
Educational Technology and Response to Intervention: Affordances and Considerations

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What is Educational Technology?

In the first half of the twentieth century, educational technology focused on media, as visual and then audiovisual tools were used to present instruction in forms such as film. This view of educational technology as hardware and software is still common today, and one might first think of educational technology in the form of computers and the educational software that runs on them (Reiser 2012).

Technology, however, involves application of research to solve practical problems and includes processes as well as tools (Clark and Salomon 1986; Twyman 2011). The notion of technology as a process became a focus of educational technology beginning in the 1950s, when educational technology came to be seen as involving the design of solutions for instructional problems and application of science to instructional practices (Reiser 2012).

In 2008, the Association for Educational Communications and Technology revised its definition of the field to include both resources and processes: “Educational technology is the study and ethical practice of facilitating learning and

improving performance by creating, using, and managing appropriate technological processes and resources” (quoted in Reiser 2012, p. 4). In describing this definition, the authors define technological processes as “the systematic application of scientific or other organized knowledge to accomplish practical tasks” (quoted in Reiser 2012, p. 5), while technological resources refer to the hardware and software that we more typically think of when we think of educational technology (Reiser 2012).

Does Technology Impact Learning?

Whether and how technology impacts learning has been debated for several decades. The focus of this debate has been on whether the media used for instruction have unique effects on learning, apart from instructional methods. For example, Clark (1983, 1985, 1994) argued that media do not influence learning. Rather, it is the instructional method employed that influences learning, with the medium simply being a vehicle for a particular method. Kozma (1991, 1994) argued that different media might influence learning when they have different capabilities. Instructional methods could take advantage of these capabilities, and this interaction between a medium’s capabilities and the methods that utilize them can result in more or different learning.

Any attempt to improve student learning must first stand on relevant, well-designed curricula and evidence-based instructional methods. Good

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instructional design requires a systematic design process that includes performing content, task, and learner analyses, clearly defining the learning objectives, determining the criterion tests to assess for understanding or mastery, establishing the entry repertoire needed by the student, building the instructional sequences, using performance data to continually adjust instruction, and ensuring student motivation by incorporating both program intrinsic and extrinsic consequences throughout the instructional sequence (Tiemann and Markle 1990; see also Dick and Carey 1996; Smith and Ragan 1999; Twyman et al. 2004). Good instructional delivery requires active learner engagement with frequent opportunities to respond (Rosenshine and Berliner 1978) and immediate, relevant, and contingent feedback (Bardwell 1981; Mory 1992; Shute 2008). Instruction should support the learner in moving forward at his or her own learning pace (Fox 2004) so that new material is not presented until the student has demonstrated mastery or application of current material (Bloom 1968; Keller 1968; Kulik et al. 1990). This requires that the progression of instruction and content be tied to actual measures of student learning, and not dictated by curriculum content chunks such as chapters or units, or the passage of marking periods or calendar years. Any viable educational technology must support, enhance, or provide these critical components.

Computer-based instruction (CBI) or computer-assisted instruction (CAI) has been the most prevalent form of hardware/software technology introduced into schools over the past half century. After initial fanfare with little tangible results (see AL-Bataineh and Brooks 2003), followed by more thorough empirical questions regarding the impact of CBI (see Shlechter 1991; Siegel 1994), the educational use of technology and CBI are gaining positive traction in the research literature. Improved outcomes have been demonstrated clearly in structured content areas such as mathematics (Valdez et al. 1999), social sciences (Kulik and Kulik 1991), and, with the growing involvement of the Internet and social connection in digital technology, contributions are beginning to be seen in other content areas as well

(Redecker et al. 2010). Modern technology tools and applications such as video, interactive whiteboards, student response systems, portable devices, virtual learning, and a 1:1 ratio of computers to students have been found to greatly increase the collection, management, analysis, storage, and communication of educational data (McIntire 2002; Wayman 2005). Numerous meta-analyses of existing research have indicated a range of improvement effects for the use of computers, game-like curricula, and interactive simulations (Niemiec et al. 1987; Vogel et al. 2006). McNeil and Nelson (1990, cited in Hattie 2008) reported great variance in student outcomes due to factors such as instructional methods, learning materials, implementation variables, as well as the purpose(s) of the media. For example, Blanchard et al. (1999) conducted a meta-analysis of more than ten multimedia/game curriculum implementations for mathematics and language arts instruction in grades 1–5, and found overall low effects for mathematics ($d=0.13$) and language arts ($d=0.18$), yet higher effects ($d=0.23$) when interventions were implemented with quality. Vogel et al. (2006) analyzed studies that reported on differences in cognitive gains or attitudinal changes for computer games and simulations versus traditional classroom instruction. They found significantly higher cognitive gains for participants using games and simulations ($z=6.05$) as well as a main effect for attitude favoring the use of games and simulations ($z=13.74$).

A notable finding from more than two decades of computer-aided and multimedia interactive education is that increased “student control” over learning (such as pacing, sequencing, time allocation for mastery, choice of practice and review items) has resulted in equivocal outcomes compared to programs that were heavily or solely teacher directed (Niemiec et al. 1996). Some more recent studies have indicated that student attitudes towards school and subject matter (Roblyer 1989; Roblyer and Edwards 2000), as well as self-image and self-confidence (Alexiou-Ray et al. 2003; Christensen 2002; Roblyer et al. 1988), can be positively affected when using technology tools, although the durability of these effects is not known clearly.

Educational Technology and Response to Intervention

The purpose of response to intervention (RTI) is to “contribute to more meaningful identification of learning and behavioral problems, improve instructional quality, provide all students with the best opportunities to succeed in school, and assist with the identification of learning disabilities and other disabilities” (National Center on Response to Intervention, n.d., n.p.). A critical feature of RTI is the seamless integration of assessment and intervention to increase student learning and outcomes. RTI commonly employs three levels of intervention: primary prevention, secondary prevention, and tertiary prevention (Fuchs and Fuchs 2009). Primary prevention entails whole-class instruction delivered by a general education teacher. This instruction may or may not be differentiated and may or may not involve small-group and independent activities. The instructional materials used may or may not be empirically validated, but the design of most core programs is based on instructional principles. Secondary prevention involves additional small-group instruction using an evidence-based intervention protocol for those students who are identified as at risk. Reading or mathematics coaches may oversee this instruction, and paraprofessionals may deliver the instruction to small groups of students. Those students who do not make adequate progress in secondary prevention may move into tertiary prevention. This level employs intensive, individualized instruction (Fuchs and Fuchs 2009). The level of progress monitoring may also differentiate tiers, with more frequent progress monitoring often occurring with more intensive intervention (i.e., secondary and tertiary). RTI implementations may adjust the intensity and frequency of supplemental instruction and rate of progress monitoring to best meet the unique needs of the students receiving services, instructional demands of the classroom, and meaningful knowledge of a student’s response to instruction.

Educational technology can help support RTI goals. The 2010 National Educational Technology Plan described five major goals for research

and development related to educational technology (US Department of Education 2010). These five goals relate to (1) learning, (2) assessment, (3) teaching, (4) infrastructure, and (5) productivity, and are consistent with an RTI model. For example, the plan calls for research and development exploring how technologies such as simulations, virtual worlds, games, cognitive tutors, and collaboration environments can effectively motivate learners, while assessing complex skills and providing immediate performance feedback and adaptive instruction. Motivation, frequent assessment, feedback, and adaptive instruction are a few of the components that are part of an effective instructional model, and integration of assessment and intervention described within these goals also is a critical feature of RTI.

Technology also may help facilitate formative assessment and instructional decision-making. While research shows the effectiveness of RTI approaches in enhancing student learning (see Burns et al. 2005), fidelity of implementation is a critical variable in large-scale RTI implementation (Burns n.d.; Gansle and Noell 2007; Ysseldyke 2005). Technology may ease RTI implementation barriers, thus making RTI more likely to occur (Ysseldyke and McLeod 2007).

The promise of technology lies in its affordances. A teacher teaching a class of 30 students may ask an individual student a question, allowing that student a response opportunity. Other students in the class may or may not respond covertly to the question. If the teacher asks all students to respond—for example, by holding up response cards—it is more likely that all students will respond (Gardner et al. 1994; Narayan et al. 1990). If a teacher has a student response system, all students have an opportunity to respond, and the teacher can collect, analyze, and track individual and group responses over time, allowing for a more detailed assessment of student understanding and progress (Penuel et al. 2007). Technologies can provide teachers with a response system in which all students participating in instruction can respond, receive corrective feedback, and experience adjustments to instruction to further accelerate their learning. Supplemental instructional programs providing adaptive

instruction and embedded assessment may also be used in all tiers—for example, as a supplement to core instruction in tier 1, for intervention in tier 2, and in a more focused way in tier 3 to help students gain fluency or fill skill gaps (Allsopp et al. 2010). The following sections describe some of the affordances technology can provide across tiers within an RTI model.

Technology in Tier 1 Instruction: Differentiating Instruction and Increasing Response Opportunities for All Learners

Many RTI theorists state that around 75–80% of children achieve adequate levels of competency with the core curriculum alone (i.e., tier 1). Approximately 20% of students are not successful in the core instruction despite good curriculum and generally effective instructional practices (Shapiro n.d.). Because most public schools in America do not have the resources to implement moderate-to-intensive intervention (i.e., tiers 2 and 3) to more than a quarter of the total student population, a strong core curriculum is foundational to student learning and a successful RTI implementation. Much work has been done in identifying evidence-based core curriculum programs and helping educators make informed decisions about what to use when teaching (especially in reading, see Foorman 2007; National Reading Panel—NRP 2000; Simmons and Kame'enui 2003).

Although instruction in tier 1 typically includes core instruction delivered to the whole class by the general education teacher, this instruction should be differentiated and include peer tutoring and flexible groupings (Lembke et al. 2012). However, in a review of the current state of RTI, Fuchs and Vaughn (2012) list differentiated tier 1 instruction as a continued challenge for classroom teachers. Although differentiated core instruction has been shown to reduce the number of students who require more intensive intervention and result in more proportionate representations of males, minorities, and English language learners in special education (Torgesen

2009; VanDerHeyden et al. 2007), this differentiation requires not only extensive knowledge of the subject matter but also the ability to use appropriate assessment tools to determine students' needs and effectively vary the type and intensity of instruction based on those needs. Improving instruction for primary prevention requires high instructional quality and opportunities to learn (Gerber 2005). Fuchs and Vaughn (2012) call for research and development of innovative instructional methods to improve tier 1 instruction. Given that the majority of instructional time is spent in a general education classroom, improving differentiated instruction in tier 1 has high potential for improving learning outcomes and decreasing the need for more intensive intervention.

Various forms of instructional technology have been found to influence and improve student learning in core curricula areas and general classroom instruction (Fadel and Lemke 2006; Flecknoe 2002; Gilbert 1996; Spector 2010). For example, student response systems have been found to improve student understanding and engagement, and create a more positive and interactive atmosphere (Caldwell 2007; Kay and LeSage 2009; Poole 2012). Reviews of research have generally agreed that the use of computers can increase student learning in a variety of subject areas and basic skills when combined with traditional instruction, and that students can learn more quickly and with greater retention when learning with computers. Student attitudes towards school and learning are also positively affected by the use of computers, and this use is most promising for at-risk and struggling learners (Fouts 2000).

Adaptive Instruction Across Tiers: Implementing Sound Instructional Methods and Progress Monitoring

Students who are struggling in an area also need explicit, systematic instruction with many opportunities for practice to build both accuracy and fluency. Instruction should also include cumulative and varied practice to promote retention and

transfer of skills (Gersten et al. 2009). However, several challenges to implementing these instructional methods exist. For example, explicit instruction in mathematics may include providing a variety of models for problem-solving, verbalizing thought processes in teaching procedures and problem-solving methods, and offering guided practice and corrective feedback. Often, however, instructional materials include models of only one or two simple problems and may not include enough practice and cumulative review. (see, for example, Jitendra et al. 1996). Interventionists may also provide less practice than is necessary and may not be expert enough in the mathematics content to supplement a lack of modeling and practice within the materials (Gersten et al. 2009; Ma 1999).

Adaptive instruction within each tier is important in helping students make adequate progress and reducing the number of students who are moved to a more intensive tier. This can save time and resources, while still helping each student to succeed. However, using assessment data to make instructional decisions can be challenging for many schools, and skill in using data and implementing interventions may vary considerably among teachers (Kupzyk et al. 2012).

There are increasingly prevalent research-based, technology-enhanced interventions that assess and analyze current skills, target student deficits, and allow for automated instructional delivery. For example, Burst[®]: Reading by Wireless Generation[®] helps teachers continuously match reading interventions to each student's current ability and changing needs. Wireless Generation reports that smart technology allows learning data to be analyzed behind the scenes, recommends student groupings based on similar needs, and aligns instruction for the group. Similarly, Scholastic's *Read 180*[®] intervention program includes a "Groupinator" tool that suggests optimal small groups for differentiated instruction and then links those groups to appropriate resources. These software tools enhance implementation by automatically translating student data into specific intervention recommendations that teachers can then implement, either in their own teaching or by accessing other technology

resources. Teachers can view what skills and concepts students have mastered, how much instruction was required for mastery, what areas might have caused particular difficulty, as well as the amount of time spent in instruction (or on a particular topic). Through analysis of the data, teachers can evaluate what educational materials produced the best outcomes and other behavioral and cognitive information relevant to academic performance over time. Such analytics can help educators determine the best instructional plan for groups of students, or any particular student (West 2011).

Motivation

Motivators are also important, as students who have historically had difficulty are less likely to engage in learning and practice opportunities as a result of frequent past failures (Fuchs et al. 2008). Motivators may be program extrinsic, such as awards, points, or badges for mastery or high levels of performance, and sites that purport to enhance student motivation through digital badges (such as Badgeville or Mozilla's Open Badges) or behavior management apps (such as Class Dojo), are just a few examples of motivational technology tools that may augment RTI. Motivators can also be program intrinsic. These motivators may arise from the instructional sequence and what mastery allows the learner to do in other contexts (Layng et al. 2004). For example, when an instructional sequence begins with a challenging task that a learner can do successfully, this experience of success may help the student more readily approach learning in that area (Fuchs et al. 2008). Computer-based programs that are able to continually assess and differentiate instruction (and therefore effectively align instruction with students' skill levels) may therefore promote student motivation by allowing for high rates of success in challenging tasks.

Games for learning have gained increasing attention in recent years, although games and "edutainment" have been part of educational technology for several decades. For example, the popular mathematics game Math Blaster[®] was

first introduced in 1987. The structure of rewards in games may be especially effective in increasing motivation for struggling students, and can offer a learning environment in which feedback is less threatening (Shute 2008). Although games such as this are often thought of as offering practice in lower-level skills such as mathematical facts, games can also offer instruction and practice in higher-order thinking skills and problem-solving (Rice 2007).

Technology and Reading Intervention

Research Research has provided us with relatively clear guidelines about how to effectively teach children to read. In 2000, the NRP concluded a review of more than 100,000 studies that met scientifically based research standards and examined the effectiveness of an instructional approach in early reading that could be generalizable to a large number of students. They identified, based on an extensive body of knowledge, the skills children must learn in order to read well: phonemic awareness (the ability to manipulate individual sounds), phonics (the relationship between individual written letters and individual spoken sounds), fluency (the ability to accurately and quickly read text), vocabulary (the meaning of words), and comprehension (the understanding of what is being read). These skills often form the basis of not only core reading instruction but also the more focused work of a tier 2 or tier 3 reading intervention.

Until recently, relatively few studies have thoroughly evaluated new technologies for reading and literacy education. For example, Kamil and Lane (1998) reviewed the research in two mainstream literary journals with the highest citation rates for literacy research (*Reading Research Quarterly* and the *Journal of Reading Behavior*, since changed to *Journal of Literacy Research*) during the years between 1990 and 1995 and found that only 1% of the articles discussed technology issues (also see Kamil et al. 2000). Within the past decade or more, there has been a growing number of examples of a technology assist for the five critical components of early reading instruc-

tion. Wise and Olson (1995) found that elementary students who received computer-assisted instruction in phonological awareness (by reading words in context and completing exercises involving individual words) made significant gains in phoneme awareness and word recognition. The use of screen-reading software (that converts text to digital speech) has helped improve comprehension, fluency, and accuracy and enhances concentration for special education students (Leong 1992; Lundberg and Olofsson 1993). Hearing a word spoken within the context of a passage helps students build decoding skills, word recognition, and vocabulary (Califfee et al. 1991). Text to speech (TTS) software has been found to support comprehension by allowing the listener to focus on the meaning of the text without disturbing the text flow, thus increasing the ability to read interesting or grade-level materials, while minimizing the need for decoding skills (Wise et al. 2000).

Recommendations The US Department of Education's Institute of Education Sciences assists educators in identifying and implementing evidence-based interventions to increase student-reading achievement. In their What Works Clearinghouse report *Assisting Students Struggling with Reading: Response to Intervention (RTI) and Multi-Tier Intervention in the Primary Grades*, they identified five recommendations for effective RTI reading interventions:

- Screen all students for potential reading problems early and midway into the school year. Monitor the progress of students identified as "at risk" for developing reading disabilities.
- Provide evidence-based reading instruction, differentiated for all students based on assessments of current reading levels (tier 1).
- Provide intensive, systematic, and evidence-based instruction on foundational reading skills in smaller groups to students who score below "benchmark" (target score) on screening measures (tier 2).
- Monitor individual tier 2 student progress frequently (at least monthly) and use the data to determine which students still require intervention and may be in need of a tier 3 intervention plan.

- Provide daily, intensive, evidence-based instruction on the necessary components of reading proficiency to students who are far from the benchmark or show minimal progress after small-group instruction (tier 3).

Each of these recommendations can be supported with technology. Efficient, reliable screening measures and assessments may be provided online and evaluated automatically by the software. A database of reading screening scores over time allows for analysis at the student, class, or school level across years. Patterns in scores may allow for the identification of students, teachers, curricula, or systems that increase or decrease reading ability levels. Data analysis tools can help educators make data-driven decisions, or recommend differentiated instruction for students at varied reading proficiency levels. Learning management tools can help teachers plan and schedule time, instructional content, and degree of support and scaffolding based on student needs. Web-based clearinghouses or review sites can assist teachers in identifying various materials that support critical components of reading instruction (such as phonemic awareness, phonics, vocabulary, comprehension, and fluency), and that are prearranged to build skills gradually based on what has been previously taught. Technology programs can offer a high level of student interaction, providing precisely engineered learning opportunities and individualized feedback on responses, often to several students simultaneously. Technology programs can easily collect a student's response to each interaction, and parse those data based on important characteristics such as error patterns (to identify concepts that may require more instruction) or response latency (which may indicate the concept is not yet firm or fluent).

Within the domain of reading, technology assists can be grouped on various dimensions depending on purpose:

Fundamental Skills Programs, software, or apps that reinforce fundamental skills such as letter or phoneme identification, phonics, word attack, sentence construction, or symbol recognition. They may teach, review, or practice these

types of skills in isolation or as part of a larger reading technology package.

Text-Reading/Text-to-Speech Software These programs convert written text into spoken words, with more modern technologies providing a more natural voice and cadence than available previously. Words may be highlighted in conjunction with their spoken output, or specific words may be selected for pronunciation or even definition.

Digital Text/Leveled Readers These resources allow teachers (and students) to identify books based on reading level or interest and may consist of classic literature, book summaries, study guides, picture books, or even interactive activities based on the material read. Many sites maintain a database of what has been read and provide “smart” recommendations (based on a user's individual choices and ratings), and often offer assistive technology enhancements like the ability to change text size, contrast, words per page, picture supports, and other enhancements.

Technology and Mathematics Intervention

Research Despite being a foundational skill critical for student success, the research base for effective mathematics instruction and intervention is not as extensive as that for reading (Fuchs et al. 2012; Lembke et al. 2012). For example, while reading studies have identified the critical component skills of phonics, phonemic awareness, fluency, comprehension, and vocabulary, component skills for mathematics have not been similarly identified. While it is possible that there are many more component skills required for mathematics (Fuchs et al. 2012), instruction in mathematics can be categorized in terms of three broad types of learning: conceptual, procedural, and strategic (Fuchs et al. 2008). For example, categorizing a story problem in terms of its type would be conceptual learning, carrying out the procedures to solve the problem would be considered procedural (Rittle-Johnson and Star 2009), and systematically attacking the problem—for

example, starting by reading the problem carefully and ending by checking the work—would be considered strategic (Montague 1992; Polya 2004; Whimbey and Lochhead 1984).

Interventions utilizing technology have been shown to increase skills in mathematics. For example, in a review of studies investigating the effects of software programs on mathematics achievement, Kulik (2003) reported that out of 16 controlled studies conducted, 9 had an effect size large enough to be educationally meaningful. In all of the studies, test scores were at least slightly higher for the students engaged in the computer-based programs, and the median effect for all 16 studies was 0.38 standard deviations. Although technology used to increase fluency of basic fact recall is common, technology-based intervention programs can be effectively used for much more. For example, software programs may be particularly suited to delivering instruction in multiple levels of abstraction, such as moving from more concrete representations such as virtual manipulatives to abstract numerical representations, working with interactive simulations, and providing a variety of strategically delivered examples and nonexamples for conceptual learning. Technology can also be used in a supportive role, as when calculators are used to assist students in problem-solving when they may not be fluent in mathematics fact recall (Allsopp et al. 2010).

Recommendations In the primary grades, students who struggle with mathematics often have difficulty with number combinations (particularly in automatic retrieval of mathematical facts) and story problems. Also, although procedural instruction in mathematics is very common, conceptual instruction is often neglected (Fuchs et al. 2008). In the What Works Clearinghouse report *Assisting Students Struggling with Mathematics: Response to Intervention (RTI) for Elementary and Middle Schools*, eight recommendations were identified for effective RTI mathematics interventions:

1. Screen all students to identify those at risk for potential mathematics difficulties and provide interventions to students identified as at risk.

2. Focus on whole numbers in kindergarten through grade 5 and on rational numbers in grades 4–8.
3. Provide explicit and systematic instruction. This includes providing models of proficient problem-solving, verbalization of thought processes, guided practice, corrective feedback, and frequent cumulative review.
4. Include instruction on solving word problems based on common underlying structures.
5. Include opportunities for students to work with visual representations of mathematical ideas.
6. Devote about 10 min in each session to building fluent retrieval of basic arithmetic facts.
7. Monitor the progress of students receiving supplemental instruction and other students who are at risk.
8. Include motivational strategies in tier 2 and tier 3 interventions.

Each of these recommendations can be supported with technology.

Screening and Intervention Several programs are available for mathematical assessment and intervention, and software increasingly integrates assessment and instruction. For example, Wireless Generation®'s mCLASS® Mathematics formative assessment tool offers screening, diagnostic interviews, and progress monitoring tools as well as offering guidance on instructional interventions based on assessment results. Dreambox® Learning offers continuous adaptive instruction by tracking each mouse click within the program, using the data to identify student strategies, and adjusting instruction accordingly. As educational data mining and learning analytics continue to advance and grow more robust, the use of technology for continuous assessment and adaptive instruction will likely become more ubiquitous in educational technology products. (Bienkowski et al. 2012).

Explicit and Systematic Instruction Systematic instruction refers to the particular skills that are taught and the order in which they are taught, while explicit instruction refers to how those skills are taught (Kupzyk et al. 2012). Explicit

and systematic instruction may include instructional techniques such as modeling, including think-aloud models of problem-solving, guided practice, corrective feedback, and frequent review (Gersten et al. 2009). Systematic instruction teaches component skills before those component skills are used in a more complex skill, building knowledge and skills in a logical order (Kupzyk et al. 2012). The sequence of instruction can also help to minimize learning challenges. For example, Fuchs et al. (2008) described an instructional sequence that began with what students already knew or could easily do for early success and then introduced new concepts and strategies as they became necessary and broadly applicable.

Several challenges exist to providing explicit and systematic instruction, and these are challenges that educational technology can help meet. For example, many instructional materials offer only a few models of problem-solving (Jitendra et al. 1996) and teachers or interventionists may not have the expertise in the subject matter necessary to provide additional models or talk through different strategies that could be used for problem-solving (Ma 1999). In addition, materials may lack appropriate levels of practice and review, particularly for students who are struggling (Gersten et al. 2009).

CBI programs that are developed based on a systematic and thorough analysis of the content and are able to analyze student errors can support teachers and interventionists by providing clear and varied models and carefully juxtaposed examples and nonexamples, can assess student strategy use and provide think-aloud models of the strategies. Finally, programs based on a mastery framework can provide practice and review based on learner performance, allowing those who have mastered the skills and strategies to move on, while providing more practice and review opportunities to those students who need them. It is important for companies developing educational software to take these instructional elements into account in the design of the program and for educators to evaluate potential software programs for these elements.

Instruction on Solving Word Problems Based on Common Underlying Structures Conceptual instruction is an important but often neglected aspect of mathematics instruction. Instruction should teach the underlying structure of different problem types, how to categorize problems based on their structure, and how to solve problems with a particular structure. However, instructional materials may not arrange instruction in a way that allows for classification of problem types and more complex problems are more difficult to classify (Gersten et al. 2009).

Although studies have shown the importance of conceptual instruction for word problems (see for example, Jitendra et al. 1998; Xin et al. 2005), conceptual instruction is not limited to word problems. For example, in her study comparing mathematics teachers' content knowledge in China and the USA, Ma (1999) described conceptual foundations of elementary mathematics. A purely procedural approach to subtracting two-digit numbers with regrouping would teach only the steps themselves, such as "borrowing" a ten from the tens column, adding ten ones to the ones column, and then subtracting. A conceptual approach, however, would teach fundamental concepts and principles that underlie the reasoning behind this algorithm, such as the meaning of place value and composing (and decomposing) a higher value unit.

Just as in providing explicit and systematic instruction, CBI programs can be developed to include instruction in a problem's underlying structure and practice categorizing and solving problems with different structures. In addition, programs can be developed to teach fundamental concepts and principles of mathematics and integrate conceptual and procedural instruction. However, it is important for companies developing programs to include this type of instruction and important for educators to look for these elements when evaluating educational software.

Opportunities For Students to Work With Visual Representations of Mathematical Ideas Mathematical ideas can be represented in a number of ways. Instructional programs should include

work with concrete manipulatives, visual representations, as well as abstract symbols, and include consistent language across representations. However, working with different representations can be difficult in a classroom, and some interventionists may not have the content expertise to fully understand different representations—particularly for negative numbers, fractions, and proportional reasoning (Gersten et al. 2009). Ma (1999), for example, reported that most teachers she interviewed said they would use manipulatives in teaching subtraction with regrouping. However, when the teachers did not have strong content knowledge, the use of manipulatives was not directly related to the concept and therefore are not useful in teaching the skill. For example, two teachers suggested using counters such as beans in learning subtraction with regrouping. If the problem was $23-17$, they would start with 23 beans and have students take away 17 beans. Although taking beans away illustrates subtraction, the students already understood subtraction, and the goal of the lesson is to teach the process of regrouping. Using manipulatives in the way that teachers described does not help students understand decomposing a higher-value unit in a base-ten system which is the key concept underlying regrouping. In fact, showing a child 23 beans and then asking the child to remove 17 to illustrate subtraction with regrouping makes no sense as an instructional strategy because it makes regrouping unnecessary altogether.

The visual and interactive nature of computer-based programs affords movement among representations and may be able to offer this type of instruction more easily and systematically than a teacher or interventionist. The National Library of Virtual Manipulatives (<http://nlvm.usu.edu/en/nav/vlibrary.html>) offers a variety of web-based virtual manipulatives in the form of Java applets, and virtual manipulatives are included in more extensive mathematics programs such as Dreambox[®] Learning.

Fluency Building Computer-based programs such as MathBlaster[®] have been offering opportunities for practice to build fluency for decades.

Practice opportunities that are “gamified” can help to increase student motivation to practice. ExploreLearning’s Reflex Math, for example, offers adaptive and individualized fluency practice with fact families in a game-playing context.

Limitations and Concerns of Technology-Based Interventions

Technology faces the same array of limitations that has plagued almost every innovation or major change impacting education. Factors such as an understanding of the purpose of the change, the need for properly trained staff, leadership and support for the change, and ongoing funding are fundamental for any successful change in schools. Ertmer (1999) grouped barriers to implementation into two broad categories: First-order barriers having to do with infrastructure such as access, time, training, support, and resources, and second-order barriers having more to do with the culture of the school and the individuals within it, such as attitudes, beliefs, practices, history of change, and resistance to change. These barriers and limitations, as well as potential solutions, are not endemic to an RTI technology implementation and have been comprehensively addressed elsewhere (see Barron et al. 2003; Earle 2002; Gülbahar 2007; Hope 1997; Leggett and Perschitte 1998; Lumley and Bailey 1993; Sheingold and Hadley 1990). Interested readers are encouraged to consult these resources.

Technology implementations may face additional barriers. Teaching (and learning) is viewed by many as a human, interpersonal endeavor, requiring an attention to the quality of the interaction and its attitudinal effects (O’Neal 1991). Technology is prevalent in every aspect of life, especially among youth, thus perhaps making learners more at ease with its use than teachers. Because technology is evolving so rapidly, knowledge and skills learned in one year may be obsolete in three to seven years, the amount of time research has shown it takes for an “implementation” to take hold and reap sustainable rewards (Fixsen et al. 2005). In addition to being facile in current technology uses, education

policy-makers, curriculum specialists, technology specialists, school administrators, as well as those who develop technology products and services are required to “stay ahead of the curve” in order to properly prepare for changes ahead.

Perhaps the greatest overarching limitation to the successful use of technology in the classroom is educators’ ability to find and effectively use technology to meet their teaching or their students’ learning needs. The number of apps, tools, and resource sites, as well as commercial or enterprise technology programs from established educational publishers is huge, and continues to grow. In just under 2 years, from September 2009 to July 2011, the number of free apps in the Education category of Apple’s® iTunes® Store grew 369%, from 866–3202. Paid educational apps grew by 202%, from 4453 to 9013 (Gammon 2011). In 2012, almost three-quarters (72%) of the top selling iTunes apps targeted preschool or elementary-aged children. Within the highly saturated games category, 32% of apps stated an intended learning objective or made a claim of educational benefit (Shuler 2012). While the data are not readily available for the Android/Google app market, it can be expected that a similar growth trend is occurring. Teachers, curriculum specialists, technology specialists, and administrators must become “educated consumers” in the technology marketplace. With so many tools and programs available, sifting through the myriad of resources is a daunting task. Rubrics, guides, or checklists of necessary or notable characteristics of good technology can be helpful in determining what to use, when, and with whom. Such tools can help educators decide a technology’s degree of:

- Relevance (Is there a strong connection between the learning goals or needs and the purpose of the technology?)
- Appropriateness (Does the technology fit the age, abilities, interest level of the learner—or educator?)
- Feedback (Does the technology let the user know when they are doing well, or provide additional help when needed?)
- Customization (Does the technology offer flexibility to alter content and settings to meet user needs?)

- Personalization (Does the technology adapt to learner needs—and interests?)
- Engagement (Does the technology increase efficient instructional time or capture learner interest?)
- Critical thinking (Does the technology encourage or support higher-order thinking skills including evaluating, analyzing, or creating?)
- Communication (Does the technology support the sharing of information or data?)

Appendices A–F provide examples of evaluation rubrics that may help educators determine the best use of certain technologies or tools. Rubrics may focus on different issues and should be carefully selected based on the context of the technology use. Some are relatively simple, like the “yes/no” checklist used in critical evaluation of an iPad/iPod App (Appendix A), while others present criteria aligned to Common Core Standards (e.g., Appendix D. Mobile Application Selection Rubric). Evaluate Apps for Special Needs, as the name implies, provides specific criteria for selecting apps to use with students with disabilities (see Appendix E). Evaluating the technology-learning environment is also important, as shown in the Arizona Technology Integration Matrix designed to help teachers to assess their own level of technology integration across learning environments (see Appendix F).

Issues for Future Research

Technology is constantly evolving, with new and innovative uses occurring all the time. The rate of technology change is accelerating exponentially (see Kurzweil 1999) across all areas of human endeavor, including education. Because of this rapid change, researchers have described their work with regard to educational technology as akin to chasing a “moving target” (Valdez et al. 1999, p. 1). Even as work is being conducted on the effects or implications of any particular educational technology, that technology itself is changing. While this evolving nature of educational technologies may hamper efforts to predict the success of, and establish guidelines for, subsequent educational practices (Leu 2000), many

of the issues related to technology use remain constant. Factors such as the need for properly trained staff, sufficient equipment, and ongoing funding are essential for any successful integration of technology to increase learning.

Teachers, Technology, and Schooling Systems

One of the most pivotal factors in the successful implementation of education technology is the teacher. Technology integration has moved beyond a handful of barely used, outdated computers in the back of the classroom or once or twice weekly class-wide forays into the computer lab to almost full-time integration of hardware, software, and Internet-access across all activities throughout the school day. When one considers that less than two decades ago barely half of our nation's teachers had Internet access at home (Becker et al. 1999), the technical savvy required of today's teachers might seem insurmountable. Expertise must surpass a basic understanding of hardware and software, and move into knowledge of the purposes of various software tools and how to use productivity tools, while following curriculum standards and adopting or maintaining a learner-centered perspective. Sang and colleagues (Sang et al. 2010) found that few teachers feel confident and competent in the goals and use of computer-based education in their classrooms. Even in classroom environments where technology is frequently used, researchers have found more emphasis on giving students access to information outside the classroom or on increasing student motivation, and less focus on how computers could improve specific academic achievement (Jostens Learning Corporation 1997) or be integrated with the curriculum or learning standards (Niess 1991; Trotter 1997).

The US Office of Technology Assessment reports one of the greatest roadblocks to integrating technology into a school's curriculum is the lack of teacher training, finding that most school districts spend less than 15% of their technology budgets on teacher training and development (US Congress, Office of Technology Assessment 1995). Ensuring understanding of pedagogical implications of technology integration is essential (Gilbert 1995; Watts and Hammons

2002). Instructional or educational technology should not be viewed as an add-on to teaching, but "integral to teaching practice" (Chism 2004, p. 43; see also Bates and Poole 2003; Grasha and Yanbarger-Hicks 2000) and critical to quality implementation (Shields and Behrman 2000). To be educated consumers of technology products, teachers must learn to select technologies that improve "the quality of teaching and learning [and] student motivation" (Gilbert 1996, p. 12), and research suggests that teachers who receive professional development focused on integrating technology into teaching may use the technology more effectively (Penuel et al. 2007).

In fact, all members of an educational ecosystem would benefit from increased understanding of effective uses of technology. "Digital media literacy continues its rise in importance as a key skill in every discipline and profession" (Johnson et al. 2011, p. 3). All educators need to be comfortable in evaluating technology resources for their students' and their own needs. They should be able to evaluate content, determine if it is culturally unbiased, current, appropriate to the curriculum standards, and respectful of student interest. Perhaps the most important quality is in understanding the educational goal before technology is selected or implemented, including a clear provision of how to seamlessly integrate the software into lesson strategies (Roblyer and Edwards 2000). As noted by Fullan (2000):

Technology generates a glut of information, but it has no particular pedagogical wisdom—especially regarding new breakthroughs in cognitive science about how learners must construct their own meaning for deep understanding to occur. This means that teachers must become experts in pedagogical design. It also means that teachers must use the powers of technology, both in the classroom and in sharing with other teachers what they are learning. (p. 582)

Educational Technology Development Educational interventions and the companies who design and develop them should also be held to a high-quality standard in terms of student learning and engagement. As previously mentioned, good instructional design requires a systematic design process. That process should include

iterative design and development with formative evaluation (Tiemann and Markle 1990; see also Dick and Carey 1996; Smith and Ragan 1999; Twyman et al. 2004). How a product is developed—whether it is developed based on best practices, evaluated for effectiveness after development (summative evaluation), or empirically tested during the design and development process (formative evaluation) should be considered when evaluating evidence of effectiveness (Twyman and Sota 2008).

Why Technology? What Technology Should Do.

By harnessing the power of digital and hardware advances merged with new knowledge and processes, we can further advance student learning and improve school outcomes. Using technology to assist teaching and learning may have started with stone carvings, papyrus, and the quill pen, progressed through the ages with the use of pencils, chalkboards, slide projectors, and TVs, and is now accelerating through the use of personal computers, laptops, tablets, and the power of the Internet and applications that leverage its reach and scale.

As noted, there is a strong literature base suggesting technology can improve instruction. However, the authors of this chapter and others (see Earle 1994; Fullan 2000; Rumph et al. 2007; Skinner 1968) suggest that it is not the “technology” (in this case hardware or software) itself that affects instruction, it is the philosophical underpinnings on which it is based *and* how it is used that influences its effectiveness. As noted by Wager (1992) “the educational technology that can make the biggest difference to schools and students is not the hardware, but the process of designing effective instruction” (p. 454). At least there is a fairly robust list of teaching and learning strategies with a strong evidence-base, across populations and subject matter, that have been shown to reliably improve learner outcomes (see Embry and Biglan 2008; Greer 2002; Lovitt 1994; Hattie 2008; Wolery et al. 1988). Any meaningful use of technology must support, aug-

ment, make easier, or make possible the myriad of things that we know empirically make a difference in children’s lives. Any innovative use of technology must enable us to do important things that were not possible before.

Implications for Practice

At the District Level

Carefully consider, design, implement, and frequently review a district-wide technology plan:

- Improve organizational effectiveness by offering district-wide coordination and training to improve communication, planning, and record keeping.
- Purchase technology that supports greater efficiencies (i.e., doing more with less).
- Provide adequate equipment with plans for necessary upgrades.
- Plan for and support the integration of tools across sites.
- Plan for and support a common database.
- Plan for district-level interim assessments that support routine evaluation of instructional programs, and that provide credible, actionable data linked to relevant instructional resources.
- Align staff development with the district/school’s technology goals.

At the School Level

- Encourage/support collaborative meetings by grade-level or subject matter to discuss planning and outcomes of technology-based instruction.
- Provide training and support in using student data and data systems to make instructional decisions.
- Conduct test runs of technology applications before widespread staff or student use (to identify any roadblocks or problems and avoid wasting valuable learning time).
- Plan for ongoing staff training to make effective use of the technology available.

- Provide professional development opportunities that are individualized to the teacher's level of expertise and experience and that focus on integrating technology into instruction.
- Identify model classrooms or peer mentors to allow other educators to see how various technologies can be integrated in teaching and learning.
- Provide peer coaching and mentor modeling to help the transition from knowing about (workshop information) to knowing how (classroom application and practice).
- Provide ongoing teacher support and opportunities for teachers to practice what they have learned (or to continue their learning).
 - Save time in administering and scoring quizzes
 - Incorporate individualized adaptive instructional programs as part of whole-class instruction as well as for intervention
- Use supplemental programs to provide additional practice opportunities.
- Consider using evidence-based educational games to increase student motivation and engagement.
- Select and use educational technology products for their affordances in terms of student interaction, engagement, and assessment (for example, use an interactive whiteboard to increase student interaction and not simply to present information).

At the Classroom/Teacher Level

- Use online tools that provide frequent or ongoing assessment to quickly understand what students know.
- Use frequent or ongoing measurement to tailor instruction to meet individual learning needs.
- Use active student response measurement systems to:
 - Check for real-time student understanding of content being taught
 - Display responses of the group and also occasion discussion and reflection
 - Gather formative data to guide instruction

At the Parent, Community Level

- Request openness and accountability, with verification of student benefit from expenditures.

At the Teacher/Administrator Pre-Service Level

- Emphasize the integration of technology into teaching, including offering courses on digital media pedagogy and literacy.

Appendix A. Critical Evaluation of an iPad/iPod App: Kathy Schrock

Name: _____ Date: _____

CRITICAL EVALUATION OF AN CONTENT-BASED IPAD/IPOD APP



©2011-12. Kathleen Schrock (kathy@kathyschrock.net)
iPads in the Classroom site: <http://linky.com/ipad>

What is the title of the app? _____ Cost: _____

Creator of the app _____ iTunes URL: _____

Content area(s): _____ Grade level(s): _____

Content and components of the app	YES	NO
Curriculum connection: Are the skills reinforced connected to targeted skill/concept?	<input type="checkbox"/>	<input type="checkbox"/>
Authenticity: Are skills practiced in an authentic format/problem-based environment?	<input type="checkbox"/>	<input type="checkbox"/>
Feedback: Is feedback specific and result in improved student performance?	<input type="checkbox"/>	<input type="checkbox"/>
Differentiation: Does the app offers flexibility to alter settings to meet student needs?	<input type="checkbox"/>	<input type="checkbox"/>
User friendliness: Can students launch and navigate within the app independently?	<input type="checkbox"/>	<input type="checkbox"/>
Student motivation: Are students motivated to use the app and select it to use often?	<input type="checkbox"/>	<input type="checkbox"/>
Reporting: Is assessment/summary data available electronically to the student/teacher?	<input type="checkbox"/>	<input type="checkbox"/>
Sound: Does the music/sound in the app add to the educational aspects of the content?	<input type="checkbox"/>	<input type="checkbox"/>
Instructions: Are the instructions included within the app helpful to the student?	<input type="checkbox"/>	<input type="checkbox"/>
Support page: Does the app's supporting Web page provide additional useful information?	<input type="checkbox"/>	<input type="checkbox"/>

Level(s) of Bloom's Taxonomy addressed with this app (check all that apply)

- Remembering Understanding Applying Analyzing Evaluating Creating

Summary of the app									
Using the data you have collected above, explain why you would or would not recommend this application for use in the classroom. Include any specific ideas you have for its use.									
iTunes Application Ratings (click on ratings while in the App Store to learn more)	<table border="1"> <tr> <td>4+</td> <td><input type="checkbox"/></td> <td>9+</td> <td><input type="checkbox"/></td> <td>12+</td> <td><input type="checkbox"/></td> <td>17+</td> <td><input type="checkbox"/></td> </tr> </table>	4+	<input type="checkbox"/>	9+	<input type="checkbox"/>	12+	<input type="checkbox"/>	17+	<input type="checkbox"/>
4+	<input type="checkbox"/>	9+	<input type="checkbox"/>	12+	<input type="checkbox"/>	17+	<input type="checkbox"/>		

Appendix B. Educational App Evaluation Rubric: Tony Vincent

App Name: _____

Educational App Evaluation Rubric

Purpose for App: _____

	4	3	2	1
Relevance	The app's focus has a strong connection to the purpose for the app and appropriate for the student	The app's focus is related to the purpose for the app and mostly appropriate for the student	Limited connection to the purpose for the app and may not be appropriate for the student	Does not connect to the purpose for the app and not appropriate for the student
Customization	App offers complete flexibility to alter content and settings to meet student needs	App offers some flexibility to alter content and settings to meet student needs	App offers limited flexibility to adjust content and settings to meet student needs	App offers no flexibility to meet student needs
Feedback	Student is provided specific feedback	Student is provided feedback	Student is provided limited feedback	Student is not provided feedback
Thinking Skills	App encourages the use of higher order thinking skills including creating, evaluating, and analyzing	App facilitates the use of higher order thinking skills including evaluating, analyzing, and applying	App facilitates the use of mostly lower order thinking skills like understanding and remembering	App is limited to the use of lower order thinking skills like understanding and remembering
Usability	Student can launch and operate the app independently	Student needs to have a teacher show or model how to operate the app	Student needs to be cued each time the app is used	App is difficult to operate or crashes often
Engagement	Student is highly motivated to use the app	Student uses the app as directed by the teacher	Student perceives app as "more schoolwork" and may be off-task when directed to use the app	Student avoids the use of the app and might complain when its use is required
Sharing	Specific performance summary or student product is saved in app and can be exported to the teacher or for an audience	Performance data or student product is available in app but exporting is limited and may require a screenshot	Limited performance data or student product is not accessible	No performance summary or student product is saved

Appendix C. Educational App Evaluation Checklist: Tony Vincent

Educational App Evaluation Checklist

App Name:
Purpose for App:

✓	Use of app is relevant to the purpose and student needs
	Help or tutorial is available in the app
	Content is appropriate for the student
	Information is error-free, factual, and reliable
	Content can be exported, copied, or printed
	App's settings and/or content can be customized
	Customized content can be transferred to other devices
	History is kept of student use of the app
	Design of app is functional and visually stimulating
	Student can exit app at any time without losing progress
	Works with accessibility options like VoiceOver and Speak Selection
	App is free of charge
	No in-app purchases are necessary for intended use of app
	App loads quickly and does not crash
	App contains no advertising
	App has been updated in the last 6 months
	App promotes creativity and imagination
	App provides opportunities to use higher order thinking skills
	App promotes collaboration and idea sharing
	App provides useful feedback
Total ✓s	<i>The more checks, the better the app is for education</i>

Educational App Evaluation Checklist

App Name:
Purpose for App:

✓	Use of app is relevant to the purpose and student needs
	Help or tutorial is available in the app
	Content is appropriate for the student
	Information is error-free, factual, and reliable
	Content can be exported, copied, or printed
	App's settings and/or content can be customized
	Customized content can be transferred to other devices
	History is kept of student use of the app
	Design of app is functional and visually stimulating
	Student can exit app at any time without losing progress
	Works with accessibility options like VoiceOver and Speak Selection
	App is free of charge
	No in-app purchases are necessary for intended use of app
	App loads quickly and does not crash
	App contains no advertising
	App has been updated in the last 6 months
	App promotes creativity and imagination
	App provides opportunities to use higher order thinking skills
	App promotes collaboration and idea sharing
	App provides useful feedback
Total ✓s	<i>The more checks, the better the app is for education</i>

This checklist is based on one originated by Palm Beach County Schools & Edumatic.com

Appendix D. Mobile Application Selection Rubric: eSkillsLearning

Mobile Application Selection Rubric

	WELL MEETS NEED	ADEQUATELY MEETS NEED	DOES NOT MEET NEED	COMMENTS
Aligned to Common Core Standards (CCS)	Documentation aligns app to CCS	App is loosely tied to CCS	App is not aligned to CSS	
Content presents in random order	Content is randomized; every game is new	App has several levels; Students will recognize game after play	App can be played once; same content repeated	
Engaging	Students will definitely like this	Students will probably like this	Students will not enjoy this	
Levels of difficulty	App will meet needs of all classroom groups	App has more than one level of difficulty	App has one level of difficulty	
Meets my students' needs	Students really need this content	App will be fun for students, but not generally needed	Students don't need this content	
Platform matches school equipment	App works with existing technology	App will work with some of school's technology	App isn't formatted to work with school's technology	
Research-based	Research-base is included with the app	Seems like there may be research to support this; I will need to find it	No research base for this app	
Scholastic presentation	App is very academic; supports serious learning	App isn't academic but has some learning value	App is a cute, fun game but little academic value	
Self-correcting	Feedback is provided; student either repeats work or is given instruction for learning	Feedback indicates right/wrong answer, then game proceeds	No feedback is provided	
Various modes of play	App allows for multiple players as well as play for different needs	App may be only used with a group	Single player only	



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Candler, NC 28715
Toll Free (800) 638-6470

Appendix E. Evaluate Apps for Special Needs: Jeannette Van Houten

Evaluate app Rubric				
Goal: What goal from students IEP/504 does this app need to support?				
Name of App:				developer
Content / Topic				developer Website:
Date reviewed	Version:			Last up date:
Review by:				Date:
				Cost:
Domain	1 Weak Quality	2 Quality	3 Good Quality	4 High Quality
Curriculum Connection	Does not meet expectation	Limited or narrow scope of the topic. Under developed.	Skills or concept are practiced and reinforced. Limited level of consideration.	Very strong connection to the skill or concept being practiced. Levels of consideration offered.
Type of Skills practices	No skill practice only "flashcard" drill	Skills are practiced in gaming format.	Simulated learning environment (virtual tasks). Scaffolds activities (Beginner - Advance)	Problem based learning with simulated environment. Program monitors and advances difficulty.
Age and Grade Level	Level is not appropriate for audience. Not suitable for age or grade level. Directions are incomplete or inadequate	Level is often too easy or difficult for target audience. Features unsuitable material. Directions are unclear.	Level is appropriate but some portions maybe to easy or difficult. Most directions are clear but some are confusing.	Level is appropriate for target audience (age and grade). Directions are clear and complete.
Languages	More than one language	2-3 languages	4-5 languages	6 or more languages
Adjustable levels	Only 1 level	2 -3 levels	4-5 levels	More than 5 levels
Prompts	No feedback offered moves forward with correct or incorrect responses	Prompt is limited to indicating wrong answer. Student needs to get it right to move forward	Prompt is specific - pre-set number of tries (can't edit) before student moves forward	Prompt is specific - can set number of tries - there is a tutorial to help student
Ease of Use	Very difficult to use. Limited or no instructions. Student needs support on every use	Student needs to be cued through the process.	Student needs support (model) from adult or another peer	Intuitive student can figure out independently
Engagement	Does not meet expectation	Held the individual attention for more than 2-3 minutes	Held the individual attention for more than 5 minutes	Held the individual attention for more than 10 minutes
Sub total				
Domain	1 Weak Quality	2 Quality	3 Good Quality	4 High Quality
Customization	None	Can turn prompts off and music	Add your own items and prompts	All features are customizable including fonts.
Alternative Access	Has no access to alternative sources	Specific interface access and works consistently	App works with at least 2 access tools works consistently	App works with 3 or more access tools. Is consistent.
Data Collected	No data offered.	Data is collected in percentage only. Data cannot be printed or stored.	Data is collected. Number of correct against total attempts. Can be printed.	Data is collected. Number of correct and incorrect responses against total attempts. Can be stored and printed.
National Curriculum	No			Yes
Gender Neutral	No			Yes
When was the app updated	a year or more	within the last 9 months	within the last 6 months	within the last 3 months
Sub total from this page 1		Sub total from this page		TOTAL /14
Count the total of points divide by 14				
Rating:	Suitable for specific use	Satisfactory	Highly recommend	Exceeds expectations
Strengths of the APP:				
Weakness of the APP:				
Skills individual needs to have or learn before use:				
Alternative apps to consider				
<small>Copyright © 2011. Jeannette Van Houten. Adapted from H. Walker for special education app selection. This document and translations of it may be copied and furnished to others, and derivative works that comment on or otherwise explain it or assist in its implementation may be prepared, copied, published and distributed, in whole or in part, modified without restriction of any kind, provided that the above copyright notice and this paragraph are included on all such copies and derivative works. jvanhoutenatp@gmail.com Modified on 2-4-12</small>				

Appendix F. AZ Technology Integration Matrix



What is the Arizona Technology Integration Matrix?

The Technology Integration Matrix (TIM) illustrates how teachers can use technology to enhance learning for K-12 students. The TIM incorporates five interdependent characteristics of meaningful learning environments: active, constructive, goal directed (i.e. reflective), authentic, and collaborative (Jonassen, Howland, Moore, & Marra, 2003). The TIM associates five levels of technology integration (i.e., entry, adoption, adaptation, infusion, and transformation) with each of the five characteristics of meaningful learning environments. Together, the five levels of technology integration and the five characteristics of meaningful learning environments create a matrix of 25 cells.

What is in each cell?

Within each cell of the Matrix, one will find two lesson plans with a short video of each lesson. Each lesson is designed to show the integration of technology in instruction and classrooms.

How should the Technology Integration Matrix be used?

The TIM is designed to assist schools and districts in evaluating the level of technology integration in classrooms and to provide teachers with models of how technology can be integrated into instruction in meaningful ways.

What is the history behind the tool?

The Technology Integration Matrix (TIM) was adapted from the Florida Technology Integration Matrix and developed through American Recovery and Reinvestment (ARRA) funds, which were administered by the Arizona Department of Education through the Pima County School Superintendent's Office. The goal of the Arizona TIM is to help provide a resource of technology integration in the classroom. Basic technology skills and integration of technology into the curriculum go hand-in-hand to form teacher technology literacy. Encouraging the seamless use of technology in all curriculum areas and promoting technology is essential in today's 21st Century Classroom. The Arizona TIM can help support the full integration of technology in Arizona's schools.

What are the next steps for developments with the Matrix?

We know that technology changes at a rapid pace. It is our intent that the TIM be a living document with additional lesson plans and videos added in the coming months and years. Districts and schools will be encouraged to use the TIM in the context of technology integration goal development and associated professional development planning. Through regular classroom observation and targeted professional development activities, it is our hope that, over time, teachers will be able to effectively monitor their progress through a continuum of technology integration levels.

Appendix F. AZ Technology Integration Matrix, cont.

→ Levels of Technology Integration into the Curriculum

Characteristics of the Learning Environment ↓	Technology Integration Matrix	Entry Teacher uses technology to deliver curriculum content to students.	Adoption Teacher directs students in the conventional use of tool-based software. If such software is available, this level is recommended.	Adaptation Teacher encourages adaptation of tool-based software by allowing students to select and modify a tool to accomplish the task at hand.	Infusion Teacher consistently provides the infusion of technology tools with understanding, applying, analyzing, and evaluating learning tasks.	Transformation Teacher cultivates a rich learning environment, where blending choice of technology tools with student-initiated investigations, discussions, compositions, or projects, across any content area, is promoted.
Active Students are actively engaged in educational activities where technology is a transparent tool used to generate and accomplish objectives and learning.	Active: Entry Students receive content through the use of technology or use technology for drill and practice type activities.	Active: Adoption Students occasionally use specified technology tools to plan or create end products.	Active: Adaptation Students choose or modify the technology-related tools most appropriate for developing learning tasks.	Active: Infusion Students focus on learning tasks, and purposefully combine technology tools to design desired outcomes based on their own ideas.	Active: Transformation Students seamlessly organize the learning tasks and formulate products, discussions, or investigations using any appropriate technologies available.	
Collaborative Students use technology tools to collaborate with others.	Collaborative: Entry Students primarily work alone in highly structured activities, using technology.	Collaborative: Adoption Students are allowed the opportunities to utilize collaborative tools in conventional ways.	Collaborative: Adaptation Students have opportunities to select and employ technology tools to facilitate and enhance collaborative work.	Collaborative: Infusion Students select technology tools to facilitate and enhance collaboration in all aspects of their learning.	Collaborative: Transformation Students seamlessly use technology tools to globally collaborate with peers and experts.	
Constructive Students use technology to understand content and add meaning to their learning.	Constructive: Entry Technology used to deliver information to students.	Constructive: Adoption Students begin to use constructive technology tools to build upon prior knowledge and construct meaning.	Constructive: Adaptation Students have opportunities to choose and manipulate technology tools to assist them in molding their understanding.	Constructive: Infusion Students make connections with technology tools to construct deeper understanding across disciplines.	Constructive: Transformation Students use technology to construct, share, and publish new knowledge to an appropriate audience.	
Authentic Students use technology tools to solve real-world problems meaningful to them, such as digital citizenship.	Authentic: Entry Students use technology to complete assigned activities that are generally unrelated to real-world problems.	Authentic: Adoption Students are allowed opportunities to employ technology tools to connect content-specific activities that are based on real-world problems.	Authentic: Adaptation Students have opportunities to select and utilize the appropriate technology tools and digital resources to solve problems based on real-world issues.	Authentic: Infusion Students select appropriate technology tools to complete authentic tasks across disciplines while modeling digital etiquette and responsible social interactions.	Authentic: Transformation Students participate in meaningful projects that require problem-solving strategies, and facilitate global awareness, through the utilization of technology tools.	
Goal Directed Students use technology tools to research data, set goals, plan activities, monitor progress, and evaluate results.	Goal Directed: Entry Students receive directions, guidance, and feedback from technology, rather than using technology tools to set goals, plan activities, monitor	Goal Directed: Adoption From time to time, students have the opportunity to use technology to either plan, monitor, or evaluate an activity.	Goal Directed: Adaptation Students have opportunities to select and modify the use of technology tools to facilitate goal-setting, planning, monitoring, and/or evaluating specific activities.	Goal Directed: Infusion Students use technology tools to set goals, plan activities, monitor progress, and evaluate results throughout the curriculum.	Goal Directed: Transformation Students engage in ongoing metacognitive activities, with reflection or connected purpose, supported by technology tools.	

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