formative assessment to improve learning and teaching depends on timely and specific feedback followed by opportunities for learners to revise and improve their thinking (Black & Wiliam, 1998). Characteristics of feedback useful for improving learning include the following:

Feedback should be given immediately after testing (Black & Wiliam, 1998; Marzano et al., 2001). Feedback is most effective when it is still relevant to the learner's task.

Feedback that is "corrective" in nature with explanations of mistakes has a positive effect on achievement, while simply indicating right or wrong has a negative effect (Black & Wiliam, 1998; Marzano et al., 2001). Effective feedback provides information that can help students understand how their thinking compares to their learning goal and that can help them attain that learning goal.

Feedback should be specific to a criterion rather than a comparison with other students (Black & Wiliam, 1998; Marzano et al., 2001). Feedback that includes grades or emphasizes performance in competition with other learners can have a negative effect on learning. Consistent with literature on goal orientation, achievement improves when the focus is on the students' effort and the task (learning orientation) rather than the students' ego and ability (performance orientation), even when feedback includes praise.

Students can effectively provide some of their own feedback through self-assessment (Black & Wiliam, 1998; Marzano et al., 2001). Activities that include self- and peer-assessment help students take more responsibility for their own learning, which builds capacity for future learning. This is discussed in the next section on student control and metacognition.

Student Control and Metacognition

As students take increasing responsibility for their own learning, the possibility of transferring their new learning to future situations increases (Alexander & Murphy, 1998; Vygotsky, 1986). Instruction that integrates metacognitive skills—self-assessment, reflection, sense-making, and self-regulation—into the curriculum across multiple subject areas can help students take increasing control of their own learning (Bransford et al., 2000).

Students' learning improves when instruction involves cycles of formative assessment, feedback, and revision (Barron et al., 1998; Vye et al., 1998). Through scaffolded feedback cycles, students can engage in increasingly independent practice and self-monitoring that lead to deeper understanding.

Summative Assessment

Summative assessments are used to measure and report learning outcomes, rather than to inform instruction and improve learning (APA, 1997; Black & Wiliam, 1998). Summative assessments provide information for recording grades and comparing groups of students.

Typically used at the end of an instructional unit, these assessments must align with the unit's learning goals (Bransford et al., 2000). Ideally, unit-based summative assessments also align with state and national accountability measures.

Digital Data Systems

Online environments offer opportunities for entering, generating, sharing, and utilizing assessment data with less effort and faster results than possible in traditional school practice, even when that is partially automated (Partnership for 21st Century Skills, 2009). As part of a transparent system, this availability of data supports improvements in student learning at the individual, classroom, and school levels. It can make formative and summative information readily available to students, teachers, and parents in real time.

Digital data systems provide opportunities for increased school time, which is linked to higher achievement (Cavanaugh, 2009; Farbman, 2009). In addition to bypassing constraints of the traditional school day with anywhere/anytime access, instructional time increases when automated data input, access, and reporting reduce time required for non-instructional activities.

Assessment and Feedback Research Applied to Apex Learning Curriculum

The Apex Learning digital curriculum seamlessly provides formative assessment and data to reveal student understanding throughout the learning process. Information about learner knowledge guides teachers in planning instruction, and informs learners about their progress during lessons. No-stakes and low-stakes assessments are embedded within the direct instruction and throughout units of study. Summative achievement is measured in high-stakes assessments at the end of units and semesters. Integrated online data and reporting systems facilitate the management of student data and make formative and summative assessment information available to students, teachers, and administrators in real time.

Timely and Specific Formative Feedback

Formative self-assessment comes in the form of frequent online self-checks that provide students with automatic computer-generated corrective feedback, freeing teachers' time from grading and giving students control over their progress through the lesson.

Teachers provide timely feedback based on student information revealed on teacher- and computer-scored activities. Teacher-scored activities primarily assess higher-order understanding and in many cases involve reflection, creativity, original thought, argument, and analysis. There are also frequent computer-scored quizzes throughout lessons that assess recall, comprehension, and application.

Student Control and Metacognition

During Apex Learning lessons, students develop increased control over their learning and improve their metacognitive skills. Students control the pacing of activities and self-check assessments. They also have responsibility for use of optional study aids. With the help of timely digital- and teacher-provided feedback, students learn to monitor their understanding and improve their own learning. Understanding deepens as students' independence increases through instructional cycles involving assessment, feedback, and revision.

Summative Assessment

At the end of each instructional unit and semester, there are high-stakes computer-scored and teacher-scored tests to report student achievement. These summative tests align with unit and course learning objectives as well as with comprehensive state and national curricular standards.

Digital Data Systems

Apex Learning offers a central role to teachers that is dramatically different from traditional practice in ways research confirms are valid, meaningful, and essential to outcomes. With the digital curriculum and data on student progress available in the online grade book, the teacher has more time to spend individualizing instruction: guiding activities, differentiating instruction, recognizing achievement, providing encouragement, and providing one-to-one support. Using timely data and insights from regularly scheduled meetings with the students (face-to-face, online tools or phone), the teacher can provide just-in-time acceleration, remediation, or extension.

Conclusion

The science of learning provides an established base of research and practice on how people learn and how to design instruction so that students learn with understanding. This paper documents how Apex Learning puts the research into practice in its digital curriculum.

With a balanced architecture of direct instruction, constructive practice, and formative feedback, Apex Learning courses are designed to give all students access to rigorous content and to the tools they need to actively build knowledge and thinking skills. The digital curriculum adheres to research-based principles for presenting knowledge using multimedia that result in improved student learning and transfer.

Research on learners suggests that learning improves when instruction takes account of learners' prior knowledge, that students engage when tasks are meaningful, and that students benefit from differentiated instruction tailored to their readiness.

Apex Learning digital curriculum meets students where they are and develops their capacities. It provides differentiated instruction for all students by taking into account pre-existing conceptions, making learning activities meaningful, and enhancing access to curriculum based on learner readiness.

Finally, research on assessment states that learning improves when students receive formative feedback that is timely and specific; when students develop the ability to reflect on their own progress and adjust their behavior accordingly. Further, summative assessment plays an important role in measuring outcomes and accounting for progress.

The Apex Learning digital curriculum seamlessly provides formative assessment and data to reveal student understanding throughout the learning process. Information about learner knowledge guides teachers in planning instruction and informs learners about their progress during lessons. Summative achievement is measured in high-stakes assessments at the end of units and semesters. Integrated online data and reporting systems facilitate the management of student data and make formative and summative assessment information available to students, teachers, and administrators in real time.

Designed in accordance with these time-tested research principles, Apex Learning digital curriculum gives all students access to the content and tools they need to achieve in an environment of academic rigor.

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Allison Moore is a learning scientist with the College of Education at the University of Washington. Her interests include problem-based learning and effective uses of technology to support teaching, learning, and assessment. She has experience designing and evaluating research-based instructional materials, including multimedia and web-based programs, as well as coordinating multi-site and distal research projects. Currently she is working with the UW team on development of interactive technology environments for 21st century teaching, learning and assessment. Recently she has worked with the UW team designing the content for Microsoft's international Innovative Schools Program. Since 2003 she has been involved in UW projects evaluating uses of web-based professional development for improving teacher practice in and through the arts and designing and assessing Young Audiences arts-integrated literacy lessons. At Vanderbilt University Learning Technology Center, Moore was a member of the multi-disciplinary team that developed and produced the video-based Adventures of Jasper Woodbury mathematics problem solving series, involving classroom-based research, professional development, multimedia teacher manuals, and commercial distribution.

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Tom Baer is an educational technology specialist at the University of Washington School of Nursing, which has been successfully using innovative distance learning technologies to increase access to nursing education. He began developing challenge-based, interactive learning technology in 1994, when he was the lead instructional designer on the award-winning Science Sleuths CD-ROM series. He produced Apex Learning's first online course, AP Calculus, in 1998. Since then he has designed and produced a wide range of online courses for high school and adults in the K-12, corporate, and higher education sectors. Tom's interests include interaction design, the role of challenges in making meaning, and building communities.

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