



Cheryl Lemke

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In this chapter, Lemke introduces three important innovations of 21st century learning: visualization, democratization of knowledge, and participatory cultures for learning. She provides an impressive demonstration of ways technology permits greater balance between a visual approach and traditional language-based communication.

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Chapter 11

Innovation Through Technology

Cheryl Lemke

There is no turning back. The Internet has become integral to life in the 21st century—a place for work, play, communication, and learning. It is easy to lose sight of just how integral it has become, and how knowledge-based the world economy has become. The combination of human ingenuity and digital tools has led to innovations that have, in some cases, become viral (Foray & Lundvall, 1998). The statistics are staggering: in 2009, the mobile world celebrated its four billionth connection (Global System for Mobile Communications, 2009); over one trillion unique URLs have been registered in Google's index (The Official Google Blog, 2008); there have been nearly sixty-one million views to date of the YouTube most-watched video, *Guitar* (Jeong-hyun, n.d.; Shah, 2005); on average, nine hundred thousand blogs are posted every twenty-four hours (Singer, 2009); over 2.5 billion tweets have been sent (Reed, 2008); YouTube was sold to Google in 2006 for \$1.65 billion (Associated Press, 2006); over one hundred million users are logging onto Facebook every day; and approximately 2.6 billion minutes globally are dedicated to using Facebook daily, in thirty-five different languages (Singer, 2009).

Regardless of whether you find these statistics energizing or overwhelming, there is no question that the line between our digital and physical lives is blurring.

Outside of school, 96 percent of nine- to seventeen-year-olds embrace the Web 2.0 culture of social networking, blogging, twittering, GPS mapping, or interactive gaming at some level (National School Board Association, 2007). These youth communicate in real time through texting, instant messaging, and sharing of media files. According to the National School Board Association (2007), they typically spend about nine hours per week outside of school using social networking and ten hours watching television. But the reality is that there are significant variations among youth across the country with respect to the type and frequency of such digital media use (Jenkins, 2007). That holds true in schools as well, with significant differences in the type and frequency of technology use across states (*Education Week* and the Editorial Projects in Education Research Center, 2009b). A June 2009 Nielsen publication reported that, while children and youth do use electronic media in excess of six hours per day, using more than one medium simultaneously 23 percent of that time, they also enjoy reading books, magazines, and newspapers. Nielsen found that 77 percent of U.S. teens have their own mobile phone, 83 percent text message, and 56 percent use picture messaging. Teens average 2,899 text messages per month, which is fifteen times the average number of voice calls (191) they log each month. It would seem that email and phone calls are now considered their “father’s mode of digital communication,” not theirs (Nielsen Company, 2009).

The responsibility of educators is to ensure that today’s students are ready to live, learn, work, and thrive in this high-tech, global, highly participatory world. To that end, U.S. school systems are conspicuously out of sync with the culture of today’s society (U.S. Department of Education, 2009).

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While the more progressive educators are seizing this moment in history to launch a quiet Web 2.0 revolution in preK–12 education, the majority have yet to act. A 2009 national survey conducted by the Consortium on School Networking (CoSN) suggests that the majority of American school districts are at a crossroads with Web 2.0. While school district administrators clearly acknowledge the potential of Web 2.0

tools for learning, the majority of school districts have yet to turn that potential to their students' advantage. According to administrators who responded to the CoSN survey, the top three reasons for using Web 2.0 in school are to (1) keep students interested and engaged in school, (2) meet the needs of different kinds of learners, and (3) develop the critical-thinking skills of students. To date, that potential remains untapped. Instead, many school districts are checking student technologies (such as smartphones, cell phones, iPods, and iTouches) at the schoolhouse door (Lemke, Coughlin, Garcia, Reifsneider, & Baas, 2009).

At the same time, U.S. Secretary of Education Arne Duncan is calling for school districts to innovate using technology. At a national institute in 2009, he said, "Technology presents a huge opportunity . . . good teachers can utilize new technology to accelerate learning and provide extended learning opportunities for students." He went on to say, "We must take advantage of this historic opportunity to use American Recovery and Reinvestment Act funds to bring broadband access and online learning to more communities" (U.S. Department of Education, 2009).

Nationally, there is a call to action for smart, innovative, and informed leadership in 21st century learning in preK–12 education. The combination of crisis and vision has served America well more than once in its two-hundred-year history as it has evolved as a nation. A crisis is now before the United States in the form of the global economic downturn. The question is whether policy leaders will create an informed, collective vision for 21st century learning to turn that crisis into opportunity, and thus turn a new page in American education.

Innovation: The Fuel for a Knowledge-Based Economy

Economists claim that innovation is the fuel for today's global, knowledge-based economy and for its recovery. As such, innovation must play a dual role in America's preK–12 education system: as a foundational principle to the new educational system, and as a 21st century skill acquired by professionals and students alike. *Innovation* is defined here as a creative idea that has achieved sufficient social and/or professional acceptance so as to become the impetus for ongoing

ripples of creativity and change (Drucker, 2002). To build upon the ideas of author Malcolm Gladwell (2000), an innovation is an idea that has tipped and is viral, influencing the system within which it spreads.

21st Century Learning and Student Engagement

In a significant turn of events, business and government leaders are now acknowledging the critical importance of preK–12 education to the economic future of the United States. To that end, policy leaders are advocating for the transformation of preK–12 schools into 21st century learning environments. For the purposes of this chapter, *21st century learning* is defined as the combination of a set of discrete 21st century skills (for example, critical thinking, collaboration, information literacy, and so on), and academic standards to be implemented through digital innovations in the context of emergent research from the cognitive sciences on how people best learn.

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The intent of this chapter is to discuss three of the innovations rippling through our society that must inform America's bold new vision for 21st century learning. A key driver for this new vision is the current lack of student engagement in American schools that has contributed to an extremely high dropout rate nationally; nearly 30 percent of students who begin their ninth-grade year of high school do not graduate (*Education Week* and the Editorial Projects in Education Research Center, 2009a). Some of the disconnect to learning is explained through the concept of *flow*, which is defined as learning with the intensity cranked up—when the learner is at the top of his or her game (Csikszentmihalyi, 1990). Teachers create opportunities for students to get into that flow by balancing the complexity of the task with the students' current repertoire of learning strategies. Too much complexity without the requisite strategies results in frustrated students unable to do the work. On the other hand, if highly capable students with strong learning strategies are given too simple a task, they rapidly become bored. Figure 11.1 depicts the concept of flow (adapted from Csikszentmihalyi, 1990; Schwartz, Bransford, & Sears, 2006).

The research by Csikszentmihalyi (1990, 2002) shows that when that balance is perfected, students enter a flow experience in which

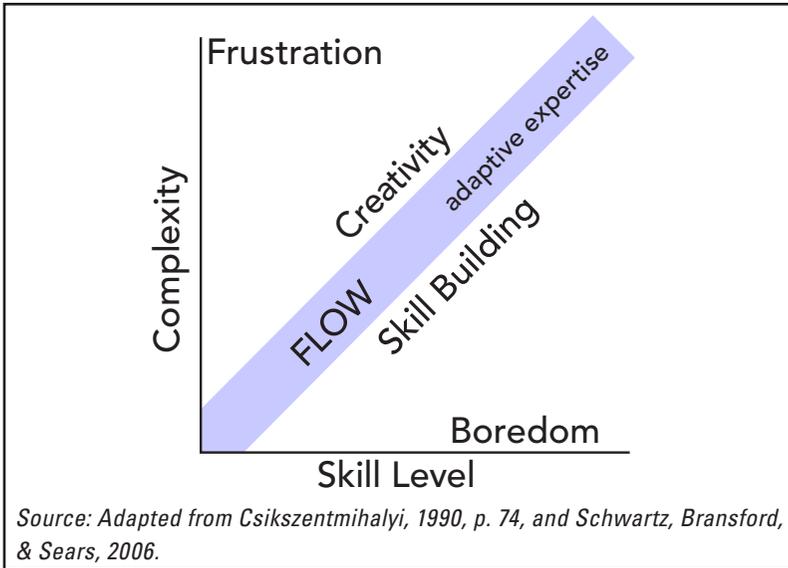


Figure 11.1: Developing adaptive expertise: Flow.

they are fully engaged, intrinsically motivated, and 110 percent invested in their learning. During flow experiences, many students report the sensation of time seeming to stand still as they engage in the experience. Leading cognitive science researchers suggest that the optimal flow experience balances skill level (that leads to efficiency in learning) with the level of task complexity (that leads to creativity and innovation). They contend that a balance between the two will lead to adaptive expertise in learners, which is necessary in dealing with the complexities of life in the 21st century.

The diagram in figure 11.2 (page 248) represents a framework for engaging students deeply in learning (Fredricks, Blumenfeld, & Paris, 2004; Lemke & Coughlin, 2008; Schlechty, 2002). In order to engage students fully in deep learning, they need to be motivated, curious learners who are in classrooms that scaffold that engagement through visualization, democratization of knowledge, and participatory learning.

Innovation One: Visualization

The link between visualization and learning can best be described as sense making. Physiologically, we are wired to swiftly process visuals, albeit differently than we process sound and text. Recent

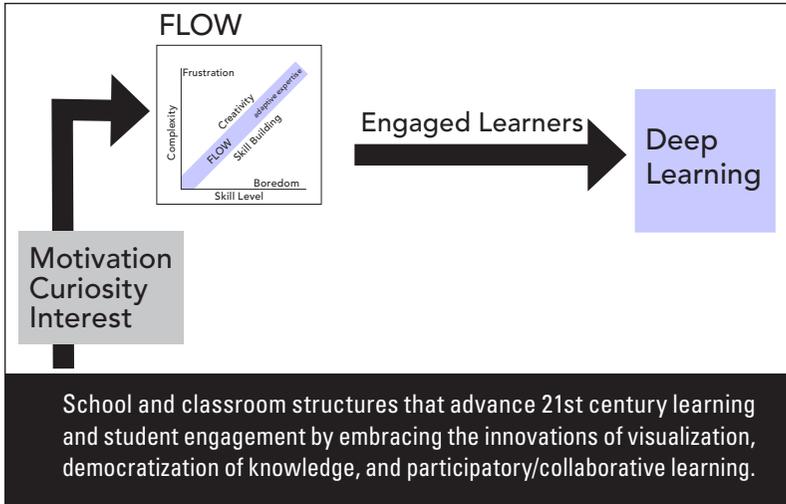


Figure 11.2: A framework for engaging students deeply in learning.
Reprinted with permission from Metiri Group.

technological advances through functional magnetic resonance imaging (fMRI) scans confirm a dual coding system through which visuals and text/auditory input are processed in separate channels, presenting the potential for simultaneous augmentation of learning. Our working memory, which is where we do all our thinking, processes visuals and text/sound differently. Both of these channels are extremely limited in their capacity.

The implications of this for education are many. First and foremost, it is important to acknowledge that people learn better from combining visuals with text and sound than through using either process alone, provided the design of learning resources follows certain multimedia principles (Mayer & Moreno, 2003).

This set of seven principles related to multimedia and modality is based on the work of Richard Mayer, Roxanne Moreno, and other prominent researchers (Chan & Black, 2006; Ginns, 2005; Mayer, 2001; Mayer & Moreno, 2003).

1. **Multimedia Principle:** Student retention is improved through a combination of words (verbal or text) and visuals, rather than through words alone, provided it doesn't introduce redundancy of content.

2. **Spatial Contiguity Principle:** Students learn better when corresponding text and visuals are physically integrated rather than separated.
3. **Temporal Contiguity Principle:** Students learn better when corresponding text and visuals are temporally synchronized rather than separated in time.
4. **Split-Attention Principle:** Students learn better when extraneous words, pictures, and sounds are excluded rather than included.
5. **Modality Principle:** Students learn better when text is presented auditorily as speech rather than as on-screen text.
6. **Individual Differences Principle:** Design effects from these principles are higher for low-knowledge learners than for high-knowledge learners, and they are higher for high-spatial learners than for low-spatial learners.
7. **Direct Manipulation Principle:** As the complexity of the materials increases the impact of direct manipulation of the learning materials (animation, pacing) on transfer also increases.

Students engaged in learning that incorporates high-quality multimodal designs outperform, on average, students who learn using traditional approaches with single modes. This was borne out by a recent meta-analysis that revealed multimodality (the use of text or sound and visuals together) can positively shift achievement—provided the multimedia principles are followed.

The meta-analysis found that, with noninteractive multimodal learning, such as text with illustrations or lectures with graphics, a student performing at the 50th percentile would, on average, increase performance to the 71st percentile (a gain of 21 percentiles). With interactive multimodal activities, such as simulations, modeling, and real-world experiences, a student at the 50th percentile would, on average, increase performance to the 82nd percentile (a gain of 32 percentiles) (Lemke, 2008).

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Outside the classroom, the 21st century brings us a myriad of visual images in multimedia through a host of technology devices, at a rapid pace unparalleled in the history of mankind. Examples abound (for live links to the following examples, and to see a full-color version of this chapter, visit go.solution-tree.com/21stcenturyskills).

- *The New York Times* provides [interactive media](#) on the economic crisis that enables users to explore the recessions of past years and compare them to that of 2009 (Quealy, Roth, & Schneiderman, 2009).
- *The New York Times* also provided an [interactive graphic](#) during the 2008 presidential debates that innovatively displayed the candidate names mentioned by other presidential candidates during the series of debates leading up to the Iowa caucuses (Corum & Hossain, 2007).

Another interactive venue for learning through visualization is online gaming. It enables participants to join multiuser groups from around the world to interact competitively and cooperatively in games, such as *Civilization* and *World of Warcraft*, or interact via an avatar in *Second Life*. Visual media also enables us to exercise with interactive videos on the Wii; link up with friends via GPS mappings; capture and post visuals and video on YouTube; and access news in real time across the globe. A prime example of this last use was the coverage of recent protests and governmental reactions following the 2009 Iraqi elections. Real-time access occurred through Twitter posts, CNN news, and YouTube video and visuals from the smartphones of those present at the scene.

Every day, student users are exposed to visuals, videos, and animations embedded in television commercials and programming, multimedia sites, communications, interactive games, Web 2.0 tools, and presentations. Contrary to popular belief, students are not born with the full range of abilities required to interpret, think with, and build simple or complex multimedia communications that involve visuals, text, and/or voice and sound. They need to learn to become informed viewers, critics, thinkers, and producers of multimedia. Just as there is a grammar and syntax for text literacy, so there is for

visual/multimodal literacy. The use of visualization is yet another way in which teachers can scaffold their students' learning.

Three strategies teachers might consider in using technology to capitalize on the power of visualization and build students' visual literacy are as follows:

1. Develop students as informed consumers of information.
2. Engage students in thinking critically and creatively using visuals.
3. Engage students in communicating using visuals.

Develop Students as Informed Consumers of Information

Students need to be informed consumers of visuals. One of the ways to achieve this is to help students analyze how advertisers manipulate images. KCTS Channel 9 in Seattle has produced a website that provides middle school students with opportunities to see the process in action. One of the offerings on the Don't Buy It: Get Media Smart site—Secrets of a Magazine Cover Model Revealed!—offers glimpses into the making of a “girl next door” into a fashion model (KCTS Television, 2004; http://pbskids.org/dontbuyit/entertainment/covermodel_1.html). Figure 11.3 shows screen captures from the process. These and other programs provide teens with an understanding of the digital manipulations routinely done in advertising. This is especially important given the pervasiveness of the idealization of models' bodies by consumers, which can lead to low self-esteem and



Source: KCTS Television, 2004, and PBS Kids. Reprinted with permission from Stephanie Malone, Drew Ringo, and KCTS Television.

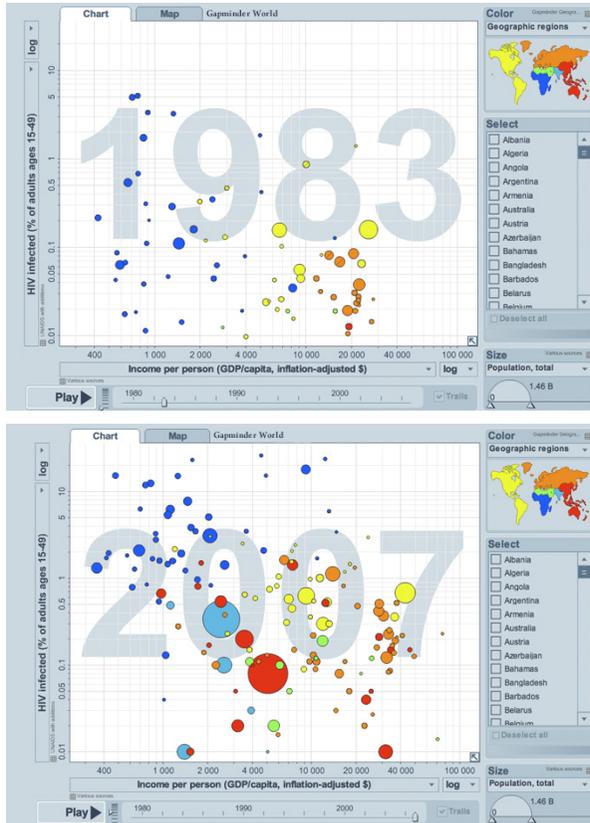
Figure 11.3: From “girl next door” to fashion model.

eating disorders among children, teens, and adults. This recognition of the potential for manipulation of media is an important first step in media literacy. An informed consumer recognizes that people are impacted emotionally, psychologically, physiologically, and cognitively by visuals and, thus, interpret media accordingly.

Engage Students in Thinking Critically and Creatively Using Visuals

Visualization can also be an extraordinary tool in a student's repertoire for critical and creative thinking. The more authentic the work, the better. Teachers and students alike can use readily accessible public datasets to engage in authentic investigations of open-ended questions concerning a range of topics. Examples abound. One digital tool that is particularly compelling for schools is free of charge on a website called Gapminder (www.gapminder.org). This visualization tool is built around a dataset from the United Nations. The dataset includes worldwide demographics, health, energy, politics, security, and other key elements (Gapminder Foundation, 2009). Each country is represented by a dot on the screen. Each continent has a unique color. The user determines the dataset to be charted on each of the axes and then watches as the tool shows the shifts in countries' positions across the years. For example, the two charts in figure 11.4 display the percentage of adults with HIV charted against the income per person for the countries of the world in 1983 and then in 2007. Students can use the visualization tool to track HIV infection in specific countries, with options for looking at specific demographics and/or income brackets within those countries. The full datasets are available for export to further analyze the data (Gapminder Foundation, 2009; visit go.solution-tree.com/21stcenturyskills for live links and to see full-color versions of the graphics in this chapter).

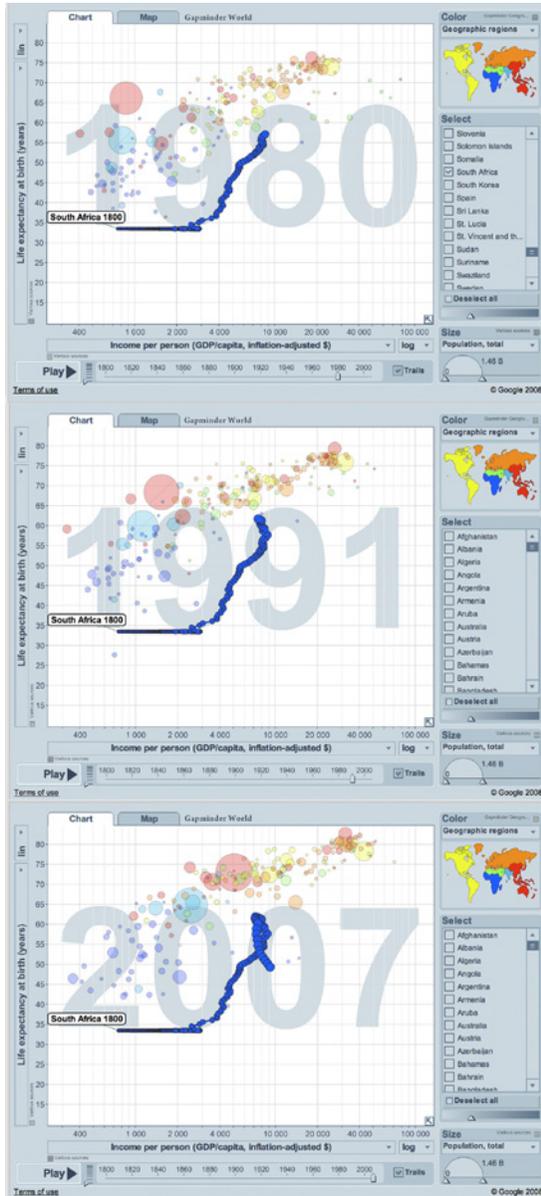
The teachable moments that can be created with this tool are unlimited. Take a look at our second example in figure 11.5 (page 254). It is three screen shots of a data run in which the average life expectancy of citizens in South Africa is charted in relationship to the average income per person over time. This chart shows a strong, steady increase for income and life expectancy in South Africa from 1932 to 1980. Then, in 1980, the income began slipping backward,



Source: Visualization from Gapminder World, powered by Trendalyzer from www.gapminder.org.

Figure 11.4: Charting the relationship over time between the percentage of adults with HIV in countries throughout the world in relation to the average income per person.

but the life expectancy continued to climb. In 1991, the upward trend in life expectancy reversed and began slowly decreasing; while at the same point in time, the income per person began slowly increasing. Those trends continued through 2007. Students exploring this data visualization quickly begin asking why the reversals happened in those specific years, and what factors caused the reversals. They might speculate that it was caused by a war, a natural disaster such as a famine or a tsunami, or perhaps industrialization. Students can rerun the scenario adding neighboring countries, zeroing in on



Source: Visualization from Gapminder World, powered by Trendalyzer from www.gapminder.org.

Figure 11.5: Life expectancy at birth by income in South Africa, 1800–2007.

particular years, charting new data elements, and, of course contextualizing their search through the use of other Web, print, and expert resources. This represents an extremely rich opportunity for critical thinking and problem solving with students.

Engage Students in Communicating Using Visuals

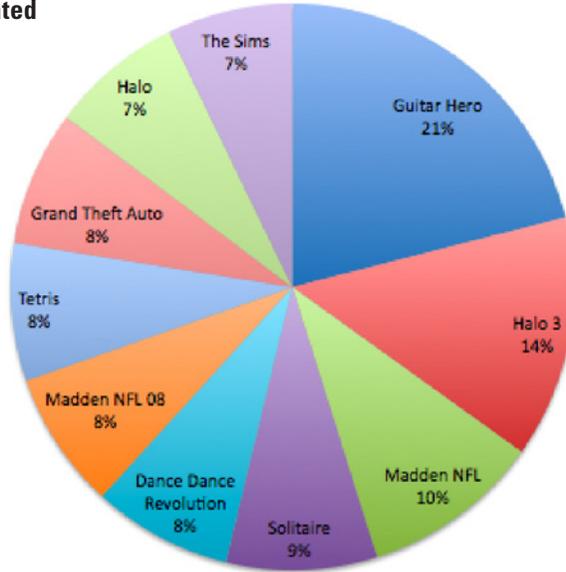
In addition to interpreting visuals, students should also understand how to create original visuals to communicate their ideas, represent their data, and tell their stories. Teachers can tap into websites that provide insight into which types of charts are most effective in displaying various types of datasets (see www.juiceanalytics.com/chartchooser/; visit go.solution-tree.com/21stcenturyskills for live links and to see a full-color version of the graphics in this chapter). As with any visual product, students need to adhere to the principles of multimodal design as described on pages 248–249. For example, in following the Spatial Contiguity Principle, charts should, where possible, integrate text into the design rather than using legends. In figure 11.6 (page 256), the cognitive load on working memory is higher for the nonintegrated example because the viewer has to look back and forth between the circle chart and the legend. In the integrated example, the load is reduced because the text is inside the chart.

A key strategy for scaffolding learning through visualization is the establishment and use of a set of guidelines that set high standards for the visual quality of student work. Many designers use a minimum of four key standards for design: contrast, repetition, alignment, and proximity (Williams, 2003) in concert with the multimedia principles listed previously. The visual design of digital products can increase or decrease the effectiveness of the communication:

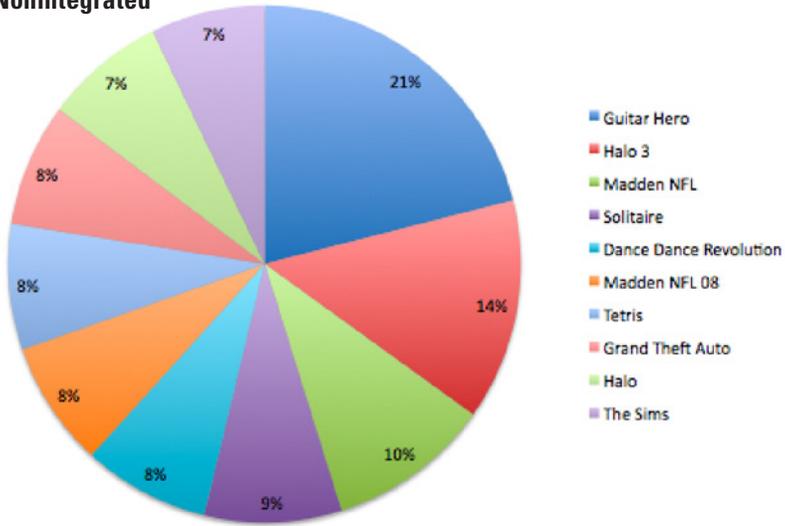
- **Contrast**—The idea behind contrast is to ensure that each element of the visual design is *significantly different* from the others. The eye is attracted to differences; it is the element that attracts the reader to the work. For example, if two or more different sizes of fonts are used, use two that are very different, such as these:

9 point 18 point

Integrated



Nonintegrated



Source: Adapted from Lenhart, Kahne, Middaugh, Macgill, Evans, & Vitak, 2008. Data is from the Gaming and Civic Engagement Survey of Teens and Parents, November 2007–February 2008. Margin of error is $\pm 3\%$.

Figure 11.6: The ten games most frequently played by teens.

- **Repetition**—Repeating elements of the design strengthens the unity of the piece. Repetition can be used with fonts, shapes, colors, thicknesses, spatial relationships, and so on. An example is shown in figure 11.7 (page 258) from the Technology Entertainment Design (TED) webpage (www.ted.com/talks/list), where each entry has the same style heading and format.
- **Alignment**—The way each element is placed on the page directs the order in which the reader's eye will move through the page. Thus, each element should have a visual connection with another element. In the example in figure 11.7, the eye is immediately drawn to the top headline and then drops to the visuals representing the six talks. For each talk, the proximity of the visual and text to its right causes the eye to flow to that text next, following the natural habit (in reading English) to move across the page, left to right. The natural inclination of the eye is to return to the visual but because the eye moves left to right, it returns to the text, and may repeat that eye movement several times. (The design thus creates eye movement that ensures all of the information in the text and visual will be processed.)
- **Proximity**—The eye prefers simple landscapes. Where possible, items that are related should be grouped close enough together to suggest to the eye that they are one visual element. This provides a clean structure, organizes information for the reader, and reduces visual noise. In the case of the Education Commission of the States Web heading in figure 11.8, there are four main elements, as outlined in the gray shading in the bottom portion of the graphic.

Visual literacy is a critical component of what it means to be literate in the 21st century. It can augment and extend students' critical thinking; deepen their understanding in science, math, social studies, and other core subjects; establish strong ties between the arts and sciences; provide a range of opportunities for expressions of what they know and are able to do; and help to ensure that they will be informed consumers of media.

Visual literacy is a critical component of what it means to be literate in the 21st century.

TED Ideas worth spreading

Themes

Speakers NEW

Talks

Translations

TED Conferences

TEDx Events

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Show talks subtitled in:

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Order talks by:

- Newest releases
- Most languages
- Most emailed this week
- Most comments this week
- Most favorited all-time
- Rated jaw-dropping
- ... persuasive
- ... courageous
- ... ingenious

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<p>TED2007</p> <p>Blaise Aguera y Arcas demos Photosynth</p> <p>07:30 Posted: May 2007</p> <p>Rated: Jaw-dropping Ingenious Fascinatn...</p>		<p>TED2006</p> <p>Jeff Han demos his breakthrough touchscreen</p> <p>08:47 Posted: Aug 2006</p> <p>Rated: Jaw-dropping Ingenious Fascinatn...</p>	
<p>TED2007</p> <p>Carolyn Porco files us to Saturn</p> <p>17:09 Posted: Oct 2007</p> <p>Rated: Jaw-dropping Fascinating Beautiful...</p>		<p>TED2007</p> <p>Hans Rosling's new insights on poverty</p> <p>18:57 Posted: Jun 2007</p> <p>Rated: Jaw-dropping Inspiring Informativ...</p>	
<p>TED2004</p> <p>Jennifer Lin improves piano magic</p> <p>24:05 Posted: Aug 2006</p> <p>Rated: Jaw-dropping Beautiful Inspirin...</p>		<p>TED2007</p> <p>Bill Stone explores the world's deepest caves</p> <p>17:43 Posted: Jun 2007</p> <p>Rated: Jaw-dropping Inspiring Courageou...</p>	

Source: *Technology Entertainment Design, n.d., www.ted.com. Reprinted with permission.*

Figure 11.7: Example of repetition and alignment.



Source: Education Commission of the States, 2010, <http://www.ecs.org>.
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Figure 11.8: Example of proximity.

Innovation Two: Democratization of Knowledge

The Internet has opened up a new opportunity for people to learn throughout their lives in both formal and informal environments, individually and in groups. Low-cost access to technology devices connected to high-speed broadband is now available to the majority of the population. Many communities are seeking broadband solutions to ensure equitable access for all members of the community. Despite this rapid growth of broadband in communities and homes, schools continue to play a role in ensuring that all students have robust access—at least within the school day.

The very ecology of learning is evolving. People are informally learning based on personal, professional, family, work, and community needs, interests, or responsibilities. Bridget Barron, a researcher from Stanford, has suggested that adolescent learning should be reconsidered in light of the informal learning opportunities now available to students (Barron, 2006). The diagram in figure 11.9 (page 260), based on Barron's work, identifies a host of formal and informal learning situations in which preK–12 students may be involved.

The implications for schools are significant. School is just one node among the learning contexts available to students; educators should be actively considering how to extend the formal learning launched in schools into other nodes. In addition, educators should seek to

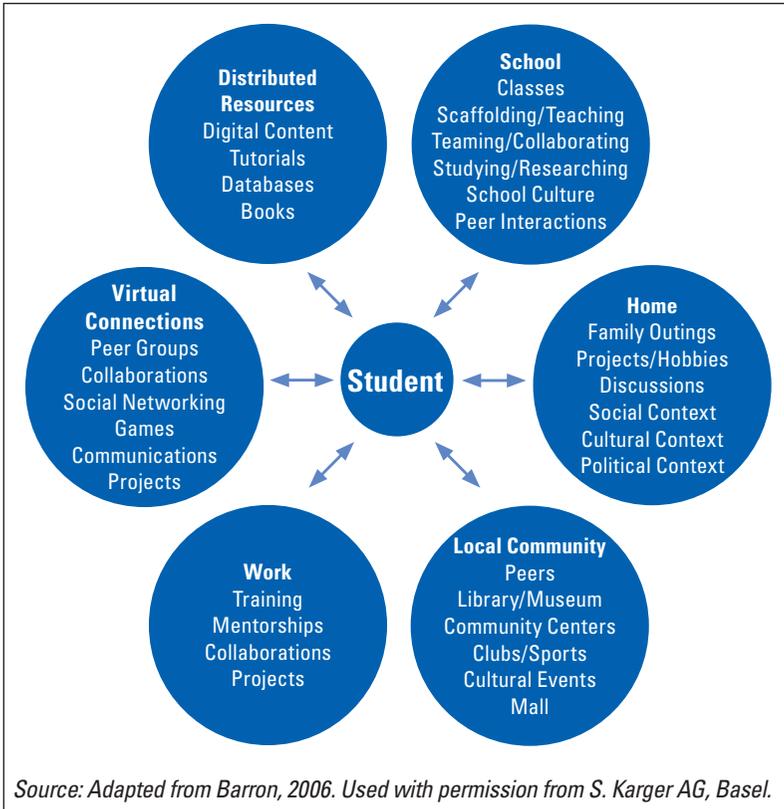


Figure 11.9: Contexts for 21st century learning.

become sufficiently familiar with the informal learning students are actively engaged in outside of school in order to integrate student interests with formal learning experiences. The intent would be to bring added relevancy and student interest to the formal work within the classroom and to integrate, to some degree, students' formal and informal learning. Another responsibility of schools is to ensure that students gain knowledge and expertise in navigating, interacting, and learning within digital environments. The taxonomy that one might consider in thinking about the democratization of knowledge includes:

- **Browsing the Net**—The universal adoption of *google* as a verb says it all. Information is truly at the fingertips of the informed Internet navigator. The key word is *informed*. While information is available, it is critical that schools provide intensive work with students on informed searching, navigating the

visible and invisible Web, critiquing websites to check for reliable sources, and persevering to ensure comprehensive, balanced searches.

- **Learning objects**—A learning object is a self-contained resource, usually digital and/or web-based, that can be used and reused to support learning. Many of the first learning objects were in the form of virtual manipulatives—dynamic objects through which students could explore properties to further their knowledge (Utah State University, 2007). Today, learning objects take the form of YouTube videos, iPod audio and/or video files, interactive websites, scripted slide shows, and so on. That means that twenty-four hours a day, seven days a week, these objects are available to interested learners. Learning objects can be used to supplement face-to-face classrooms, can be embedded in virtual classes, and can easily be accessed by students who are studying, but have not yet mastered the topic. For example, the National Council of Teachers of Mathematics Illuminations website provides many virtual manipulatives, including one that enables students to manipulate the areas that represent each element of the equation $(a + b)^2 = a^2 + 2ab + b^2$ (National Council of Teachers of Mathematics, 2009; visit <http://illuminations.nctm.org/Activity/Detail.aspx?ID=127> to view this manipulative). A second example is a calculator students can use to determine the emissions of their homes. The program enables them to manipulate entries to see the results on carbon emissions (U.S. Environmental Protection Agency, n.d.; visit <http://www.epa.gov/CHP/basic/calculator.html> to view this manipulative).
- **Simulations**—The depth of student learning increases when students are able to experiment with the parameters behind a visual simulation. For example, in a new generation of tools called Yenka, a U.K. firm enables students to learn some rudimentary steps in programming by controlling a dancer's onscreen actions through their creation and running of a flowchart. These resources are available, free of charge, for use by individuals in their homes, and can also be licensed for a fee by schools (Crocodile Clips, 2009; visit www.yenka.com/en/Yenka_Programming/ to view the simulation). A

free-of-charge simulation, SimCalcMathWorlds, enables students to experiment with rate, linear functions, and proportionality through graphing calculators and computers that generate math functions. For example, students are able to determine speed and rate of acceleration of two fish along a linear path while simultaneously watching the functions charted on a grid (see www.kaputcenter.umassd.edu/projects/simcalc/).

- **University courses available to the public**—In the first decade of the 21st century, many universities in the United States have made their courses available online. Currently, MIT Courseware (Massachusetts Institute of Technology, 2009) and Rice Connexions (Rice University, n.d.) have made thousands of courses available. Another digital access point for thousands of free university courses, lectures, and interviews is iTunes University.
- **Online courses for K–12 students and teachers**—According to a meta-analysis on online learning released by the U.S. Department of Education in May of 2009, online learning for both K–12 students and teachers is one of the fastest growing trends in educational technology (Means, Toyama, Murphy, Bakia, & Jones, 2009). The report indicated that the number of K–12 students enrolled in technology-based distance learning courses had increased by 65 percent from the 2002–2003 school year to the 2004–2005 school year. A recent report by the Sloan Consortium (Picciano & Seaman, 2009) estimated that more than one million U.S. K–12 students were engaged in online courses in 2007–2008, which represents a 47 percent increase since 2005–2006. The authors of that study reported a wide range of needs that were fulfilled through online courses, from those seeking advanced placement and college-level courses, to those needing credit recovery or remediation. This access provides a tremendous opportunity for students who are seeking an alternative to the local offerings in terms of courses available, timing of courses, and mode of learning.

The Florida Virtual High School (FVHS) is an example of one of the largest virtual high schools. In the 2007–2008 school

year, FVHS enrolled approximately one hundred thousand students nationally (diplomas are granted by the student's local community school). FVHS announced in the summer of 2009 a new American History, full-credit high school course to be conducted completely within the gaming environment Conspiracy Code (Nagel, 2009).

- **Online course units**—Many school districts and individual teachers are leveraging online learning as a supplement to classroom work. In some cases, teachers are using online units as an integral component of their courses. One example of online units is from the federally funded web-based Inquiry Science site hosted at the University of California, Berkeley (<http://wise.berkeley.edu>). The science inquiry units offered on this site are free of charge to participating schools. Four of the self-contained units are as follows: Airbags: Too Fast, Too Furious? (Grades 11–12); Global Climate Change: Who's to Blame? (Grades 6–9); TELS: Mitosis and Meiosis (Grades 9–12); and Wolf Ecology and Population Management (Grades 7–12). The units are typically four to five days (one class period) in length, are aligned to standards, include lesson plans, and are highly interactive for student teams through the website.

The democratization of knowledge provides the opportunity for lifelong individual and group learning. For students to leverage that opportunity fully requires critical thinking, information literacy, and a measure of self-direction, all of which need to be developed in part by our school systems. The democratization of knowledge also provides tremendous opportunities for educators to begin transforming their schools into physical and virtual places of 21st century learning. One of the critical differences from conventional education is a solid foundation in inquiry learning

that is student-centered and authentic. Educators are at a crossroads. They can embrace this democratization of knowledge by authentically connecting their students' formal and informal learning. Or they can ignore it and run the risk of obsolescence, becoming certification mills for the interactive learning that takes place out of school.

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Innovation Three: Participatory Learning

Today's schools are focused on individual acquisition of knowledge, student by student, despite the fact that, increasingly, society, community, and work emphasize teaming, collaboration, and participatory learning.

While the Internet of the 1990s gave previously underrepresented groups a public voice, the Web 2.0 tools of the 21st century have given rise to a participatory culture. The advent of Facebook, YouTube, Flickr, Twitter, RSS feeds, GPS tracking, smart mobile devices, and robust international broadband networks have enabled millions to interact in real time twenty-four hours a day, seven days a week. Web 2.0 tools have enabled everyone with sufficiently robust Internet access to post, exchange, and comment on video, audio, and text files; share tagging perspectives through sites such as Delicious.com; interact on social networking sites; participate in live chats; interact and share perspectives within communities of interest/practice; use GPS tracking and texting to connect in real time; participate in interactive, online games and gaming communities; and stay connected and informed through RSS feeds, Flickr, and Twitter.

New social patterns are emerging at unprecedented rates. People now expect to be active participants in these virtual communities, not just passive observers. At the heart of these communities is the evolutionary nature of community norms, content, discourse, and life cycle. Yes, someone establishes the foundational tools, but the community is seldom carefully and strategically planned. Rather, it evolves over time, shaped by dialogue, discussion, shared resources, responses to inquiries, commentary and critique, and levels of participation based on perceived value. An innovative example is the use of Facebook by a teacher to engage students in learning about the periodic table. (Visit go.solution-tree.com/21stcenturyskills for live links and to see full-color versions of the graphics in this chapter.)

At High Tech Middle School in San Diego, students used social networking to personally identify with the elements in the periodic table (see figure 11.10; <http://staff.hthcv.hightechhigh.org/~jmorris/period%20table%20page.html>). Students were asked to list personal characteristics, identify the attributes of elements, and then select which elements' attributes most closely aligned to their personal

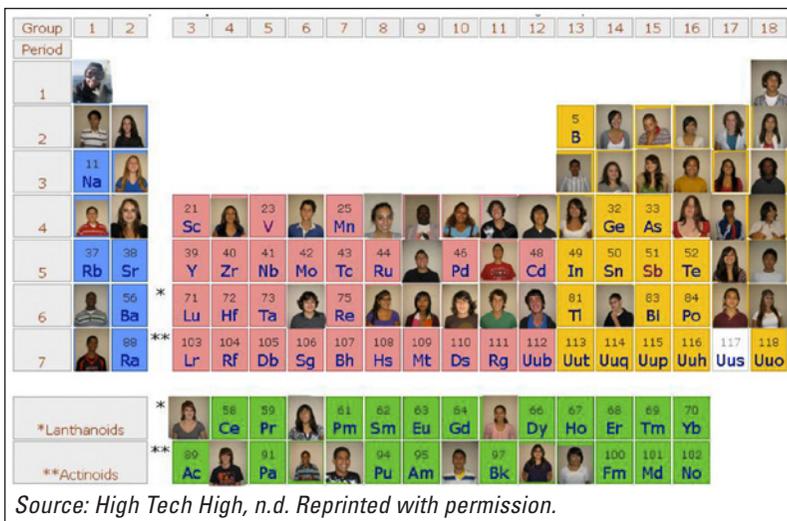


Figure 11.10: The Periodic Table: Students’ Facebook pages on the elements.

characteristics. Once their Facebook page was established for their element, they proceeded to “friend” other elements in alignment with their elements’ attributes.

By clicking on the live site, each student’s Facebook page reveals the characteristics of attributes they share with the element they believe aligns most closely to him or her. See figure 11.11 (page 266) for an excerpt.

That participatory culture is reflected in today’s economic globalization. Multinational corporations in particular epitomize this participatory culture, where the success of an individual is directly tied to the success of the teams within which they work. Often the effectiveness of the teams lies in the social and emotional maturity of the members, the diversity of members’ expertise, and members’ leadership and commitment. This is indicative of Web 2.0 participatory cultures where the power lies in the quality, frequency, expertise, backgrounds, and commitment of the participants.

From an educational perspective, it is important to note that participation is not synonymous to collaboration. A participatory culture can range from the harmonious to the acrimonious. The topic of interest that brings a community together may range from social justice to the intellectual, the political, the social, the economic,

Student Entry: What I have in common with Hydrogen.

Gets Along Well With Others: I have an easy-going nature about me and would consider myself to have a go-with-the-flow personality. Just like Hydrogen, I like to be near others and hanging out with friends any chance I get. In this fast-paced world we live in, sometimes it's nice to just spend some time relaxing with friends.

Low Boiling Point (-252.87 C): Generally, I am a calm and collected individual. As is true of anyone, I have my moments of high stress and low patience, but for the most part I am a calm and caring individual. I share my cool nature with Hydrogen.

Just like Hydrogen, I am little but powerful. I have always thought of myself as someone who is small but mighty. I am a strong individual who can take care of herself and others. I am someone you can depend on for strength and dependability. I share this strength and usefulness with Hydrogen.

Source: High Tech High, n.d. Reprinted with permission.

Figure 11.11: Student's Facebook page on Hydrogen.

a community perspective, or simply entertainment and personal interest. The size of the community, its purposes, its longevity, and the norms within those communities vary considerably.

As the three innovations (visualization, democratization of knowledge, and participatory learning) introduced in this chapter ripple through society, people are using their ingenuity to use those innovations for their own purposes. In doing so, they continually influence and redefine the very ecology of the society—hence the ripple effect. This same phenomenon is true of learning. Researcher Kai Hakkarainen and his colleagues discuss how educators think about learning in three distinct ways (Hakkarainen, Palonen, Paavola, & Lehtinen, 2004). The first is an acquisition model, which emphasizes what the individual knows and is individually able to learn. The second model is participation. In this case, the educator goes beyond the acquisition model to acknowledge the social aspect of learning. While students in this model might engage in collaborative work, the measure of success is still largely focused on how much the individual is able to learn, accompanied perhaps by a measure of the student's ability to work within a group, community, network, or culture. The third model is knowledge

creation. In this model, the output of the group or community is a valued asset, complemented by a measure of the individual's contributions to the team and acquisition of knowledge. The reality is that educators should be encompassing all three perspectives on learning.

Today's schools are out of sync with society—they are still operating on the acquisition model. They do register some forays into the participation model through collaborative learning, but they neither regularly establish structures that measure and value the group or community's collective knowledge construction, nor document the contributions of the student to that work. This translates into a need to restructure learning, teaching, and assessment to increasingly emphasize and value the participation in groups and the group's knowledge creation, in addition to the individual's acquisition of knowledge. This is necessary if schools are to graduate students who are ready to thrive in this new participatory culture.

Implications of the Three Innovations

Students who are learning in schools influenced by the innovations of visualization, democratization of knowledge, and participatory cultures need different skills than prior generations. Tremendously important to these students are the skills discussed throughout this book, including critical and creative thinking, self-direction, collaboration, multimodal learning, and adaptability. The ecology of learning will itself evolve over time, with students taking stronger, more active roles in shaping their learning trajectories, often blending informal and formal learning in face-to-face, virtual, and hybrid learning never before possible. One of the immediate ways in which schools can immerse students in such learning is through authentic learning. Such learning is defined by Fred Newmann as learning that has three key elements: (1) deep inquiry (Higher Education Academy, 2009) into the subject matter (as opposed to surface learning), (2) relevancy beyond the school day (students are working with teams outside of the school on projects that matter), and (3) knowledge construction (students are producing

Students who are learning in schools influenced by the innovations of visualization, democratization of knowledge, and participatory cultures need different skills than prior generations.

and constructing actual products to contribute to the community of interest as they demonstrate what their team now understands and what they individually understand).

Getting There From Here

To ensure U.S. students are ready to thrive in today's global, knowledge-based society, our schools need to embrace the innovations of visualization, democratization of knowledge, and participatory cultures for learning. This begins through leadership's creation of a culture of openness, risk taking, and adaptability within schools, where learners, teachers, and their communities can investigate how these innovations will change, grow, and adapt learning inside and outside of school. A first step is to gauge your school's readiness for 21st century learning. Metiri Group's Dimensions of 21st Century Learning (D21) provide a framework for gauging such readiness (Metiri Group, 2008):

- **Vision**—Does your school system have a forward-thinking, common vision for 21st century learning that represents societal innovations to serve as a unifying and energizing force of change?
- **Systems thinking/leadership**—Are all educators and staff thinking and acting systemically to embrace innovation in ways that advance the vision?
- **21st century skills/learning**—Has your school system adopted 21st century skills in the context of research-informed learning strategies?
- **21st century learning environments**—Is the vision of 21st century learning coming to life in your schools?
- **Professional competencies**—Are your teachers, administrators, and other staff ready to facilitate, lead, and assess 21st century learning among students, the community, and parents?
- **Access and infrastructure**—Is the access to technology devices and the infrastructure sufficiently robust to support 21st century learning?

- **Accountability**—Are learners, educators, and the system held accountable for making progress, while also provided with the data and support for achieving results?

For educators, this framework translates into a need for leadership that (1) establishes a culture of openness to new ideas in and outside of education, (2) encourages calculated risk taking, and (3) is sufficiently insightful to establish a process that accelerates the spread of powerful, creative ideas that have the potential to “tip and ripple.” Authors from the *Harvard Business Review* suggest such leaders should be strategists, those who generate organization change in highly collaborative ways that, at times, challenge and change current assumptions (Rooke & Torbert, 2005).

It is time to challenge assumptions in today’s preK–12 school systems and embrace the ripple effects of these three innovations: visualization, democratization of knowledge, and participatory learning.

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