Using Apple Technology to Support Learning for Students with Sensory and Learning Disabilities

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Introduction

The science of learning seeks to understand the relationship between brain development, social interaction, and learning by drawing on the fields of psychology, neuroscience, machine learning, and education.[1] This research holds great promise for improving our teaching practices for all students and helping us develop more effective approaches to teaching children with sensory and learning disabilities.

Many of the universal design features built into Apple hardware and software offer simple but powerful ways to support diverse learners' needs, both in classrooms and at home. This white paper provides an overview of educational technology policy and practice with concrete examples of how teachers, students, and parents can use Apple technology to make a difference for students with sensory and learning disabilities.

Educational Technology Today

Technology is regularly integrated into educational programs and practice to facilitate learning for students of all abilities across all grade bands. As specialized features are offered within mainstream products, students with disabilities are increasingly able to interact with classroom technologies and teachers are increasingly able to customize content for varying students' needs or preferences. Moreover, new technology uses and educational applications specifically for students with disabilities emerge daily from researchers, curriculum developers, teachers, parents—and even students themselves. These factors are contributing to a national dialogue on changes in policies and instructional methodologies that can affect when and how technology is used in special education.

Policy background

The 2004 reauthorization of the Individuals with Disabilities Education Act (IDEA) details the requirements and resources for special education services in the United States. The following categories of disability can qualify a student for special education services:

- Autism
- Deaf-blindness
- Deafness
- Emotional disturbance
- Hearing impairment
- Mental retardation
- Multiple disabilities
- Orthopedic impairment
- Other health impairment
- Specific learning disability
- Speech or language impairment
- Traumatic brain injury
- Visual impairment

The IDEA requires Individualized Education Program (IEP) teams, which include parents, to review and recommend assistive technologies (ATs) and determine required accommodations for an individual student. This includes specialized technologies required for students with sensory or learning disabilities to access or produce printed materials, interact with classroom content, or communicate with their teachers and peers.

Many more students, however, could benefit from more deliberate use of new features built into today's technologies. Currently, the largest number of students receiving special education services are in the "specific learning disability" category. This growing student population experiences difficulty in oral expression, written expression, listening comprehension, basic reading skills, reading fluency skills, reading comprehension, mathematics calculation, or mathematics problem solving. For many students, these learning difficulties will remain lifelong challenges, but others will develop compensatory skill sets or successful coping strategies. Technology use can be a key factor for some students in turning a learning *disability* into a learning *difference*.

The 2002 reauthorization of the Elementary and Secondary Education Act—better known as No Child Left Behind (NCLB)—stresses ongoing assessment to identify and remediate the academic performance of underachievers and at-risk students before they fail and potentially become eligible for special education services. NCLB gave rise to a new paradigm for instructional practice embodied in the Response to Intervention (RTI) model. RTI programs utilize benchmark assessments to identify struggling students and then deliver tiered interventions designed to improve

academic performance as documented by progress monitoring. Many states, districts, and school programs are implementing RTI models that call for classroom implementation of differentiated instruction. Consequently, administrators, specialists, teachers, parents, and students are eager for personalized and efficient methods to access information and interact with content to deepen understanding. Technology use can also be a key factor for these models.

Differentiated instruction and technology

No one knows better than teachers that one size does not fit all. Differentiated instruction requires teachers to provide content that is adapted appropriately for the range of students in each classroom, to teach using flexible strategies that offer varying ways for students to interact with the content and with each other, and to offer students a range of methods for documenting their learning.[2]

Within both preservice teacher training and professional development, teachers are increasingly trained to identify and compensate for learning differences and disabilities in their instructional practices. Given the trend towards mainstreaming, general education teachers need these skills to provide the bulk of day-to-day instruction for students with disabilities in inclusive classrooms, with input and support from special education staff and specialists.

Schools are also increasingly offered technology-enabled curricula that provide scaffolded methods of interaction and understanding for students with learning disabilities, some of whom also have sensory or motor disabilities. Many of these curricula incorporate flexible design approaches based on brain research and/or universal design principles. For example, Richard Mayer proposes evidenced-based multimedia design principles that illustrate how learning is enhanced when instructional materials anticipate the cognitive processing load required at every stage of learning.[3] He offers specific multimedia design recommendations that:

- Reduce extraneous processing
- Support essential processing of key facts and concepts
- Foster generative processing to build knowledge

Mayer's findings indicate that the proper combinations of input—such as animation with narration or images with the relevant words adjacent to them—can increase how much students learn from multimedia materials. His research also shows that students learn better when lessons are written with a conversational rather than a formal style, suggesting that our social engagement with the material affects how we learn.

One of the most widely adopted curricular frameworks for differentiated learning is the Universal Design for Learning (UDL) defined by the Center for Applied Special Technology (CAST). UDL encourages the development of curricular content that provides children with learning and physical disabilities with multiple pathways, motivating feedback, alternate content presentations, and scaffolded supports.[4] UDL takes as a given the wide range of variation within groups of students and the need to offer approaches that work for individual students. CAST's National Center on Universal Design for Learning offers a comprehensive set of guidelines and checkpoints that encourage developers to provide:

- Multiple methods of representation
- Multiple means of action and expression
- Multiple means of engagement

The center's website offers examples of technology supports and a growing research base for each UDL principle as well as guidance on how to provide options for all students.

A chart in the appendix of this white paper maps the built-in features and applications found in Apple hardware and software to the principles of CAST's Universal Design for Learning and offers links to research that can support the use of each feature with different populations.

Technology use at school and at home

Four to six percent of students in U.S. public schools have been identified with a learning disability, totaling 2.7 million children in 2007.[5] More than half of those students spend most of their school day in general education classrooms.

To help schools, teachers, and parents explore how technology can support disabled students' learning, the TechMatrix website offers a searchable database of educational and assistive technology products and research. Similarly, the National Assistive Technology Research Institute (NATRI) offers resources and information to help school personnel develop or improve AT policies and practices for students with disabilities. The Quality Indicators for Assistive Technology (QIAT) Consortium has established criteria with guidance and checklists for schools to measure how well they are integrating technology into a student's individual education plan at every stage: consideration, assessment, documentation, implementation, evaluation, and transition planning. The QIAT criteria also address the administrative support or professional development and training required to use technology effectively.

Technology resources that support students with disabilities are becoming more available, but classroom use still lags behind. It is estimated that only between 25 and 35 percent of students with learning disabilities "are being provided with assistive technology to support their instruction and learning," according to Candace Cortiella.[6] Specialized knowledge of AT may be required to meet the needs of students with certain sensory or motor disabilities, but technology assessments even in these cases are often lacking. A national survey of 400 teachers who instruct students with visual impairments found that less than one-third of their students had ever had an assistive technology assessment.[7]

Numerous innovative features within today's technology products can customize learning inputs and outputs, support efficient use of study time, and facilitate communication, thereby minimizing frustration and supporting persistence on task. Absent a formal assessment and a tech-savvy expert on hand to provide training and support, most teachers and parents explore the use of these inclusive features to facilitate, organize, or scaffold a student's learning through trial and error. Often, students themselves are more technically adept than their teachers, and many will suggest ways to use iMovie software or iPod devices in specific learning tasks. However, without some structured experimentation, many students with disabilities cannot possibly know which modality works best for different tasks or with different content. A student's preferences for how best to receive, organize, explore, or produce information may not always prove to be the modality best suited for deep understanding of certain kinds of content, or it may not adequately support that student's progress in meeting the expectations of higher grade levels.

Determining effective uses of technology for learning becomes particularly important in supporting students' independent learning. As students with disabilities get older, they can be impatient with parent-assisted strategies and want independent methods for access to, interaction with, and production of schoolwork. This desire for independence in adolescence occurs just as students' daily routines become more complex, interactions expand with multiple teachers and peers, and homework demands escalate.

Research conducted by the Harvard Family Research Project suggests eight ways in which teachers and school staff can invite parents' involvement in homework to help children develop and strengthen learning skills. Fully half of the suggested practices require significant parental expertise and/or parent-focused training and teacher support. These include parents' direct involvement in homework to support their child's understanding and completion of assignments as well as parents' explicit development of metastrategies that match tasks to their child's knowledge, skills, and abilities and that foster learning processes and behaviors to support their child's success with homework. Recommendations reflect studies that show a positive impact from teacher-parent collaborations and parent-to-parent support groups in developing and supporting personalized homework strategies for all students.[8]

For many students with disabilities, however, family involvement in homework is both necessary and the norm. Through the Individualized Education Program process, parents and teachers of students with disabilities are already engaged in a school-based team effort to build a shared understanding of how best to support and scaffold an individual student's learning. As part of the National Longitudinal Transition Study-2 (NLTS2), the report *Family Involvement in the Educational Development of Youth with Disabilities* documents that families and caregivers of most students with disabilities are also very involved in supporting their children's educational development at home.[9] Seventy-five percent of students with disabilities are being helped with homework at least once a week, compared with 55 percent of students in the general population. Twenty-one percent of students with disabilities are being helped with homework five or more times a week, compared with only four percent of students in the general population. Despite the likely use of technology by parents and caregivers in providing homework support to students with disabilities, there is little research about technology use in the home by students with disabilities.[10] Yet we know that technology use in the home by parents and children alike is pervasive and growing.

What technology works for which students?

The National Center for Learning Disabilities defines a learning disability as "a neurological disorder that affects the brain's ability to receive, process, store, and respond to information." Such a disorder can affect an individual's listening, speaking, reading (dyslexia), writing (dysgraphia), or mathematics (dyscalculia) abilities. Attention and organizational disorders or nonverbal learning disorders (NVLD) affect both cognitive and interpersonal capacities. Students with sensory disabilities have hearing or vision loss and may also have related or unrelated learning or organizational disabilities. All of these disabilities can be co-occurring.

Technologies that help address physical and time constraints can have a measurable impact on students' engagement with learning, as can technologies that scaffold reading, writing, and organization. We know that students who struggle to understand print, visual, and auditory inputs are less able to experience deep engagement while learning new content because the decoding process consumes a disproportionate share of working memory. We know that students who struggle with expressive language disorders are less able to show their learning through speech or text. Students with attention disorders struggle with the organization of material, time, and ideas and find it difficult to begin, sustain, and complete learning activities within a reasonable time frame. Similarly, many students with sensory disabilities must spend significantly more time just accessing information—whether through talking books, Braille, text, or sign language—than their nondisabled peers.

Education researchers, psychologists, and teachers agree that it is important for students to understand how their particular disability impacts their learning. Howard Gardner's work on multiple intelligences encourages student self-identification of strengths, weaknesses, and preferences in different domains of learning: kinesthetic, logical, intrapersonal, visual/spatial, linguistic, interpersonal, musical, and naturalistic.[11] Similarly, the All Kinds of Minds (AKOM) institute utilizes a series of "neurodevelopmental constructs" to provide teachers, students, and parents with a framework for understanding learning differences and their impact on behavior. PBS' Misunderstood Minds website focuses on AKOM's approach and offers resources for teachers, parents, and students, including interactive exercises that simulate what it is like to experience various reading, writing, math, and attention disorders.

Future brain research can potentially suggest personalized assessments that could measure varying levels of learning performance using different technology-enabled strategies at different stages in a student's development. This would benefit all students but could prove game-changing for students with disabilities who face progressively complex challenges with keeping pace in an educational system that assumes a growing facility in reading, listening, and organizational skills. As these students progress through higher grades, they are asked to plan, organize, and complete reading, writing, and math assignments that take increasing amounts of time—and often require exactly the skills they lack. Technology can support the development of compensatory skills to accomplish these tasks and, ideally, to engage students in strengthening skills through regular and repeated use.

How Apple technologies can help

The following examples illustrate how universal design features within Apple technologies offer ready access to alternate methods of input and output and to compensatory and organizational tools that can support learning. Use of these features may help students with disabilities succeed in the classroom and in planning, managing, or completing homework.

Apple Technology and Students with Mathematics Disabilities

Several technologies built into Apple products can benefit dyscalculic students. For example, children who struggle with math can use an iPhone or iPod to record classroom lessons and instructions for later review. And the audio and visual features of the Calculator and Grapher applications can help students understand and remember equations.

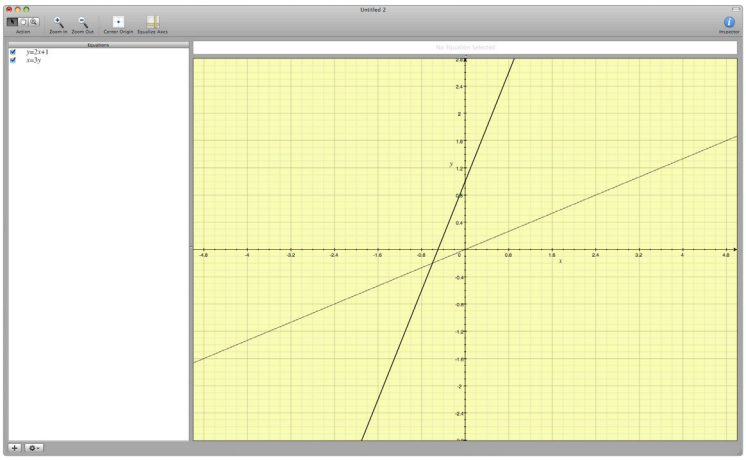
Example #1: A middle-school student with dyscalculia

Peter is an eighth-grade student who has trouble with math. He usually understands the lessons in class, but when it's time to do the work at home, he has trouble remembering everything. He finds that writing math equations is difficult and slow and frequently forgets what symbols to use and in what order they should appear. He also has a hard time keeping track of all the steps needed to reach a result.

To help him, Peter's teacher uses Voice Memos on her iPhone to record classroom lectures. She later uploads them to the class Mac mini with Mac OS X Server version 10.6 Snow Leopard, where podcasts can be downloaded by any student using iTunes. For ease of use, the teacher also links to them from the class web page.

Each evening before dinner, Peter uses iTunes on his notebook computer to automatically download these daily recordings. Later in the evening, when he's working on math homework, he listens to the podcasts to help him remember the lesson from earlier in the day. Peter also syncs the podcasts to his iPod touch; if a new concept is especially tricky, he can review the lesson on the school bus the next morning. Some of the other students in the class have also been using these podcasts to study for exams.

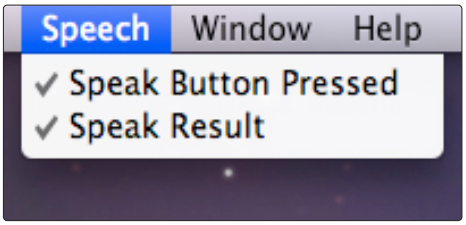
When Peter's class begins a unit on graphing equations, he takes advantage of a tool called Grapher that comes on his Mac computer. This utility allows him to generate graphs for any equation. He can input each equation his teacher discussed in class, as recorded in the podcast, so he can see plenty of visual examples to solidify concepts as they are introduced. He can also experiment with new equations to test his expectations of how graphs will appear.



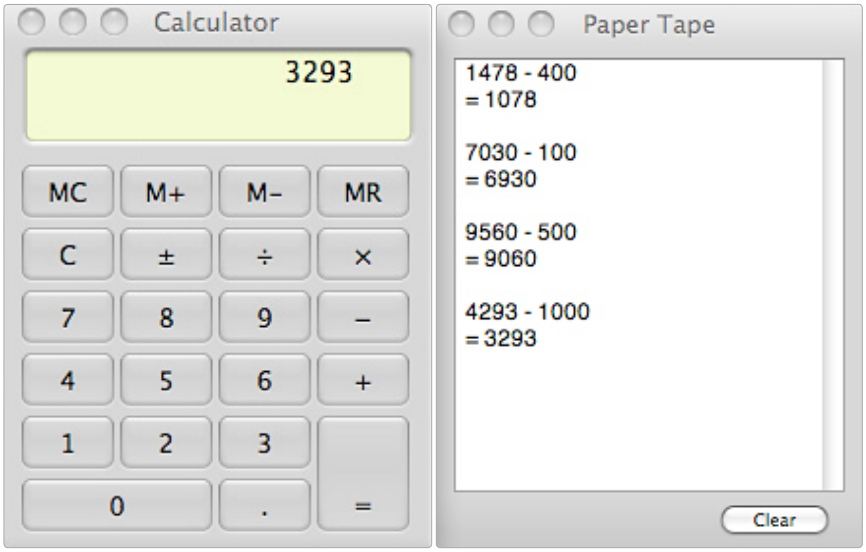
Peter has also found some useful apps in the App Store that he can use on his iPod touch to help him improve his math skills. One application leads him through the steps necessary to write and solve a problem, and it can show him the answer if he wants to see it before he solves the equation. Another includes many examples of equations and figures. When Peter is trying to learn a new equation, he can locate a similar problem in the application to see how it is written and whether there are variations on the problem that will strengthen his knowledge of a particular process.

Example #2: An elementary-school student with dyscalculia

Georgia, a third grader, also struggles with math and benefits from using technology. The Calculator application on her Mac has an option that speaks individual key presses as well as the result when the equals key is pressed. She finds that having Calculator speak both the key presses and the results reinforces the correct work process and helps her stay focused.



The paper-tape function of Calculator provides a visual record of each calculation. Keeping the paper-tape window open next to Calculator helps Georgia keep track of keystrokes and identify errors. When she practices from the examples in her textbook, she saves the tape to a text file that she can refer to the next time she performs the same operation. She can also use Calculator to produce a larger number of worked examples to reinforce new concepts. The tape also comes in handy when an assignment doesn't go well: Georgia emails the tape to her teacher, who can then pinpoint the spot where Georgia made a mistake or suggest a more efficient way to solve the problem. The teacher can also save the tape to keep track of Georgia's work, either verifying that she is improving or identifying areas where she needs help.



Apple Technology and Students with Reading and Writing Disabilities

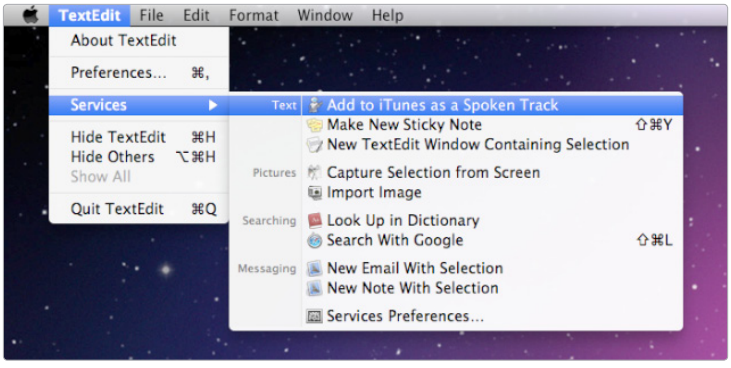
Technology can make it easier for teachers to foster understanding for students who struggle with reading print or who have difficulty writing or taking notes.

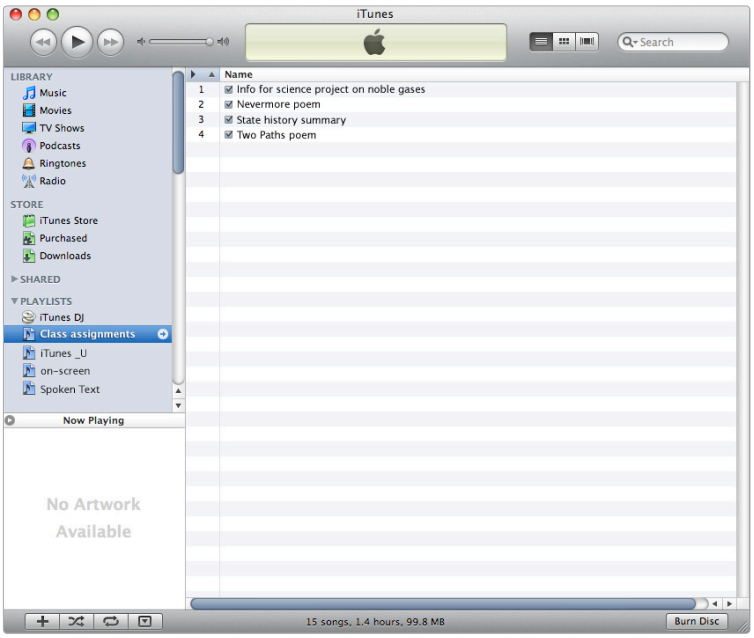
Example #3: A middle-school student with dyslexia

Lindsay is a seventh-grade student with dyslexia. She gets talking books delivered to her school, but they are available only for the main textbook in each class. Both the supplemental reading she requires and the research she must do are an ongoing challenge.

Lindsay's school doesn't have a lot of technology, but her teachers have worked out a simple system. Whenever possible, she does her research assignments using a classroom iMac so that she can use VoiceOver (the screen reader built into the Mac OS) to read the text to her. The teachers put any files they create on the iMac as well, so Lindsay can access them with the screen reader. VoiceOver can be configured to highlight sections of text as they are read aloud, so Lindsay can follow along visually as well as aurally.

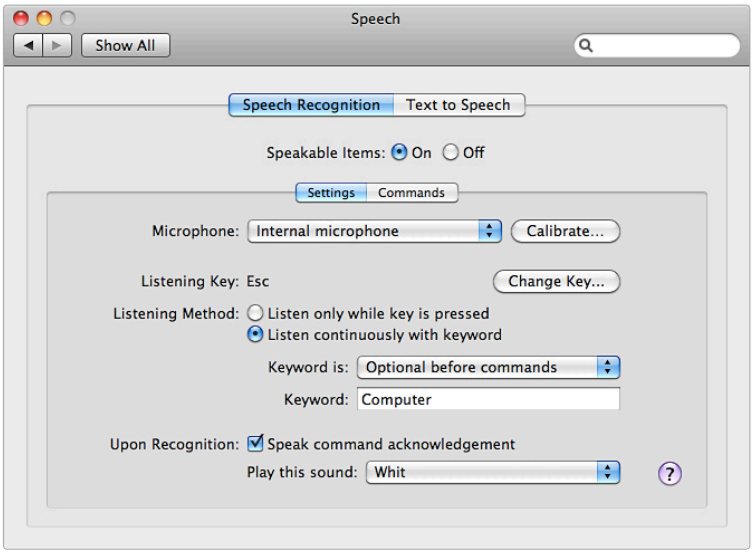
Lindsay doesn't have a computer at home, but she needed a way to have access to audio files for her homework. Lindsay's science teacher showed her the "Add to iTunes as a Spoken Track" service on the class iMac, which automatically converts text from almost any application into an audio file and copies it into iTunes. Now when Lindsay is surfing the web in Safari, reading a PDF file in Preview, or creating a document in Pages, she can select any portion of text, convert it, and then sync the newly created audio file to her iPod by connecting it to iTunes on the Mac. Then she can use the iPod to review material outside of school when she is working on her homework.





Example #4: An elementary-school student with dysgraphia

Joey is a third grader with a lot to say and many creative ideas for stories. But his fine-motor-control problems were leaving him frustrated because he couldn't write quickly enough to express all of his ideas. Additionally, his teachers found it difficult to read his handwriting. Joey began learning to type in second grade and now regularly uses the Pages application on his classroom's iMac to complete most of his work. He is also using the speech recognition features built into the Mac OS to navigate the screen, because the fine-motor movements required to use the mouse are hard for him to control. As Joey moves into higher grades and the number of written assignments increases, using the iMac will save time and make it easier for his teachers to review his work than if he wrote by hand.



Example #5: A teacher of students learning to read

JoAnn is a second-grade teacher. She has a number of students who, for various reasons, are experiencing difficulty with reading. Each week, JoAnn posts on the school website a list of 20 vocabulary words that will be used in upcoming language arts lessons. Parents can then download these words and use them at home.

One of her students, Philip, has been diagnosed with an audio processing disorder that causes him to mishear and subsequently mispronounce parts of words, which is slowing down his ability to decode new words and develop reading fluency. Ongoing pull-out sessions with a speech and language specialist are having an impact, and Philip's parents are working closely with him at home using suggested word games and computer programs.

Philip's father, George, is an artist who has begun loading the weekly vocabulary and other words into a flash card iPhone application he found on the App Store. George creates silly images (photos, clip art, drawings) on his computer, records an audio pronunciation of the word to accompany each card, and loads the resulting audio and images onto his iPhone. Philip loves playing with this personalized deck on his father's iPhone. Whenever they are in the car or doing errands, Philip eagerly plays with the flash cards, testing his ability to recognize and pronounce each word.

JoAnn has been intrigued by how many students in her class love the idea of making their own multimedia flash cards. She applied for a grant and used the funds to purchase 10 iPod touch devices for the class. She has begun expanding the cards and audio for certain target words to create customized homework decks that directly address specific students' learning challenges with decoding and phonemic awareness. She has hundreds of images and examples to use from worksheets and has also invited her colleagues to help build out this literacy and language arts tool.

JoAnn's students also use the iPod units to record themselves reading, which helps them improve their fluency. JoAnn attaches an external microphone to each iPod and lets the students record themselves. She imports the audio files into GarageBand and saves two copies of each: one original to allow her to keep a history of the student's progress and one where she removes unwanted elements such as "umms" and "ahhs." She downloads the cleaned-up versions back onto the iPod devices so the students can hear what they sound like when they read more fluidly.

Example #6: A teacher of students with learning disabilities

June is a teacher in an inclusive fifth-grade classroom that includes students with learning disabilities. She starts each science unit with a demonstration and discussion to get her students engaged in the new topic. She wants all students to focus on watching the demonstration and taking part in the conversation about it, but they also need notes on the results to complete their reports on the experiment afterward.

June's students have a wide range of attention and writing abilities that are likely to make note-taking a distraction, so she came up with the idea of making a video of the demonstration as she performs it. She has one student use her iPod nano to take a video while she carries out the demonstration. She shows the students what she is about to do and asks them for a hypothesis about the outcome. Then she shows them the results and asks what they see. After school, she uses iMovie to export and edit the video and iWeb to update her class web page with the video.

The video captures the entire process of hypothesizing, observing, and reflecting on how well the results match the different hypotheses the students had. Students can view the video demonstration as many times as they need to, at home or on the classroom's computer, and make notes to write their report. All of the students can participate in the group discussion during the demonstration without worrying about taking notes, and each can write a report at his or her own level of ability.

Apple Technology and Students with Processing and Organizational Disabilities

Getting organized, staying focused, and participating appropriately in class are challenges for many students—but they can be particularly difficult for those with processing and organizational disabilities. Desktop, laptop, and handheld Apple products offer these students built-in features and tools that can help ease many everyday challenges.

Example #7: An elementary-school student on the autism spectrum

John is a fifth grader in an inclusive classroom who is performing at grade level in most subjects. He gets upset by unexpected changes in routine, but as long as he is well prepared, he can successfully manage most transitions and new experiences. Thinking ahead to next year, his parents bought him an iPod touch and have been working with the teacher on successful classroom strategies that John can use in middle school.

John loves technology and carries his iPod everywhere, at home and throughout the school day. Now when he gets upset, he leaves the room to hum along with a few favorite songs to calm down. He also checks the time on his iPod regularly to monitor his schedule. Each week, the teacher's aide adjusts his calendar to set a series of auditory reminders 10, 5, and 2 minutes before daily transitions such as moving from one subject area to another, going to lunch, or going out to recess.

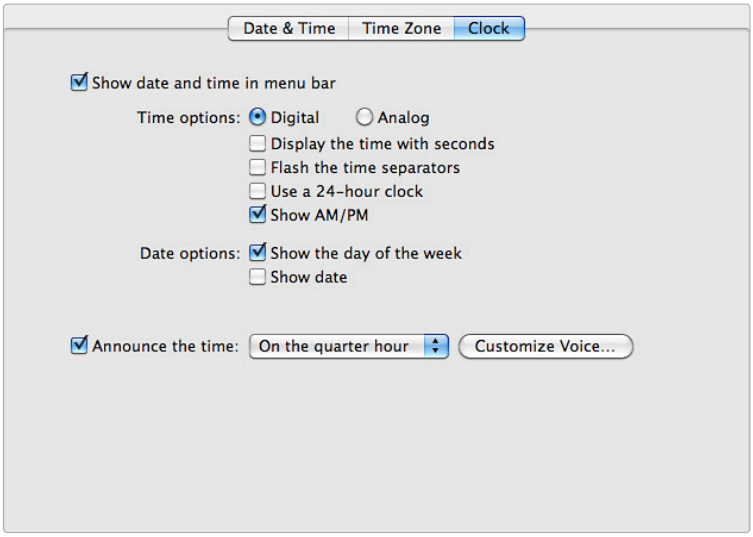
John also uses the iPod to help manage his class participation. He is working hard at waiting until the teacher indicates he can contribute comments or ask questions, but he often just can't refrain from speaking out, interrupting the teacher or his peers and disrupting the lesson. His teacher has suggested that instead of interrupting, he quietly use Voice Memo on his iPod to record his comments. This way, he stays engaged with the lesson by creating a private ongoing commentary and is better able to wait his turn to share only certain thoughts with the class. After the discussion, he and his aide can sit together and listen to his commentary, making sure that all of his opinions and questions are heard and addressed.

Example #8: A high-school student on the autism spectrum

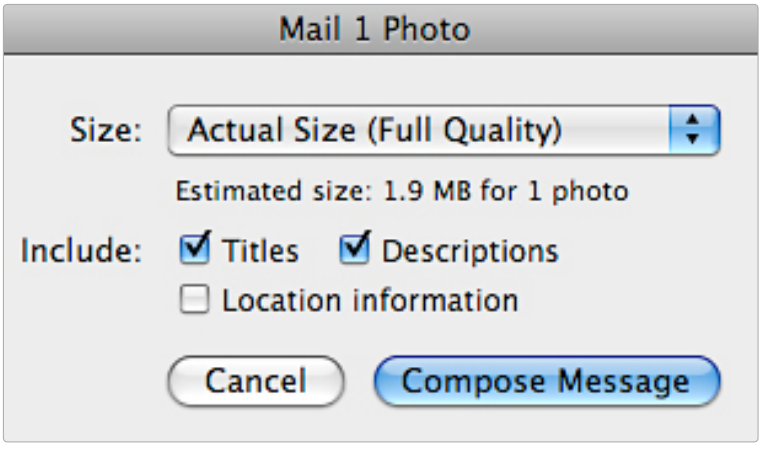
Bryan, a high-school senior, is a hard worker at school but needs to have everything around him organized in a specific fashion to get things done. He adapts slowly to change and prefers to maintain a specific routine.

To help him focus on his homework, his father showed him how to set up his own account on the family iMac that has been customized and organized to reflect Bryan's organizational needs. For example, together they use a feature of Mac OS X v10.6 called Spaces to create a unique place for each of the applications Bryan uses the most: TextEdit, Calculator, and Safari. When Bryan logs in to his account, each application automatically opens in the same space every time. He assigned keyboard shortcuts to each space so that he can switch between applications quickly and predictably. For example, pressing Control-1 always brings TextEdit to the front, and pressing Control-2 does the same for Safari.

Bryan also has difficulty managing his time, often spending too long on one subject at the expense of another. His mother downloaded a countdown widget to Bryan's iMac that keeps track of how long he has been working on a specific task or subject. This helps Bryan keep to the schedule he has planned. He also uses the built-in talking clock on his iMac. Bryan finds that having the clock announce the time every 15 minutes helps him keep track of his time more effectively than the visual clock, which he often forgets to check.



Bryan has a hard time making new friends and carrying on casual conversations. As a result, he often feels isolated. One of his few friends shares an interest in insects, and the boys enjoy swapping pictures of bugs they find in their neighborhoods. Bryan's parents gave him an iPhone for his birthday, which he uses daily to take pictures of bugs he finds in the woods behind his yard and in a nearby park. Bryan now has a huge collection of insect photos that he shares with his friend via email. The pictures he takes with his camera are quite large and need to be resized in order to be emailed. Manually resizing them would be time-consuming and an ongoing distraction for Bryan, but the Email function in iPhoto allows him to automatically adjust the size of the images before he sends them.



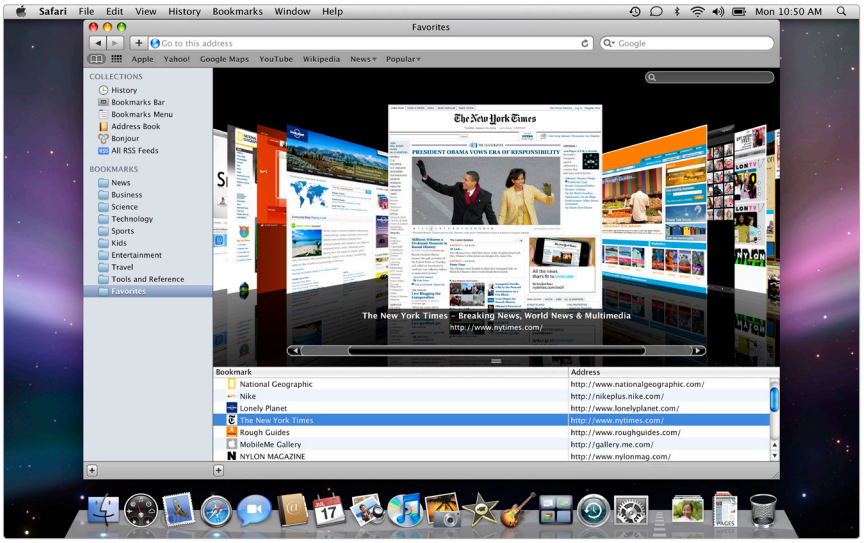
Example #9: A high-school student with attention-deficit hyperactivity disorder (ADHD)

Bradley is a high-school junior. He earns high grades, but because he has ADHD he struggles to organize his work and stay focused. He often misplaces his homework assignments, and when he finally does begin them, he is easily distracted and jumps from task to task before each is completed. As a result, he often finds that it takes him longer than his peers to complete his work.

To help him organize tasks more effectively, and to save time when preparing to do homework, Bradley's teacher showed him how to structure folders on his MacBook Pro so that documents and files can be found more easily. Each week he sets up a new folder with subfolders for specific subjects such as chemistry, English, and history. He drags the weekly folder into the Dock at the bottom of his screen so he can easily locate and open it. He also sets the folder view to show everything alphabetically, making it simple to find everything he needs. Additionally, Bradley has organized his Dock so that similar applications are grouped together and has removed all unnecessary applications to minimize clutter. Bradley has also set the Dock size and magnification levels to high so he can easily see what applications are available.

Bradley also uses his MacBook Pro to take advantage of the text-to-speech functionality built into the Mac OS. Whenever he has to read more than a paragraph, Bradley turns on Speech and lets it speak the text to him as he reads along. Hearing the text as he reads it helps him stay focused and retain more of what he reads.

Cover Flow for Safari bookmarks has also become useful for Bradley, allowing him to reduce the amount of time spent organizing information found on the web. In history class, for example, Bradley wrote a research paper about Italy during World War II. He bookmarked many websites during his research but later found that the bookmarked names alone didn't convey enough information to him as he tried to recall which sites he wanted to revisit. To help organize the information and resources he found during web searches and to provide visual bookmarks, the teacher showed Bradley how to view his bookmarks in a Cover Flow format so he could see full-page previews of the websites as they looked when he last visited them.



Example #10: A teacher of students with learning disabilities

Larry teaches a seventh-grade language arts class that includes several students with learning disabilities. Some of his students frequently have a difficult time keeping their attention focused on visual aspects of teaching in the classroom, such as work taking place on the board.

Larry has found that using audio along with visual materials holds these students' attention longer than materials without audio. Larry likes to use an electronic whiteboard to project and mark up paragraphs of text from the material the class is currently reading, but there is no audio output from it. Instead, he uses his MacBook Pro to project the text onto a screen. He also turns on VoiceOver, the screen reader built into the Mac OS.

Using Apple's Multi-Touch gestural interface that operates VoiceOver, Larry can use the trackpad to control what VoiceOver reads relative to what he is showing on the screen. Additionally, he turns on the VoiceOver cursor, which draws a box around the text that is currently being spoken, making it easier for his students to see the text that is being read aloud. Larry can silence VoiceOver and read the text himself, or he can let VoiceOver read the text for him. Either way, his students hear the information while simultaneously receiving visual reinforcement.

Apple Technology and Students with Sensory Disabilities

Today's computers can open up new worlds for children with sensory disabilities. Students who are deaf can use video iChat to communicate in sign language with friends and family. Like many other visual learners, they may also benefit from using multimedia tools to document their learning. Students who are blind can take advantage of Apple's built-in screen-reading and Braille-output capabilities.

Example #11: An elementary-school student who is deaf

Mary is a deaf student in sixth grade and an enthusiastic contributor to discussions in social studies class. She is fluent in American Sign Language (ASL) but is below grade level in English reading and comprehension. She works hard, but she dislikes writing and consistently has trouble organizing and completing writing assignments. Mary's teacher and parents are always looking for ways to motivate her to write more and to value the editing process.

For one assignment, the teacher asked students to write a short research paper on energy conservation. Mary began by emailing several aunts and uncles, asking them about energy-conservation efforts in their communities. After she received their responses, Mary got together online with her sister, Marcia, a freshman at a college in another state. Marcia can hear and is also fluent in ASL. Mary and Marcia used iChat on their MacBook computers to hold video chats in which they signed to each other, discussed the responses, and planned an approach to writing the paper. Then, using iChat to share desktops, Marcia helped Mary edit and organize all the responses into a detailed outline.

Mary supplemented her paper with a short video describing energy-conservation efforts at Marcia's college dorm. Mary conducted an interview with her sister by using video iChat, saving the video on her computer at home. Her mother helped her import the movie into iMovie, then showed her how to edit it into a 90-second presentation and add captions. She finished by saving it as a QuickTime movie that she uploaded to the class website so everyone could see it.

A number of students in Mary's class are now interested in learning ASL. Some have downloaded one of the sign-language apps available on the App Store and are eager to practice what they are learning with Mary. She uses Photo Booth to record video clips of herself signing, which she then sends to her friends so they can get more experience with understanding ASL. This is a fun interaction for both Mary and her classmates.

Example #12: A high-school student who is blind

Tom is a blind high-school sophomore who has always excelled in English reading and composition. He also reads Braille. Tom's parents bought him a MacBook Pro as well as an iPod touch so he could take advantage of the accessibility features found on both.

During the school day, Tom takes notes using his Mac. At home rereads the notes using VoiceOver—the screen reader build into Mac OS—as well as Safari for homework and research. He also uses iTunes U to find and download materials for research papers. The iTunes interface is fully accessible and can be navigated using VoiceOver, so Tom has hundreds of podcasts and other materials from which to choose. Once he downloads the materials he wants, he can sync them with his iPod touch and listen on the bus on the way to school.

There are times when Tom finds it easier to read Braille than to listen to a screen reader, and in those instances he takes advantage of his Mac computer's Braille-output capabilities. He can attach his favorite refreshable Braille display to his Mac and read the page from the Braille display. When he's finished, Tom types his assignments using TextEdit and emails them back to his teacher. He also emails his homework to himself so he can download the documents to his iPod touch. Using VoiceOver on his iPod touch, he can quickly find and review his homework during the school day.

Conclusion

These examples illustrate how universal design features within Apple products are energizing the creative use of applications to support disabled students' learning and study at school and at home. Students, teachers, and parents who are already familiar with iPod and iPhone devices as well as software such as iTunes and iLife are actively exploring how these hardware and software options can help focus attention; make content accessible and more meaningful; and diminish difficulties in communication, classwork, and homework. Moreover, new educational applications appear in the App Store each week, many of which offer benefits to students with disabilities. Some are carefully designed for people with specific disabilities, and others offer more universal benefits. This explosion of innovative applications and practices provides teachers with new tools and techniques to meet the needs of their diverse students and offers researchers rich new ground for further study.

For More Information

For more information about the topics and resources mentioned in this white paper, please visit the following websites:

- Apple resources for special education
  www.apple.com/education/special-education
- CAST National Center on Universal Design for Learning
  www.udlcenter.org
- Misunderstood Minds
  www.pbs.org/wgbh/misunderstoodminds/
- National Assistive Technology Research Institute (NATRI)
  natri.uky.edu
- NSF Science of Learning Centers
  www.nsf.gov/funding/pgm_summ.jsp?pims_id=5567
- Quality Indicators for Assistive Technology (QIAT)
  natri.uky.edu/assoc_projects/qiat
- TechMatrix
  www.techmatrix.org/index.aspx

Appendix: Apple Product Features Mapped to CAST's Universal Design for Learning Principles

Apple Product Features	Mac	iPhone	iPod touch	iPod nano	iPod shuffle	iPod classic	Multiple Means of Representation	Multiple Means of Action and Expression	Multiple Means of Engagement
Simplify desktop (Simple Finder)	•						G1	G6	G7
Organize desktop (Spaces)	•						G1	G6	G7
Preview file contents (Cover Flow and Quick Look)	•						G1, G2	G6	
Organize applications (Dock)	•						G1, G2	G6	G7
Search content (Spotlight)	•	•	•				G1	G6	
Locate, focus, or hide open windows (Exposé)	•						G1	G6	
Automate tasks and conversions (Automator)	•						G1, G2, G3	G4, G5	G7
Magnify the screen (Zoom)	•	•	•				G1, G2		G7
Change contrast (Contrast)	•	•	•				G1		G7
Change brightness and font size	•	•	•	•			G1		G7
Screen reader (VoiceOver)	•	•	•	•			G1, G3	G5	G7
Speak menus (Spoken Menus)				•	•		G1	G5	G7
Convert text to speech (TTS)	•						G1	G5	G7
Control using speech (Speech)	•	•	•				G1	G4	
Record audio (Voice Memo, GarageBand, QuickTime, iChat)	•	•	•*	•			G1	G4, G5	G7, G9
Real-time communication using text images, audio, and video (iChat)	•						G1	G5	G7, G8
Share text and images in real time (Messages, Safari-based chat)		•	•				G1	G5	G7, G8
Check spelling and suggest words (Mac OS X, iPhone OS)	•	•	•				G2, G3		
Check grammar and automatically complete words (Mac OS X)	•						G2, G3		
Set alarms and reminders (iCal)	•	•	•					G6	G8, G9
Hear alert messages and warnings (Talking Alerts)	•							G6	G8, G9
Hear time of day (Talking Clock)	•	•	•					G6	G8, G9
Speak calculations (Calculator)	•	•	•				G1, G2, G3		G8
Enlarge website text (Safari)	•	•	•				G2, G3		G7
Summarize documents (Summary)	•						G2, G3		
Retain key presses (Sticky Keys)	•							G4	
Perform multikey actions (Slow Keys)	•							G4	

Apple Product Features	Mac	iPhone	iPod touch	iPod nano	iPod shuffle	iPod classic	Multiple Means of Representation	Multiple Means of Action and Expression	Multiple Means of Engagement
Customize mouse pointer and tracking speed (System Preferences)	•							G4, G6	
Assign and customize keyboard shortcuts (System Preferences)	•							G4, G6	
Play audio or video (iTunes, QuickTime, iPod)	•	•	•	•	•	•	G1	G5	G7, G9
Record video (QuickTime, iPod)	•	•		•			G1, G2	G5	G7, G9
Organize and synchronize digital media (iTunes)	•	•	•	•			G1	G5	G7, G9

*8GB iPod touch requires external microphone.

Principle I: Provide Multiple Means of Representation
Guideline 1: Provide options for perception
Guideline 2: Provide options for language and symbols
Guideline 3: Provide options for comprehension and fluency
Principle II: Provide Multiple Means of Action and Expression
Guideline 4: Provide options for physical action
Guideline 5: Provide options for expressive skills
Guideline 6: Provide options for executive functions
Principle III: Provide Multiple Means of Engagement
Guideline 7: Provide options for recruiting interest
Guideline 8: Provide options for sustaining effort and persistence
Guideline 9: Provide options for self-regulation

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2 Tomlinson, 2001.

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8 Walker, Hoover-Dempsey, Whetsel, and Green, 2004.

9 Newman, 2004.

10 Bouck, Okolo, and Courtad, 2007.

11 Gardner, 2007.