Executive Summary

This paper reviews the most effective and research-based methods of instructional models, instructional strategies, and domain-specific design features. Based on major reviews of research conducted over the past ten years, this paper provides current findings on what works in K-12 education. As such, this paper provides detailed scientific research to support the instructional design and specific features embedded in Odysseyware courses and support tools.

The specific areas comprising the research base for this program are as follows:

- Transforming the learning landscape with pedagogical flexible models
- Standards-based, personalized learning using an adaptive instructional model and customization
- Systems of assessment, instruction, intervention, and monitoring tools
- Use of frequent, meaningful interactions and embedded feedback
- Dynamic, interactive curricular content including visualizations, virtual labs, and simulations

Odysseyware is based on sound pedagogical principles, instructional strategies, authoring tools, reporting tools, dynamic content, and curricula resources that provide standards-based, adaptive, differentiated instruction to address the diverse needs and abilities of all learners. A comprehensive system of assessment, instruction, intervention, and reporting tools allow teachers to provide and customize differentiated activities and assignments. The reports are especially useful in helping teachers and schools analyze progress toward standards mastery and individual growth.
The sheer diversity and flexibility of the Odysseyware system requires a comprehensive review of research in education to adequately cover its research base. The system incorporates a wide range of instructional models to teach the broad range of subject matter courses as well as the extensive offering of computer technical education courses. The modularity of the system creates great flexibility and adaptability and affords the implementation with a vast array of curricular and instructional programs. However, reviewing every design feature, instructional strategy, and usage condition would not be a feasible endeavor.

Instead, this review focuses on the most frequently used instructional models and strategies to report what the research says and how Odysseyware puts into practice the evidence-based instructional models and strategies in various contexts. The purpose of this approach is to embed Odysseyware in the overall context of research on instructional technology effectiveness and provide the deepest understanding of the power of Odysseyware in the digital learning ecosystem.
K-12 online learning is experiencing rapid growth. The estimated number of K-12 students enrolled in virtual online schools ranges from 200,000 to 275,000 (Miron, Horvitz and Gulosino, 2013; Watson et al., 2012). Furthermore, Wicks (2010) estimated 1.5 million students took online courses during the academic year 2009-2010, and a projected five million K-12 students (primarily high school students) will enroll in an online course by 2016 (Picciano, Seaman, Shea, and Swan, 2012). The K-12 online learning growth curve from 2001-2010 is equivalent to the exponential growth of K-12 connectivity from 1995-2005 (Means, Bakia, and Murphy, 2014).
What are the factors prompting this growth? A contributing factor is the belief that online learning addresses several persistent educational issues, including the achievement gap and the dropout rate. In the United States, the average graduation rate is less than 80 percent in 34 states (Chapman, Laird, and Kewal Ramani, 2010). Another factor is the use of online courses for credit recovery. This is the fastest growing K-12 education segment. An additional factor is economic. Many districts seek the flexibility of online courses to deliver summer courses and core classes to save money by not hiring full-time instructors. However, the most important factor is the belief that online learning provides a more engaging learning experience for students.

Online learning can differentiate the learning experience by providing embedded assessments to determine the learning gap and the appropriate level of difficulty. In addition, the online system can provide the teacher with both classroom- and individual-level data to determine next steps. But as more students experience online courses, more questions and concerns are raised regarding the rigor and quality of online learning.


Although the findings of these studies establish that online learning is generally as effective as classroom instruction, these studies do not yield findings on how to design and implement online learning. However, a meta-analysis on blended learning conducted by Means et al. (2013) found blended learning significantly outperformed face-to-face classroom instruction. Moreover, the study established that pedagogical setups for blended learning make the difference. In this case, the students exposed to both collaborative interactive learning and teacher-directed expository instructional conditions significantly outperformed students only engaged in active self-study. In addition, the Means et al. study represents a shift from defining studies by the technology used to defining studies by their pedagogical pattern.

For this paper, online learning is instruction and assessment experienced fully online via Internet-based delivery. Blended learning is a combination of face-to-face and online experiences, with the many shades of blended learning referred to as hybrid learning, which represents everything in between fully online and fully face-to-face learning (Graham, Allen, and Ure, 2005; US Department of Education, 2010; Watson et al., 2010).

Although online and blended learning can be designed in myriad ways, research suggests that the following design features influence learning outcomes (Means et al., 2010):

<table>
<thead>
<tr>
<th>Design Feature</th>
<th>Fully online, blended, web-enabled</th>
</tr>
</thead>
<tbody>
<tr>
<td>MODALITY</td>
<td></td>
</tr>
<tr>
<td>PACING</td>
<td>Independent, mastery-paced, class-paced, mixture</td>
</tr>
<tr>
<td>PEDAGOGY</td>
<td>Expository, practice environment, exploratory, collaborative</td>
</tr>
<tr>
<td>ONLINE COMMUNICATION SYNCHRONY</td>
<td>Asynchronous, synchronous, both</td>
</tr>
<tr>
<td>INTENDED INSTRUCTOR ROLE ONLINE</td>
<td>Active instruction, small presence, none</td>
</tr>
<tr>
<td>INTENDED STUDENT ROLE ONLINE</td>
<td>Listen and read; complete problems and answer questions; explore simulation and resources; collaborate with peers in building knowledge</td>
</tr>
<tr>
<td>ROLE OF ONLINE ASSESSMENTS</td>
<td>Determine if student ready for new content, tell system how to support student, provide student and teacher with information about learning state, calculate student’s risk of failure</td>
</tr>
<tr>
<td>SOURCE OF FEEDBACK</td>
<td>Automated, teacher, peers, mixed, none</td>
</tr>
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</table>
Blended or hybrid approaches with online resources afford a flexible and effective model for instruction (Aycock, Garnham, and Kaleta, 2002; Bowen, Chingos, Lack, and Nygren, 2012; Hill, 2012). By changing the mode of content delivery to online and outside class time, blended courses allow more time for instructor feedback, applications, and interaction (Aycock et al., 2002; Hill, 2012). Although no “standard” approach to blended courses exists, the degree of linkage between online and face-to-face components is an important dimension.

**Keeping Pace With K-12 Blended Learning.**

Staker and Horn (2012) view the blended learning landscape as four emerging learning models (see figure 1).

Researchers view the benefits of blended learning as follows:

- Increases active learning, collaboration, and customization by reducing direct instruction (Osguthrope and Graham, 2003; Christensen, et al., 2008; Blouin et al., 2009)
- Increases interactivity between learner and content; immediate feedback for students and teachers; customizability of the pace, content complexity, and amount of scaffolding; ability to render concrete visuals of abstract concepts (Means, Bakia, and Murphy, 2014)
- Students learn on their own time and at their own pace (Khan, 2012)
- Increases learner engagement (Singh, 2003; Taylor and Parsons, 2011)
- Supports personalized learning (Patrick, Kennedy, and Powell, 2013)
- A significantly higher percentage of students perceive self efficacy (Enfield, 2013)
- Broadens avenues for teacher communities of practice (Cavanaugh, 2013)

**The Digital Learning Ecosystem**

The details of the digital ecosystem illustrated in Figure 2 impact the difference in online learning outcomes. The effective use of online learning systems is achieved by the appropriate blend of context, learning resources, and instructional strategies comprising the ecosystem and supporting students’ learning efforts. Research (Darling Hammond, Zielezinski, and Goldman, 2014) has found interactive, online learning systems that determine students’ level of understanding, customize the material for them, provide an interactive set of instructional activities with feedback to students, produce detailed reports about students’ progress, and offer teachers who supplement instruction by explaining concepts and facilitating student discussion yield higher results for low-achieving students on state assessments (Hannafin and Foshay, 2008) and mastery of complex concepts (Bos, 2007).

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**Fig. 1**

Blended-Learning taxonomy
Fig. 2

Digital Learning Ecosystem
Research:
Instructional Models
Pedagogy for the Blended, Flexible Learning Era

The emerging models of online learning respond to the need for new pedagogies that help foster flexibility as a capability in both teachers and students. Flexibility is more than addressing change in terms of delivery mode and variety of engagement; it is rethinking the learning environment in terms of time, location, instructional pace, and learner entry (Ahmed, 2010; Bichsel, 2013; Carter, Salyers, Page, Williams, Hofsink, and Albl, 2012; Fisher, 2009; Hanover, 2011; ITC, 2013; Johnson, Smith, Willis, Levine, and Haywood, 2011; McLinden, 2013; Salyers, Carter, Barrett, and Williams, 2010).
Effective online learning environments must address the needs of diverse learners, apply effective pedagogical strategies, use evidence-based design principles, support multiple technologies, and provide for flexible learning (Buzzetto-More, 2007; Hussin, Bunyarit, and Hussein, 2009; Moore, Dixon-Deane, and Galyen, 2011; Oblinger and Oblinger, 2005; Orellana, Hudgins, and Simonson, 2009; Sun, Tsai, Finger, Chen, and Yeh, 2007). Collis and Moonen (2001) describe flexible learning in terms of customizing the instructional materials, learning activities, and media of a course to address the needs of individual learners.

In addition, teachers customize content to address local needs and specific learning goals (Davis and Varma, 2008), and effective customizations are based on evidence from students’ responses (Black and Wiliam, 2010). In flexible learning environments, teachers are co-designers and re-designers of instructional materials (Cviko, McKenney, and Voogt, 2014) and their design decisions are influenced by practical concerns, state standards, and beliefs toward teaching, learning, and technology (McKenney, Voogt and Boschman, 2012).

Means, Bakia, and Murphy (2014) posit that online learning resources be designed and structured to flexibly integrate with teachers’ instructional plan, be aligned to curriculum standards, and be easily researchable by grade-level standards. In addition, the online learning system needs to allow the teacher to customize and assign content and tasks to students at a topical level. Research indicates that customizations based on evidence from student work leads to improved learning outcomes (Matuk, Linn, and Eylon, 2015). Wang (2009) weighs in with blended learning best practices as the need for a fast-paced, convenient, and flexible course, a thorough curriculum, practical examples, and teachers responsive to student questions. Manning (2010) provides a list of fourteen best instructional practices in blended learning, including hands-on experiences, a variety of assignments, teacher accessibility for students, facilitating student interaction with the content, actively involving students, and providing prompt feedback as needed. Although best practices provides guidance toward an effective design, an evidenced-based blueprint for how to establish a blended course or program for every setting still needs to emerge from the ongoing research efforts.

Research on Effectiveness of Standards-based, Individualized Learning

The current standards movement in US education is based on the concept of establishing clear, measurable, academic standards for all students in order to help provide educational equity and bridge the achievement gap. States adopted standards to define and describe what content teachers are expected to teach, and students are expected to master in preparation for college and careers. Content standards provide “broad descriptions of the knowledge and skills students should acquire in a particular subject area” (National Education Reform, 2010) and are available for math, language arts, science, social studies, technology, art, music, physical education, and foreign languages. Content standards may be grade-level specific or address “more than one grade if grade-level content expectations are provided for each of grades 3 through 8” (U.S. Department of Education, 2007, p. 2).

Grade-level academic content standards developed by states are anchored to standards created by national organizations. For example, The National Council of Teachers of Mathematics (NCTM, 1989 and 2000), the National Council of Teachers of English (NCTE), National Council for the Social Studies (NCSS), the National Research Council (NRC), and more recently the Council of Chief State School Officers (CCSSO, 2010) and the National Governors Association Center for Best Practices (NGA Center, 2010). The more recent content standards, referred to as the Common Core State Standards, developed by CCSSO and the NGA Center emphasize student depth of knowledge, higher-order thinking skills, and adaptive application.

Research studies have found that standards-based curricula benefit students (Fuson, Carroll, and Druke, 2000; McCaffrey et al., 2001; Post et al., 2008; Reys, Reys, Lapan, Holliday, and Wasma, 2003; Riordan and Noyce, 2001). Riordan and Noyce (2001) found that a standards-based curriculum had a statistically significant positive effect on students’ state standardized achievement tests when compared to a traditional curriculum. Additionally, researchers have also found the effects of standards-based mathematics curricula extend beyond state assessment achievement to an increase
in the number of years students select mathematics courses in school and increase in student ratings of self-confidence in mathematics (Cichon and Ellis, 2003; Webb, 2003).

Research conducted without computer implementations of standards-based, individualized instruction showed effect sizes in the range of 0.5 to 1.0 (Bloom, 1982; Kulik, Kulik, and Bangert-Drowns, 1990), and the Murphy et al. (2002) study found an effect size of just .14. Research conducted with computer implementations of standards-based, individualized instruction had an average effect size of up to 0.58 for reading and 0.44 for math (Murphy et al., 2002). The research on online learning using the standards-based, individualized instructional model is consistent with the general research on the individualized learning model. Regardless of medium of instruction, Marzano’s meta-analysis (1998) concluded that identifying specific learning objectives for a student yields one of the strongest effect sizes of any instructional technique: 1.37.

Huebner (2010) asserts that teachers differentiate instruction three basic ways by adjusting one or more of the following: (a) the content (what students learn), (b) the process (how students learn), or (c) the product (how students demonstrate their mastery of the knowledge or skills).

Research on Assessment

The No Child Left Behind (NCLB) idea of systemic reform aimed at “every child matters” represents an evolution in educational thinking. Based on results from the National Assessment of Educational Progress (NAEP) and the Program for International Assessment (PISA), current strategies are not enabling every child to learn the higher-order and critical thinking skills required by not only current state standards but also required to succeed in today’s world. The demand for deeper learning outcomes, problem-solving capabilities, collaboration, uses of new technologies, and the capacity to self-regulate learning necessitate rethinking how to determine readiness to learn with robust assessment systems. Darling-Hammond, Wilhoit, and Pittenger (2014) assert that the emerging accountability paradigm be (a) anchored in this new digital ecosystem, (b) positioned to move toward a system of multiple assessments coherently aligned to systemic changes, and (c) supportive of a culture of inquiry and continuous improvement. Moreover, these researchers envision this new accountability system anchored on three pillars: (1) a focus on meaningful learning, (2) enabled by professionally skilled and committed educators, and (3) supported by adequate and appropriate resources. In addition, this system should include multiple measures.

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Diagnostic, formative, and summative assessments are all critical components of the learning process. Diagnostic assessment informs educators about the level of prior knowledge a student brings to the learning environment. Formative assessment as part of the teaching process helps map the learning path by indicating the knowledge state of a student throughout the learning process. Summative assessments inform teachers about the student knowledge after course or academic year completion and helps determine program effectiveness, school improvement goals, curriculum alignment to standards, or student placement in specific programs (Ehringhaus and Garrison, 2007).

Multiple studies have found that classroom assessment (or formative assessment) has the greatest impact on student learning and achievement than any other researched educational innovation (Black and Wiliam, 1998a). A comprehensive research review by Black and Wiliam (1998a) concluded that formative assessment improved scores of students compared to students who did not take formative assessments (Black and Wiliam, 1998a). Additionally, research shows an increased interest in formative assessments to better prepare students for summative assessments on state standards. Formative assessments generally require an interaction between the student and the teacher in which real-time feedback from the assessment is used to re-mediate areas the student may be lacking (Black and Wiliam, 1998b). It also serves as a platform for finding out where a student is in the “developmental corridor” (Bransford, Brown, James, and Pellegrino, 2000).

Research has established the following essential elements of formative assessment:

- Identification by teachers and students of learning goals, intentions or outcomes, and criteria for achievement; conversations (with feedback) between teachers and students that build on what is known and what is to be learned
- Active involvement of students in their own learning, and teachers responding to identified learning needs and strengths by modifying and/or adapting teaching strategies, materials, and approaches (Black and Wiliam, 1998; Boston, 2002; Fontana and Fernandes, 1994; Fredrickson and White, 1997; Guskey, 2003; Liang and Creasy, 2004; Shepard, 2000; Stiggins and Conklin, 1992; Stiggins, 1992).
Effective integration of online, formative assessment has the potential to facilitate and sustain meaningful interactions among learners and the teacher, and in turn foster development of effective learning communities to support meaningful learning and its assessment (Sorensen and Takle, 2005). Moreover, this provides a systematic structure for effective support and scaffolding through ongoing monitoring of learning and provision of adequate formative feedback. Ongoing learner support has been identified as a critical requirement for effective online learning, and can be essentially facilitated through sustained interactive collaboration among the teacher, peers, and the individual learner (Ludwig-Hardman and Dunlap, 2003). In effect, this supports learners to engage productively and stimulates self-regulation, which in turn supports learners to assume primary responsibility for their learning, an important requirement for successful online learning.

Online assessments afford students the benefits of being able to take the assessment at any time, being able to take it multiple times, and receiving instant feedback. Studies have also found a reduction in anxiety when students take formative assessments before the summative assessment (Zakrzewski and Bull, 1999; Clariana, 1997).

**Using assessments to drive instruction.**

Black and Wiliam (1998) defined formative assessment as all activities undertaken to “provide information to be used as feedback to modify the teaching and learning activities” (p. 2). These authors empirically showed that the effective use of formative assessment is positively correlated with student achievement gains; however, the ways in which teachers incorporate formative assessment in their classroom varies. Researchers have identified effective formative assessment strategies such as setting and sharing clear learning goals and providing feedback (e.g., Heritage, Kim, Vendlinski, and Herman, 2009; Wiliam, 2007).

**Teachers play a pivotal role in the process of using formative assessments in the classroom (Cizek, 2010). Research has established that formative assessment is a useful instructional tool (Black and Wiliam, 1998/2010), but not useful unless the teacher takes action with the information (Black and Wiliam, 1998/2010; Guskey, 2007b; Popham, 2006). Teachers need support and guidelines as they make instructional decisions for the class and individuals. In addition, teachers need to ensure students are engaged in the learning process and help students reach their intended learning goals (Black and Wiliam, 1998/2010). Research has established that formative assessment can help all students, but it yields significantly positive results with low achievers by concentrating on specific problems with their performance, and provides them with feedback on what is wrong and how to make it right (Black and Wiliam, 1998; Wiliam, 2003). Black and Wiliam (1998) report effect sizes between .4 and .7 for students taught in classrooms where formative assessments are used.

**Reporting**

“How is my student doing?” Is the primary concern for
parents and teachers alike. It is important the teacher, parent, and student are able to interpret the report. Reports often include too little data or data with technical jargon incomprehensible to the reader. To generate an effective report, it must show appropriate triangulation of data, address discrepancies, and present a rich and accurate profile of a student’s major strengths and weaknesses (Wiggins, 1998, p.242). Moreover, it is important for the teacher, parent, and student to have full comprehension of what is presented. [insert Cleveland, Tufte, Few]

**Feedback Loop**

The feedback provided through the formative assessment process helps learners be more aware of gaps in their understanding and provides guidance on actions to take in order to achieve the intended learning goal (Guskey, 1997; Ramaprasad, 1983; Sadler, 1989). The most helpful type of feedback provides specific comments about errors and specific suggestions for improvement, and encourages students to focus on understanding and not on just getting the right answer (Bangert-Drowsn, Kulick, and Morgan, 1991; Elawar and Corno, 1985).

Research findings suggest that formative assessment might be more effective in English language arts (ELA) than in mathematics or science, with estimated effect sizes of .32, .17, and .09, respectively. The two types of formative assessment implementations that appear more effective are implementations based on professional development and on the use of online formative systems, yielding mean effect sizes of .30 and .28, respectively (Kingston and Nash, 2011). Inarguably, the role of feedback is critical when using formative assessments (Filesecker and Kerres, 2012; McMillan, 2010). Researchers assert that process feedback is most powerful when provided during instruction rather than after instruction (Bell and Cowie, 2001; Filesecker and Kerres, 2012; Heritage, 2012). Researchers also view student involvement to be equally important for effectiveness (McManus, 2008; McMillan, Venable, Varier, 2013). A recent meta-analysis investigated the effects of providing item-based feedback in a digital learning environment on students’ learning outcomes. Results found that elaborated feedback (e.g., providing an explanation) produced the higher effect sizes (.49) than feedback regarding answer correctness (.05) or providing the correct answer (.32). Moreover, elaborated feedback was even more effective than correctness feedback and correct answer for high-order learning outcomes. The use of elaborated feedback also yields larger effect sizes in mathematics compared to social sciences, science, and languages. Finally, effect sizes were negatively affected by delayed feedback timing with elementary and high school students (Van der Kleij, Feskens, and Eggen, 2015).

The National Council of Teachers of Mathematics (2013) stated their position on the use of formative assessment in mathematics classrooms: “The use of formative assessment has been shown to result in higher achievement. The National Council of Teachers of Mathematics strongly endorses the integration of formative assessment strategies into daily instruction” (p. 1).

Although previous meta-analytic research has determined the effectiveness of formative assessments on student learning, recent researchers have presented results showing smaller effect sizes using new methods (e.g., Briggs, Ruiz-Primo, Furtak, Shepard, and Lin, 2012; Kingston and Nash, 2011; 2012; McMillan, Venable, and Varier, 2013). However, they do not contest the positive effects—just the size of the effect on student achievement.

**Adaptive Instruction**

Online learning environments enable the ability to individualize the nature and sequence of digital learning materials and e-activities for each learner to facilitate the learning process (Corbalan, Kester, and Van Merrienboer, 2005). Individualization of learning materials is known to optimize learning because based on a learner’s responses and interactions, the adaptive engine creates a learning path tailored to a student’s specific needs. By providing an individualized learning path, students learn more effectively and efficiently because presented activities and instruction are appropriate to their current learning needs (Chen, 2008). Adapting instruction to individual needs provides relevant learning opportunities, adjusts learning paths based on diagnostic assessment, provides just-in-time guided practice, and advances students based on mastered competencies.

Research on this instructional model has determined that it has the largest effect size of any instructional model. Moreover, studies have shown that adaptive learning systems are more efficient and more effective in achieving
student outcomes relative to traditional methods (VanLehn, 2011). VanLehn found adaptive systems to be nearly as effective as one-on-one human tutoring. Graham, Harris, and Hebert (2011) conducted meta-analysis on formative writing assessment and recommended that teachers should “use formative writing assessment to enhance students’ writing,” including feedback from both teachers and peers, instructing students to assess their own writing, and monitoring students’ writing progress over time (p. 66.)

Shute (2007) believes current teaching methods are not adequately addressing learner variability. Research indicates that incoming knowledge about the learner is the most important data element to determine subsequent learning (Alexander & Judy, 1988; Glaser, 1984; Tobias, 1994). Therefore, assessing students’ current knowledge state prior to instruction is a logical starting point for teaching. The success of any adaptive technology to promote learning requires accurate diagnosis of learner characteristics (e.g., knowledge, skill, motivation, persistence). The collection of learner information can then be used as the basis for the prescription of optimal content, such as hints, explanations, practice problems, encouragement, and metacognitive support. Shute and Zapata-Rivera (2012) developed a four component cycle including capture, analyze, select, and present. This framework intends to adapt the appropriate instructional content and materials for the learner by a cycle of inputs to derive a learner model (see Figure 5).

Adapting instructional content and materials to meet students’ cognitive needs (i.e., knowledge state and different abilities) has been shown to foster better learning (e.g., Arroyo, Woolf, & Beal, 2006; Arroyo, Beal, Murray, Walles, & Woolf, 2004). Research supports the belief that if students receive instructional content and materials they are not ready to learn to learn, then the instruction will not effectively foster learning. (Woolf, 2006)

**Customization**

Customized education is also referred to as Flexible Learning (Collis & Moonen, 2001). This type of instructional model supports differentiation as the type of learning where instructional materials, types of learning activities, and resources used to support learning activities can all be made flexible in order to address the needs of individual learners. Teacher curriculum customizations enable teachers to adapt online content to address individual and local needs as well as instructional goals (Davis & Varma, 2008). An online learning system with the affordance of customization provides a flexible curriculum that maintains the integrity of the designed content while simultaneously differentiating learning as needed (Rose & Meyer, 2002). Teachers’ design decisions are driven by multiple factors, e.g., practical concerns; state standards; and beliefs and orientations toward teaching, learning, and technology (McKenney, Voogt & Boschman, 2012). Successful customizations are based on evidence from students’ ideas (Black & Wiliam, 2010).
Research:
Domain Specific Learning Models
Reading

The Common Core ELA Standards require students to analyze a variety of complex texts, conduct frequent research, use technology to gather information, use academic vocabulary in speaking and writing, and create eloquent arguments with clear evidence—in both speaking and writing. Reading material, by the intermediate grades, is to be at least 50% informational (nonfiction, expository) text and up to 70% informational or nonfiction text by grade 7. A standard receiving strong emphasis is one requiring students to derive evidence from a text during teacher-supported “close reading.”
The ACT college-admission testing program reported that postsecondary students who do not succeed missed items on the ACT reading comprehension tests that require interpretation of complex text. This and additional research findings lead the Common Core ELA leadership team to conclude (a) that texts given to secondary school students need to be more challenging and more complex, (b) that teachers needed to do a better job teaching advanced and sophisticated reading comprehension, and (c) that “close” and “deep” literary and informational text reading should be the main outcome of standards-based instruction (Moats, 2012). One instructional strategy to foster text complexity is to create a sequence of ever more complex texts that students experience as they progress through a planned sequence of complexity (MetaMetrics, 2010). This approach embeds scaffolding in the digitally delivered reading environment. By using an adaptive engine to facilitate the complexity level and scaffolding, students receive differentiated content, and the teacher can focus on providing individuals with targeted instruction focused on deeper learning.

Meta-analyses have established phonemic awareness, phonics, fluency, vocabulary and comprehension as the central approaches in literacy education (e.g. Hattie, 2009, p. 140). Beyond the initial acquisition of decoding skills, interventions by the end of elementary school should provide targeted comprehension instruction (Wanzek, Wexler, Vaughn & Ciullo, 2010) with a strong emphasis on meta-cognitive knowledge and strategic behavior (e.g., predicting, summarizing and comprehension monitoring) (Van Kraayenoord, 2010).

Research has shown that effective reading programs include differentiated instructional supports to enhance children’s learning and understanding. Examples of instructional supports include providing children with ample opportunities to independently practice and apply concepts, skills, or strategies in a variety of contexts (Swanson & Hoskyn, 2001; Swanson & Deshler, 2003) and adjusting instructional and content levels to meet children's diverse needs and abilities (Tomlinson, 1999; Vygotsky, 1986). These support components have been shown to be effective in addressing the learning needs of struggling students, individuals with special needs (Broderick, Mehta-Parekh, & Reid, 2005; Swanson & Hoskyn, 2001), and gifted students (VanTassel-Baska & Little, 2003; VanTassel-Baska & Stambaugh, 2005).

Effective Tier 1 instruction in the early grades includes explicit instruction in phonemic awareness, phonics, and automatic recognition of high-frequency irregular words; instruction in making meaning from text, including an emphasis on vocabulary and the development of background knowledge; and many opportunities to read and respond to connected text to promote reading fluency and comprehension (Chard, Vaughn, & Tyler, 2002; Ehri, 2004; Jitendra, Edwards, Sacks, & Jacobson, 2004; National Reading Panel, 2000; Snow et al., 1998).

Motivation plays an important role in the reading process (Baker, Dreher, & Guthrie, 2000) and has been positively linked with children’s achievement in school (Guthrie, et al., 1996). However, research suggests that children tend to develop less positive attitudes toward reading with age (McKenna, Kear, & Elsworth, 1995; Mazzoni, Gambrell, & Korkeamaki, 1999). To combat this trend, reading instruction should be engineered to engage and motivate readers. Effective programs include rewards, emphasis on individual’s efforts, and providing interesting and appropriate texts while teaching comprehension strategies (Block, Gambrell, & Pressley 2002; Guthrie & Davis, 2003). Research reviews and meta-analyses have found that students with reading difficulties benefit from instruction that is purposeful and targeted at important objectives that students need to learn, progressing logically from easier to more challenging skills (Foorman & Torgesen, 2001; Gersten et al., 2008; National Reading Panel, 2000; Snow et al., 1998; Swanson, 1999; Torgesen, 2004; Wanzek & Vaughn, 2007). Within such a program, students’ mastery of key skills and strategies is carefully monitored so that reteaching can be provided if needed.

Technology has often seen as a solution for the needs of struggling readers (e.g., Anderson-Inman & Homey, 2007; Boone & Higgins, 2007; Curry, 2003; Roblyer & Doering, 2013; Silver-Pacuilla & Fleischman, 2006; Stetter & Hughes, 2010). Digital learning systems can adapt to the individual needs of struggling readers, building on what they can do and filling in gaps. Computers have been found to stimulate motivation for most students (Kamil, Intrator, & Kim, 2000; Leu, 2000), and computers can mimic some behaviors of expert human tutors (Lever-Duffy & McDonald, 2008). The potential of technology applications to enhance learning, and specifically to help struggling students have been anticipated for many years (Kamil et al., 2000; Lever-Duffy & McDonald, 2008; Roblyer & Doering, 2013).
Although there is considerably less research investigating the characteristics of effective reading instruction for English language learners (ELLs), there is evidence that, just as native English speakers, ELLs benefit from explicit, well-organized early reading instruction that addresses their needs in phonemic awareness, phonics, reading fluency, vocabulary, and comprehension (August & Shanahan, 2006; Vanderwood & Nam, 2007). In addition, effective instruction for ELLs includes a focus on the development of oral language, including vocabulary instruction with extended opportunities to practice new words in speaking and listening activities, as well as in reading and writing (Crosson & Lesaux, 2010; Pollard-Durodola, Mathes, Vaughn, Cardenas-Hagan, & Linan-Thompson, 2006). Crosson and Lesaux (2010) found a strong relationship between the reading fluency and comprehension in native English readers is moderated by ELLs’ oral language development. Therefore, research recommends early reading interventions for ELLs and native English speakers who have limited oral language development should target vocabulary, listening, comprehension, and reading comprehension (Gersten et al., 2008).

Duke et al (2011) identified the following 10 research-based essential elements of effective reading comprehension instruction implemented within a gradual release of responsibility model:

1. Build disciplinary and world knowledge.
2. Provide exposure to a volume and range of texts.
3. Provide motivating texts and contexts for reading.
4. Teach strategies for comprehending.
5. Teach text structures.
6. Engage students in discussion.
7. Build vocabulary and language knowledge.
8. Integrate reading and writing.
10. Differentiate instruction.

**Gradual Release of Responsibility Model**

The gradual release of responsibility (Pearson & Gallagher, 1983) model of instruction is considered an effective approach for improving literacy achievement (Fisher & Frey, 2007), reading comprehension (Lloyd, 2004), and literacy outcomes for English language learners (Kong & Pearson, 2003). This model proposes that the cognitive load should shift slowly and purposefully away from the dependency on teacher-as-model to learner and teacher having joint responsibility and then to independent practice by the learner (Pearson & Gallagher 1983).

**Mathematics**

Research has identified eight research-based principles of mathematics instruction: (1) preteaching prerequisite skills, (2) teaching math vocabulary, (3) explicit instruction, (4) selecting instructional examples, (5) building conceptual understanding using math models, (6) multiple and varied practice and review opportunities, (7) teacher-provided academic feedback, and (8) formative feedback loops.

Preteaching prerequisite skills. Teaching prerequisite skills involves connecting previously learned information with newly acquired knowledge (Bransford, Brown, Cocking, Donovan, & Pellegrino, 2000; Kame'enui & Simmons, 1999; Caldwell, Karp, & Bay-Williams, 2011).

Math vocabulary. Imprecise use of mathematics language and definitions can lead to later misconceptions (Wu, 2009). Math vocabulary instruction facilitates mathematical discourse, including math verbalizations (Gersten et al., 2009).

Explicit instruction. Research has established that explicit and systematic instruction is the most effective method for teaching students with or at risk for mild disabilities (Baker et al., 2002; Gersten et al., 2009; NMAP, 2008). Explicit and systematic instruction includes concise directions, opportunities for modelling, scaffolded instruction, guided practice, and teacher-student-student interactions.

Instructional examples. To optimize student understanding, digital learning systems need to provide clear and appropriate teaching examples (Chard & Jungjohann, 2006; Doabler et al., 2012). In a meta-analysis of instructional interventions for students with learning disabilities, Gersten et al. (2009) found a mean effect size of 0.82 for intervention studies withcarefully sequenced instructional examples. Instruction starts with simpler teaching examples, and limited use of negative examples.

Math models. Research has found the concrete–representational–abstract (C-R-A) process of instruction to be an effective method for building student conceptual understanding (Hudson & Miller, 2006). C-R-A instruction systematically provides opportunities for students to use...
visual representations like number lines, tally marks, strip diagrams, and counting blocks. Math models (Gersten et al., 2009) have been shown to help struggling students understand the relationship between math representations and abstract symbols with a reported mean effect size of 0.46.

Practice opportunities and cumulative review. Review and practice opportunities foster student automaticity of math skills and retention of previously learned material (Kilpatrick et al., 2001). Discrimination practice should be used for generalizing math skills in other contexts (Stein, Silbert, & Carnine, 2006).

Academic feedback. Providing student feedback is inarguably an important aspect of math instruction (Stein et al., 2006). Unattended errors have the potential to become persistent issues and math misconceptions.

Formative feedback loops. Research findings suggest providing teachers with recommendations on how best to adjust instruction based on student assessment results tends to have a significant impact on students with mild disabilities. Meta-analysis of math interventions providing feedback to teacher on students with math disabilities found a small but statistically significant effect size (0.23) (Gersten et al., 2009). When math programs provide teachers with in-depth, detailed information, for instance the type of content to teach and when to move on to new material, the findings revealed even stronger effects.

Researchers have found most mathematics programs provide limited opportunities for students to engage in discrimination practice between new and previously learning content (Stein et al., 2006). Math programs should support teachers by providing procedures for providing academic feedback. These procedures remind teachers to correct student misconceptions and suggest when to provide extra practice opportunities before moving on to new material (Stein et al., 2006).

Core math instruction should reflect the following empirically validated instructional math strategies for students with or at risk for mild disabilities (Baker, Gersten, & Lee, 2002; Gersten, Chard et al., 2009): (a) explicit and systematic instruction, (b) visual representations of mathematical ideas, (c) opportunities for students to verbalize their thought processes, and (d) carefully selected and sequenced teaching examples.

One of the most consistent research findings on students with mild disabilities show these students benefit more from consistent use of explicit and systematic instruction (Gersten, Beckmann, et al., 2009) compared with other instructional strategies (NMAP, 2008). Explicit and systematic instruction provides students with clear teacher demonstrations, scaffolded instruction, guided practice, academic feedback, and cumulative review. Recent meta-analyses on studies that tested the effectiveness of math instruction support the use of explicit and systematic instruction for improving the learning outcomes of struggling learners (Baker et al., 2002; Gersten et al., 2009; Kroesbergen & Van Luit, 2003).

Baker et al. (2002) found that explicit instruction had the largest effects (d = 0.65) on math achievement for at-risk learners. Gersten et al. (2009) also found the use of explicit instruction with learning disabled students yielded a large effect (g = 1.22). In addition, Gersten and colleagues reported large effects for interventions that selected and sequenced instructional examples (g = 0.82) and used visual representations of math concepts during instruction (g = 0.46).

Baker et al. (2010) suggest the following for teachers working with at-risk learners: (a) teacher to student interactions, (b) types of student responses, (c) checks for student understanding, and (d) student practice opportunities. Baker et al. (2010) recommend teachers begin instruction with a brief explanation of the lesson’s purpose and targeted content. This sets clear learning expectations and objectives for students.

Research has found rich and varied practice opportunities like written exercises and math verbalizations to be effective with struggling students (Gersten et al., 2009). Math verbalizations are students thinking aloud while solving a problem. Clarke et al. (2011) found that student verbalizations were more effective than control classrooms without verbalizations in raising mean achievement levels of students with and at risk for mild disabilities. Clarke and colleagues also found that classrooms with higher rates of practice opportunities were more beneficial to students with and at risk for mild disabilities than classrooms with lower rates of student practice.
Gerstan and Clarke (2007) identified the following evidenced instructional strategies for helping struggling learners in mathematics:

- structured peer-assisted learning activities
- systematic and explicit instruction using visual representations
- modifying instruction based on data from formative assessments
- providing opportunities for students to think aloud while they work

One of the long-standing approaches to improving mathematics performance in both elementary and secondary schools is the use of educational technology. As stated in the NCTM Principles and Standards for School Mathematics, “Technology is essential in teaching and learning mathematics; it influences the mathematics that is taught and enhances students’ learning” (National Council of Teachers of Mathematics, 2011).

**Multiple representations**

Ainsworth et al. (1997) found that students gain a deeper understanding of mathematics when exposed to multi-representational digital learning systems. The use of multiple representations and the flexibility to translate among representational forms facilitates students’ learning and has the potential to deepen their understanding (Lesh, Landau, & Hamilton, 1983; Suh, & Moyer, 2007). According to The Principles and Standards for School Mathematics (NCTM, 2000), manipulatives often contain multiple representations to explain concepts, so students can translate and transfer knowledge when solving problems. Research has also shown that the power of virtual manipulates lies in the ability to combine multiple dynamic representations of a concept in a single environment, enabling learners to derive meaning and form relationships from their own actions (Moyer-Packenham, Salkind, & Bolyard, 2008). A study by Suh and Moyer (2007) found the students in the physical and virtual manipulative environments gained significantly in achievement and showed flexibility in translating and representing their understanding in multiple representations: manipulative model, pictorial, numeric, and word problems.

**Science**

Many science education researchers believe inquiry should be the primary instructional approach (AAAS, 1993; National Research Council, 1996) and scientific literacy for all students (AAAS, 1993; National Research Council, 1996; National Research Council, 2011). The National Research Council (1996, p. 22) defines scientific literacy as the “knowledge and understanding of scientific concepts and processes required for personal decision making, participation in civic and cultural affairs, and economic productivity” and more recently added science practices as well (National Research Council, 2011).

Research on inquiry-based teaching methods (Slavin et al., 2014) found the use of science kits did not yield positive outcomes on science achievement measures (weighted ES = +0.02 in 7 studies); the inclusion of professional development but no kits did yield positive outcomes (weighted ES = +0.36 in 10 studies); and technology-based programs with video and digital resources with cooperative learning yielded higher positive outcomes (ES = +0.42 in 6 studies). Slavin et al (2014) concluded their review noting that science teaching methods using cooperative learning, science-reading integration, and technology tools have significant potential to improve science achievement.

A meta-analysis of the influence of teaching strategies on student achievement in K–12 science supports the use of inquiry based strategies (Schroeder et al., 2007). More recently, a research synthesis of 138 studies on K–12 student science conceptual learning revealed a trend favoring inquiry-based instruction, especially approaches that emphasized active thinking and drawing conclusions from data (Minner, Levy, & Century, 2010). Inquiry-based lessons utilize standard research methods and provide an authentic learning environment for students to explore topics. Additionally, inquiry-based approaches have been shown to enhance students’ motivation to learn in contrast to approaches that rely on the passive reception of knowledge (Edelson, Gordin, & Pea, 1999; Wu & Hsieh, 2006). Additionally, meta-analysis on the effect of specific science teaching strategies on student achievement found the use of instructional technology yielded a significant effect size of 0.48 (Schroeder, Scott, Huang & Lee, 2007).
Research:
Effective, Evidence-Based Instructional Strategies
Video-based Direct Instruction

Compared to traditional classroom methods, video learning is student-centered, asynchronous, and available anytime and anywhere (todd et al., 2011). Compared with the traditional linear video, interactive video can provide instruction better fitted to students’ pacing needs and more engaging, thereby improving learning effectiveness (chen, 2012).

Studies (zhang, zhour, briggs, & nunmaker, 2006) conducted comparing video lectures to in-person lectures show that video lectures slightly outperform in-person lectures, with interactive online videos doing even better (effect size=0.50). In addition, the mean effect size for studies on blended learning with instructor-directed expository was (+0.36) Compared to (+0.15) For independent, active online learning (u.S. Department of education, 2009).
Researchers found online students overconfident in their learning from video-based modules, but by interleaving assessments students’ judgment of understanding was more in-line with their actual achievement level (Dunlosky & Rawson, 2012). On the other hand, students taking only one assessment at the end of the module resulted in unrealistic judgments of learning (Szpunar, Jing, & Schacter, 2014). Researchers have found students in an online learning environment have difficulty sustaining attention (e.g., Khan, 2012 & Koller, 2011); lapses of attention are a significant impediment to learning (Szpunar, Moulton, & Schacter, 2013) and inattentiveness during lectures has a negative impact on note taking and retention (Bunce, Flens, & Neiles, 2010; Lindquist & McLean, 2011; Unsworth, McMillan, Brewer, & Spillers, 2012).

Feedback

Instructional feedback is typically used to verify the validity of the learner’s response (i.e., whether or not the answer is correct or incorrect) and provide pertinent cues to help guide the learner toward a correct response (Kulhavy & Stock, 1989). Providing ongoing performance feedback can help learners identify errors, become aware of misconceptions, improve self-regulated learning, and foster overall motivation and achievement (Bangert-Drowns, Kulik, Kulik, & Morgan, 1991; Narciss & Huth, 2004).

Research suggests that providing students with feedback can support and enhance the learning process and has shown it to be a vital element of effective instruction and practice in a variety of educational contexts (for reviews see Azevedo & Bernard, 1995; Hattie & Timperley, 2007; Kluger & DeNisi, 1996). Struggling learners, in particular benefit from feedback that is given immediately following a task or response (Azevedo & Bernard, 1995; Kulik & Kulik, 1988). When used effectively, feedback provides one of the most powerful influences to enhance learning and achievement outcomes (Hattie & Timperley, 2007; e.g., Kulik & Kulik, 1988). However, the degree of feedback influence varies by the type of feedback offered. For example, providing information about a task or methods to perform the task more effectively tends to enhance performance more than providing praise, punishment, or extrinsic rewards. In addition, providing learners with cues or reinforcement in the form of video-, audio-, or technology-enhanced instruction has also been found to be effective.

The use of an informative feedback system within a digital learning system is critical to providing an efficient learning process (Narciss, & Huth, 2002; Narciss, Kornble, Reimann, & Muller, 2004). Elaborative feedback may also be provided in the form of an explanation of the correct and/or incorrect answers, information about common errors or errors committed by other student, or a list of sources with additional information.

Visualization

Visualization is the process of constructing and transforming visual mental images and visual representations (Presmeg, 2006). Therefore, visualization covers both processing and interpreting information and facilitates all three phases of information processing: search, recognition, and inference (Stylianou & Silver, 2004). In addition, visual representations offer advantages for displaying certain types of information, such as spatial relations between components of a problem. Research suggests that visualization processes provide students with unique insights that can enhance their understanding of mathematical skills and concepts (Arcavi, 2003; Presmeg, 2007). Visualization affords students the opportunity to better ‘see’ mathematical relationships through the investigation and manipulation of symbols, images, diagrams, objects, or tools.
Despite studies pointing to the potential of visual approaches for supporting mathematical learning and problem solving, many students struggle to make connections between their visualizations and analytical thought (e.g., see Eisenberg & Dreyfus, 1991). Thus, a central priority should include developing strategies, approaches, and experiences that support visualization in conjunction with analytic thinking to help students construct rich, meaningful understandings of mathematical concepts. When visualization tools are learner facing, learners gain insight into their habits and the impact of their learning activities, thereby improving their self-awareness and self-regulation (Suthers, D. & Rosen, D. 2011). Additionally, researchers found the use of visual imagery (e.g., diagrams) during mathematical problem solving significantly correlated with students’ problem solving performance (Brenner et al., 1997).

Scaffolding

Scaffolding facilitates instruction by providing conceptual, procedural, strategic, and metacognitive supports to help close the gap between what students are capable of doing on their own and what they are capable of doing with the help of a more knowledgeable other (Hannafin, Land, & Oliver, 1999; Wood, Bruner, & Ross, 1976). Digital learning systems design scaffolding to supplement teacher scaffolding (Hannafin et al., 1999; Saye & Brush, 2002). Meta-analyses indicate that scaffolding-related interventions increase student learning (Lin et al., 2007; Swanson & Deshler, 2003; Swanson & Lussier, 2001) by making thinking visible (Kali & Linn, 2008). Scaffolding is not a stand-alone intervention and should be used with instructional approaches such as problem-based learning (PBL) (Saye & Brush, 2002), learning by design (Puntambekar & Kolodner, 2005), or case-based learning (Lajoie, Lavigne, Guerrera, & Munsie, 2001).

Belland et al (2015) found preliminary evidence that scaffolding is effective, producing an average effect size of 0.53. Scaffolding’s effect is (a) considerably stronger than that of the average instructional intervention designed to promote critical thinking (0.34) (Abrami et al., 2008), yet (b) lower than that found for one-to-one human tutoring (0.79) in a recent meta-analysis (VanLehn, 2011).

Kali and Linn (2008) found scaffolding not using fixed fading had higher effect sizes (g = 0.79) than studies using fixed fading (g = 0.20). Studies using conceptual scaffolds exhibited superior (g = 0.67) learning outcomes to those using metacognitive (g = 0.25) scaffolds. In addition, studies show advantages of dynamic over static images (Hoffler & Leutner, 2007), especially when combined with inquiry scaffolds (Clark, 2006; Ryoo & Linn, 2012). Research has found that effective use of visualizations includes instructional scaffolds (Gilbert, 2008; Lowe, 2004; Moreno & Mayer, 2007; Xie & Tinker, 2006). Specifically, students need guidance on making predictions, using visualizations to generate ideas, conducting observations or virtual experiments on their predictions, and reflecting on their progress (Linn & Eylon, 2011).

Virtual Labs

Several studies report that virtual experiments are equal to or more effective than hands-on experiments for helping students understand scientific concepts (Klahr et al., 2007; Triona & Klahr, 2003; Zacharia, 2007; Zacharia, Olympiou, & Papaevripidou, 2008). Sun, Lin and Yu (2008) comparative study of virtual and hands-on science labs found an effect size of +0.18 favoring the virtual lab condition.
Research:
Implementation Factors
No technology has an impact on learning on its own; it all depends on how it is used. (Nesta, 2012)

Any meta-analysis of the effectiveness of technology has found a wide range of effect sizes. Researchers attribute this wide range to the degree to which a product, program, or instructional strategy was implemented as designed. O’Donnell (2008) termed this measure as the Fidelity of Implementation and the key components that characterize the intervention are defined as the “essential features that must be measured to determine whether a program is present or not” (Century et al., 2010). The average effect size of studies with high levels of implementation (d=+0.23) is significantly greater than those of low implementers (d=+0.05). The effect size of studies with a medium level of implementation is +0.16 (Cheung, 2013).
Obviously, the benefits of any online learning activity accrues only if the duration of the activity meets minimum practice. However, the majority of implementations do not use technology-based products to the degree recommended by designers, so mixed and weak results are not surprising. In general, programs used more than 30 minutes a week have a bigger effect than those used less than 30 minutes a week (Cheung, 2013). Kulik’s meta-analysis (2003) found typical implementations only give students 15% to 30% of the recommended amount of time on the computer. Morris et al., (2012) recently showed that high school poor readers can improve .5 standard deviations in reading after intensive, closely monitored, comprehensive, integrated instruction was delivered for 70 hours.

**Application with Special Needs Populations**

Recent research findings using economically underserved students yielded significant gains in achievement and engagement in digital learning systems that engages students in interactive learning using multiple representations and feedback (Darling Hammond, Zielezinski, & Goldman, 2014). Researchers have also found that “teacher assistance seems to be mandatory for the online learning of underprivileged students” (Kim & Lee, 2011, p 2403). In Kim & Lee’s study, students learned more in the blended learning condition if they received real-time support and encouragement from their teachers. Furthermore, students who interacted with their teachers were much more likely to develop an interest in the subject and increase their academic standing. In contrast, students working online independently were more likely to neither change their interest nor their academic standing (2011).

Englert et al. (2007) examined the effectiveness of an online writing program with elementary-aged special education students. Students using the online writing program prompts focused on topical organization and idea structures during the writing significantly outperformed (effect=+0.74) students in the control group using similar paper-and-pencil format prompts in a paper-and-pencil format.

Research (Darling-Hammond, Zielezinski, Goldman, 2014) indicates three important variables for success with at-risk students who are learning new skills:

- interactive learning;
- using technology for exploring and creating and not for “drill and kill”; and
- the right blend of teachers and technology.

Furthermore, Warschauer and Matuchniak (2010) found drill and practice type of activities used in low-SES schools tend not to achieve positive results, but uses of technology in high-SES schools tend to achieve positive results.

**Linkage between Career and Technical Education (CTE) and STEM Education**

The Association for Career and Technical Education (ACTE) posits that CTE programs offer an instructional approach that strengthens students’ understanding of STEM content and helps attract more students into STEM career pathways (ACTE, 2009). Furthermore, Stone (2011) states CTE programs address some aspects of science, mathematics, and technology and asserts that STEM-focused education can be infused into any CTE system and pedagogical approach.

CTE courses have been found to improve mathematics achievement by helping teachers reinforce students’ mathematical understanding both inclusive and exclusive of the occupational curriculum (Stone et al., 2006). These researchers (2006) found that by enhancing instruction in the mathematics embedded in the curricula of five diverse occupational areas improved students’ mathematical achievement.
CTE courses have been found to improve mathematics achievement by helping teachers reinforce students’ mathematical understanding both inclusive and exclusive of the occupational curriculum (Stone et al., 2006). These researchers (2006) found that by enhancing instruction in the mathematics embedded in the curricula of five diverse occupational areas improved students’ mathematical achievement.
Research:
Practice
The review of the research on online learning found blended learning significantly outperforms face-to-face classroom instruction (Means et al., 2013) and the pedagogical pattern used with online learning makes the difference. For instance, when students experience blended learning with both collaborative learning activities and teacher-directed instruction, the blended learning students significantly outperform students only engaged in active self-study. Moreover, the research says effective online learning environments address the needs of diverse learners, apply effective pedagogical strategies, use evidence-based design principles, support multiple technologies, and provide for flexible learning (Buzzetto-More, 2007; Hussit, Bunyarit & Hussein, 2009; Moore, Dixon-Deane & Galyen, 2011; Oblinger & Oblinger, 2005; Orellana, Hudgins & Simonson, 2009; Sun et al., 2008). Collis & Moonen (2001) describe flexible learning in terms of customizing the instructional materials, learning activities, and media of a course to address the needs of individual learners.
In addition, research says that interactive, online learning systems that determine students' level of understanding, customize the material for them, provide an interactive set of instructional activities with feedback to students, provide detailed reports about students' progress, and with teachers supplementing instruction by explaining concepts and facilitating student discussion (Darling Hammond, Zielezinski, & Goldman, 2014) yield higher results. Moreover, research indicates that customizations based on evidence from student work leads to improved learning outcomes and blended learning best practices include the need for a fast pace, convenient, and flexible course; a thorough curriculum; practical examples; and teachers responsive to student questions. Research studies have also found that standards-based curricula benefit students (Fuson, Carroll, & Drueck, 2000; McCaffrey et al., 2001; Post et al., 2008; Reys, Reys, Lapan, Holliday, & Wasma, 2003; Riordan & Noyce, 2001).

Odysseyware is based upon a hierarchy of customization and implements standards-based, individualized learning by using an adaptive instructional model. Odysseyware lessons share the following characteristics of research-based best practices and standards-based instruction:

- Learning outcomes are defined by standards-aligned learning objectives
- Lessons are divided into small learning units each with its own objective
- Lessons may be customized by teacher and individually assigned
- Learning materials are identified and appropriate instructional strategy employed
- Assessment types or each unit includes formative and summative assessments that measure the student's entry level knowledge and developing progress
- Knowledge of student progress is fed back immediately to the student to act as reinforcement and motivation

**A Coherent System**

Research says the effective use of formative assessment, which includes teacher customizations based on student performance data, is positively correlated with student achievement gains. Odysseyware provides a seamless process of assessment and diagnosis, intervention activities, retesting, and further intervention (as needed)—making it possible for teachers to use real-time data to meet the needs of individual students. The assessment and intervention features build on the evidence that learning is enhanced when teachers have access to the knowledge learners bring to the lesson, use this knowledge to customize and differentiate instruction, monitor students' changing conceptions as the lesson proceeds, and provide appropriate intervening instruction.

Research says assessment of incoming knowledge about the learner is the most important data element to determine subsequent learning. In addition, research has established the following essential elements of formative assessment:

- Identification by teachers and students of learning needs
- Performance data is used to adapt instruction to the learner's needs

Guided by the design principles of Understanding by Design and the Gradual Release of Responsibility, Odysseyware's research-based pedagogical models emphasize the creation of logical learning paths that initially present learners with big-picture concepts and rich, background knowledge including real-world concepts, and then systematically proceed to more granular, essential, and supporting standards, with multiple opportunities for practice, deeper learning, and evidence of mastery.
goals, intentions or outcomes and criteria for achievement, conversations (with feedback) between teachers and students that build on what is known and what is to be learned

- active involvement of students in their own learning, and teachers responding to identified learning needs and strengths by customizing and/or adapting teaching strategies, materials and approaches

Because of the importance of diagnostic and formative assessments, Odysseyware employs a robust assessment engine, Flex Assessment. Using this engine, Odysseyware assesses students in a way that ensures appropriate placement into the course. Formative assessments are given throughout the program to inform the teacher about the level of instructional tools that are appropriate for a given student and continuously guide the adaptive instructional path. Summative assessments enable both the students and teacher to reflect on what has been learned and the level of mastery attained. Flex Assessment ensures students’ progress is monitored and that appropriate levels of instructional material are provided.

Research on adaptive instructional models has demonstrated that it has the largest effect size of any instructional model. Odysseyware puts into practice an adaptive instructional model using the Credit Recovery Mode (CRx). This adaptive engine provides students with prescriptive learning paths based on assessed content mastery in higher grades. Pretests before each instructional unit determine whether it will be skipped or added to a student’s instructional path. This capability supports efficient and targeted preparation for success on End of Course exams.

Research says teachers play a pivotal role in the process of using formative assessments in the classroom. Odysseyware provides a Teacher Authoring Tool to empower teachers to create anything from a single lesson, project, quiz, or test to an entire course. Featuring a WYSIWYG interface and drag-and-drop functionality, the Teacher Authoring Tool allows educators to embed a rich variety of content into lessons such as Web 2.0 tools, videos, animations, text and learning games and activities.
Conclusion:
The research summarized here shows how Odysseyware puts into practice the most effective and best-researched instructional applications of digital learning. The instructional strategies incorporated in Odysseyware courses have consistently demonstrated the largest effect sizes of any instructional strategy, especially when implemented as blended learning. The effectiveness has been demonstrated in a wide range of content areas, but the strongest evidence is in math and reading.

Odysseyware lessons, assessments, and instructional tools equip learners with resources for college and career success, incorporating a mix of grade-appropriate text, direct-instruction videos, learning activities, and games. Odysseyware lessons also embed numerous instructional supports to address diverse learning styles and allow ongoing collaboration between learners and teachers.

Research also investigated the range of ways in which digital learning systems such as Odysseyware can be implemented, and the benefits of using the system as a way to leverage teacher time and thus improve learning and even improve cost-effectiveness and as an engaging learning environment for students. However, the research also emphasizes the importance of fidelity of implementation and the need to give students sufficient access to peers, teachers, and technology, if the benefits of Odysseyware are to be realized. Thus, careful implementation planning, professional development, and adequate resource planning are critical.
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