Collecting Data with Mobile Technologies

Mobile devices are an integral part of children's lives and they are here to stay. Our national debate must shift from whether to use these devices to support learning, to understanding how and when they might best be used. Just as Sesame Street introduced generations of children and their families to the potential of television as an educational medium in the 1970s, today's children will benefit if mobile becomes a force for learning and discovery in the next decade. (Schuler, 2009, p. 9)

Today's students are very different from those only a few years ago in terms of their experiences with and expectations of technology. This is a digital generation—one that has no memory of life without a multitude of mobile technology tools. Mobile devices come in many forms. They may be iPhones and other mp3 players, digital cameras, personal digital assistants (PDAs), small tablet notebooks, iPods, or cell phones. All of these and more are part of daily life for many young people, and the lines of functionality between these devices are blurring. Cell phones and PDAs take pictures and have calendar functions; iPods record video and play podcasts, and videos transferred from a laptop or cell phone. Wireless technology augments the increasing number of things one can do with these devices, as easy access to the Internet allows one to upload and download data anywhere there is an accessible wireless access point.

Prensky (2001, 2003, 2005) has labeled this generation "digital natives" and cautions those who were born into but later adopted digital technology (the "digital immigrants") about the different language spoken by natives versus immigrants. While many "immigrants" have embraced technology as fully as the "natives," the point is well taken—we must understand the fundamental differences between the ways natives and immigrants perceive, value, and use technologies. Otherwise, we risk designing learning experiences with little relevance, interest, or meaning for students.

Cell Phones, iDevices, and PDAs

Many countries, notably countries in Europe, China, Japan, and the Philippines, are using cell phones as learning tools (Prensky, 2005). Prensky states, "Cell phones have enormous capabilities these days: voice, short messaging service (SMS), graphics, user-controlled operating systems, downloadables, browsers, camera functions (still and video), and geopositioning. Some have sensors, fingerprint readers, and voice recognition. Thumbnails keyboards and styluses as well as plug-in screens and headphones turn cell phones into both input and output mechanisms" (p. 12). Prensky envisons cell phones as tools for accessing animations to support learning, for narrating guided tours, or to access language or vocabulary training.

When one looks quickly and effortlessly a teenager can key in a text message on a cell phone, it's reasonable to imagine a future where innovative educators take advantage of young people's familiarity with cell phones. The Kaiser Family Foundation reported that two-thirds (66%) of all 8- to 18-year-olds own their own cell phone, up from 39 percent five years ago (Rideout, Foehr, & Roberts, 2010). These numbers can be expected to increase as cell phones become as commonplace as televisions and radios.

Teachers have reported that different types of these handheld devices can be effective tools for instruction and positively impact student motivation (Crawford & Vahey, 2002; Swan, Van't Hoog, & Kratzoksi, 2005; Vahey & Crawford, 2002). The relative low cost and small size of mobile devices makes them ideal for ubiquitous learning and data collection in the field. Students can gather data and display and manipulate them to test predictions using mobile devices in authentic environments. Using wireless or 3G technologies, they can access the Internet while doing fieldwork. Field notes can be recorded using text, audio, and/or video.

For several years, most handhelds used in K-12 schools were Pocket PCs, which run a form of the Windows operating system, or devices running the Palm operating system. At one time PDAs were a fast growing segment of handhleds; however, they have been eclipsed by iPods, iPod Touch, tablets, and cell phones. Palm has discontinued its educational program and no longer supports the former PDA models that schools used, referring to them as "historical devices." Many of the applications that ran on Palm handhleds have been reworked and are now available for downloading to an iPhone, iPad, or iPod Touch. The convergence of features and ease of use of smartphones with computerlike operating systems makes them inexpensive option for many educational purposes, including instruction. Schuler (2009) said, "While it is important to understand how the latest innovations in mobile technologies—GPS, QR Codes, accelerometers, etc.—can be used for education, in order to develop scalable models, one should also consider features that will become ubiquitous. Relying on features that are more common on less expensive phones will help ensure that mobile technologies can help close rather than amplify the digital divide" (p. 34).

Perhaps the most commonly perceived problem with handheld use is the small screen size. While reading on a miniature screen seems unworkable for many adults, it appears that children don't regard it as difficult (Prensky, 2003). Most students, accustomed to the scale of portable gaming devices and of texting on cell phones, have no trouble with the small screen. However, the inexpensive keyboards that can be purchased for some devices make them more closely resemble a computer and can make data input faster and easier. Mobile devices should be synced regularly with a computer to back up information. Other management issues include the need for regular recharging, physical use and storage of the devices throughout the school day, ownership, and acceptable use policies.
Sensor Technology

Sensor technology surrounds us, from red light traffic cameras to automatic soap dispensers to sensors that are integrated into a myriad of mobile devices, including global positioning systems (GPS). A sensor is a device that receives input to which it responds by converting the data to an electrical or optical signal that is recorded in digital or analog format. Sensor technology can support scientific investigation. ProbeWare, a term describing equipment and software used to gather and analyze data, can be combined with laptops or graphing calculators for highly interactive learning experiences. For example, Vernier's LabPro offers an assortment of sensors, software, and hardware interfaces that can be combined for collecting and analyzing data. This type of package might be used with a computer, graphing calculator, handheld or GPS unit, or on its own as a remote data collector. USB connections simplify the transfer of data from probes.

Using probeWare sensors and interfaces with mobile devices facilitates interactive, inquiry-based learning by providing multiple representations of data as experiments are being conducted. Probes also make scientific experiments easier for students to perform and analyze (Tinker & Krajcik, 2001). ProbeWare is quite visual, with real-time data displayed as tables, graphs, meters, or values. Manipulating variables is easily accomplished, with instant visible results that graphically portray relationships, rules, and principles.

Probes can be used to support learning in chemistry, biology, math, and physics. They may measure such things as temperature, pH levels, voltage, pressure, force, motion, and magnetic fields. Probes use a transducer to convert the physical phenomena to an electrical signal, which is then converted to a number by analog interface circuitry or digitally and communicated to the computer. The analog interface may either be built into the sensor or be a separate piece of equipment in between the sensor and the computer.

Digital probes contain a microcomputer chip that can calibrate information and convert measurements to digital format. The sensor attaches to a laptop via the USB port, and additional software applications can extend what happens to data once it has been transferred. Built-in Bluetooth technology is another method of data exchange. Bluetooth uses radio frequencies to transfer information between Bluetooth-compatible devices nearby, like computers, mobile phones, and other handhelds.

Wireless technology can also allow students to share data with other students as it is being collected. Imagine teams of students who are collecting information about water quality in a river. Team data might be shared by mobile devices, allowing students in the field to analyze data, look for trends, formulate hypotheses, and be guided toward other investigation. Using Documents to Go on a cell phone or PDA, students could enter data in Excel spreadsheets or share data from graphing calculators attached to probes.

GPS

The GPS, a satellite-based navigation system comprised of a network of 24 satellites, was created by the U.S. Department of Defense for military applications but was made available for civilian use in the 1980s. GPS is free and works worldwide, anytime, in any type of weather.

Garmin, a navigation and communications equipment company, describes GPS functioning as follows:

GPS satellites circle the earth twice a day in a very precise orbit and transmit signal information to earth. GPS receivers take this information and use triangulation to calculate the user's exact location. A GPS receiver must be locked on to the signal of at least three satellites to calculate a 2D position (latitude and longitude) and track movement. With four or more satellites in view, the receiver can determine the user's 3D position (latitude, longitude, and altitude). Once the user's position has been determined, the GPS unit can calculate other information, such as speed, bearing, track, trip distance, distance to destination, sunrise and sunset time and more.

Mobile devices such as cell phones are an excellent source for built-in GPS, with half the phones in the United States equipped by late 2009 (Schuler, 2009). In other cases, small GPS units may work in conjunction with other mobile devices. Separately purchased GPS devices can be used in the field, with data transfer to a laptop or, later, to a desktop computer. A standard GPS receiver not only will place you on a map at any particular location but also will trace your path across a map as you move. If you leave your receiver on, it can stay in constant communication with GPS satellites to see how your location is changing.

GPS units can be used in an interesting activity known as geocaching. Like a treasure hunt, geocaching involves physically searching for a hidden cache whose location is given through GPS coordinates on a website. The cache container contains a logbook and items as rewards; finders are asked to leave something for the next person and to record the date and time in the logbook. On its own, geocaching utilizes students' problem-solving skills, mathematical thinking, and mapping abilities. Geocaching might be combined with a study of geology, the environment, or biology. As students navigate, they may encounter plants, animals, rocks, historical sites, and any number of things that lend themselves to additional learning. Teachers often find that nature guidebooks, digital cameras, audio and/or video recorders, and notepads are useful in GPS activities. Sensor technologies are a good fit when students take to the field for geocaching or other GPS work. There are many geocaching—The Official Global GPS Cache Hunt Site (www.geocaching.com). GPS units and mobile devices can also be used in conjunction with geographic information systems (GIS) (see Chapter 9).

Conducting Field Experiments

Let's explore some uses of mobile technologies to see how they have been used with students in authentic learning situations. The following examples highlight the rapidly changing nature of technology, particularly in the realm of small handheld devices. Although Palm PDAs were used for these field activities, other mobile devices could easily substitute (e.g., iPad, smart phone, laptop). One widely used PDA application was Documents to Go, which allowed users to transfer Microsoft Office files between a computer and handheld. Documents to Go and Sketchy, both used in the following example, are among the thousands of apps now available through iTunes, with more being developed every day.
Water Analysis Water quality evaluation is frequently conducted using handheld probes (Vahey & Crawford, 2002). Students take handhelds and probes to a nearby stream or other body of water. After individual students measure different points along the streambed, data are combined by beaming them to one another or aggregating them on one unit. When students return to the classroom, handhelds are used to graph and analyze the combined data set. For many teachers, finding nearby bodies of water to sample will be relatively easy. Depending on the results of the water analysis, students might research solutions for improving water quality, hypothesize about the effects on aquatic and amphibian life, determine where runoff is originating, or design a plan for filtering water.

Nature Mapping The Nature Mapping Program (http://naturemappingfoundation.org) is combining GIS (see Chapter 9) use with data collection in authentic work that connects schools with experts and communities. The program's vision is "to create a national network that links natural resource agencies, academia and land planners with local communities primarily through schools." NatureMapping incorporates species identification and data collection; data analysis, statistics, and graphics; and computers, remote sensing, GIS, local area networking, and the Internet.

Diane Petersen (2005) described some NatureMapping work done in Waterville Elementary School in Waterville, Washington. Beginning in 1999, Petersen's fourth graders began working with local farmers to collect data about short-horned lizards, an at-risk species. Farmers, who were frequently in locations where these lizards might be spotted, logged information about when and where they were seen. Later, farmers and students worked together to locate fields on maps and create tables with the data. Using aerial photographs of farmers' fields overlaid on digital maps, computer maps were then generated that depicted lizard sightings. Students also made spreadsheets to display related data. Students then generated questions, analyzed the data, and selected what was needed to graph information and answering the question. Petersen describes this project as strengthening the school-community relationship. The serious, real-life contribution students are making has resulted in students who view themselves as scientists, with technology enhancing the work and partnerships. Initially, students collected data, but because the farmers were frequently in their fields and available to log information, they supplied most data in this particular case. However, students can do similar data collection, using mobile or simple logging devices to record information.

Arbor Day/Earth Day Tree Exploration Let's look next at an effective yet easy use of mobile devices to collect field data. Suzanne Stillwell, a fourth-grade teacher at a rural school in Hallsville, Missouri, described an Arbor Day/Earth Day activity using the school grounds as her students' laboratory. Before beginning the activity, students spent three 45-minute periods practicing with the technology so they would know how to use it. They also brainstormed data they could collect from trees on the school grounds. The information they decided to collect was height of the tree (1 meter above the ground), height of the tree's shadow (correlated to the height of the tree, if measured at the right time of day), and types of leaf and tree identification. Students used this website to help understand the measurement of the tree's shadow: http://micro.magnet.fsu.edu/primer/java/scienceoptic/shadows.

Each partner team selected two trees on the school grounds and did the following:
1. Took a picture of the tree using the handheld cameras
2. Collected a leaf sample and took a picture of the leaf
3. Measured the girth of the tree in centimeters and recorded the information in an Excel table in Documents to Go on the handheld
4. Measured the shadow of the tree and recorded the information in an Excel table in Documents to Go on the handheld

After returning to the classroom, students beamed their information about the trees to two other teams. Each team then had information on six trees. Students uploaded the tree data to computers and made graphs showing the information of tree girth and height.

Students used their leaf samples and digital pictures to identify trees with the Missouri Department of Conservation tree manual and these online sources: www.grownative.org/index.cfm and www.mdc.mo.gov/nathis/plantpage/flora/motree/s.

Because this was one of the first projects the students had done with handhelds, they were excited about the assignment. Some of the students figured out how to put the pictures of their trees in the Excel file with the graph and data table. There was strong motivation for students to record data and share information with each other through beaming between handhelds.

Denali National Park Fire Succession Study This last example illustrates how sensor technology can be used along with other mobile devices. In the summer of 2004, the Denali Borough School District teamed with the Eastern Area Fire Management of the National Park Service to study fire succession by monitoring the vegetation recovery in three burn areas in Alaska's Denali National Park and Preserve. Using Palm handhelds equipped with digital cameras and SmartList to Go, a program that allows one to create, view, and manage databases on a handheld, students first created a field guide of plants and animals they observed.

Next, students used a Vernier temperature sensor (ImagiWorks) and software (ImagiProbes) to measure permafrost temperature and depth at each burn site. Documents to Go software (www.dataviz.com/products/documentstogo/) enabled the creation of a Microsoft Excel spreadsheet recording temperature data and numbers of plant species found in each transect.

Handhelds were synced with a laptop to transfer and combine data for a complete count of species coverage. Participants also represented their concept of fire succession by using handhelds to draw animations on their handhelds using Sketchy (see Figure 2.9).

In each of these instances, students are engaging in active, real-life work that goes beyond the classroom to involve data collection in the field. The use of technology enables students to measure, record, manipulate, share, and represent data as they are used to answer important questions. Activities such as these place students in the role of investigating scientists and motivate them through interesting, authentic work that is relevant to their world.
A third-grade teacher described using a simple online survey to begin a nutrition unit with her students. As students answered questions about their eating habits and knowledge of nutrition, they also learned math skills. After data were collected, students created graphs depicting information such as the number of students who ate breakfast every day, how frequently students drank soda, and their favorite food selected from a list of 12 items. These results served as a springboard for discussions concerning reasons that students selected cookies as their favorite food, the influence of sugar in our diets, cause and effect, healthy eating, and how to make good food choices.

While the nutrition survey was conducted within a classroom, online surveys enable data collection from a wide audience. Students who are creating surveys themselves first need guidance in creating well-constructed survey questions. Timmerman (2003) suggests looking at examples of poorly and well-written questions, explaining the difference between open-ended and closed-ended questions, and considering how easily responses can be analyzed and graphed. Table 2.2 provides suggestions and examples for writing good surveys.

<table>
<thead>
<tr>
<th>Table 2.2</th>
<th>Suggestions for Writing Surveys</th>
</tr>
</thead>
<tbody>
<tr>
<td>Use simple language</td>
<td>Unnecessary: How often do you eat dinner at home? What time do you eat dinner? Better: How often do you eat dinner at home?</td>
</tr>
<tr>
<td>Include only one concept per question</td>
<td>Complex: With what regularity do you frequent your preferred dining establishments? Better: How often do you eat at your favorite restaurants?</td>
</tr>
<tr>
<td>Avoid biased or leading questions</td>
<td></td>
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<tr>
<td>Avoid confusing questions where respondents are unclear as to what is being asked</td>
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<tr>
<td>Avoid double-barreled questions that contain more than one question where respondents may agree with one but not the other.</td>
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</tr>
</tbody>
</table>

We live in a culture that is saturated with market research and opinion polls to find out what people think about all kinds of things. What is your opinion regarding this candidate, this issue, this media personality? What is your favorite (fill in the blank)? How often do you purchase this product, read this magazine, or eat at this restaurant? What do you think about the latest environmental problem? What are you willing to do or do without to solve it? Sampling is done via phone, paper questionnaires, and websites.

Online survey tools enable data collection opportunities across the curriculum. These tools range in functionality, ease of use, and cost. Some are free online survey websites (e.g., Free Online Surveys); others offer tiered services ranging from a free option to paid subscription levels. Frequent users may appreciate the added features that a subscription survey site offers (e.g., SurveyMonkey, Cool Surveys, Zoomerang). Free survey sites typically limit the number of questions, responses, and/or participants that are allowed. Subscription survey tools are more likely to allow unlimited surveys, customizing options, and data analysis tools that filter results to help users find patterns in the data. Other survey tool features can include sharing of results, downloadable files for export to spreadsheets, randomizing the order of answer choices to reduce bias, and requiring responses to questions the survey creator specifies.

Some online survey tools support participants’ responses in real time after the survey has been created on the survey website. An example is Poll Everywhere, which collects responses sent by cell phone text messages, Twitter, or the Web and embed that data in live charts inside PowerPoint or Apple Keynote presentations. Mobiodoce, another survey tool, collects responses from cell phones, displaying results in real time on the Web interface or in Excel. Although many schools currently ban cell phone use, we envision a day when students are able to use these devices to enhance learning. A student might create a presentation on the effects of a city’s recycling initiative and, during the presentation, survey other students in the class to determine their recycling habits. Of course, students could respond to such questions simply with raised hands, but this method provides anonymity and automatically presents results in a graph.
Survey participants may be members of the originating class, students in other classes within the school or in other schools, students in other countries, teachers, or parents, depending on the purpose of the survey. Community groups or organizations could be used to identify potential respondents. For example, students might contact the Audubon Society or World Wildlife Federation for an environmental survey needing expert opinions.

When students create surveys, they engage in learning that is intentional and authentic. Identifying the purpose of a survey, making decisions about the information that is needed, formulating well-designed questions that will elicit that information, and selecting the most appropriate respondents for gaining that information entail many cognitive processes. After data are collected, students must then analyze and evaluate the results, determining trends, possible causes and effects, and other phenomena that inform their purposes. Thus, an online survey may culminate in this data analysis or it might be the beginning of a larger, more inclusive project. For more on online surveys from an assessment perspective, see Chapter 10.

Conclusion

When students are given opportunities to investigate relevant, interesting phenomena and use the information they gather to solve problems, answer their questions, or inform others, they engage in learning that has significance and value. As we have seen, technologies can support and extend student investigations. Internet resources reach far beyond text files, with audio and video, graphics, and online simulations widely available. Tools such as online survey sites offer students a mechanism for data collection from a worldwide pool of participants. We are a digital information society, which means that it is imperative that students understand the online environment—the nature of online spaces, as well as the skills to access, manage, and evaluate information found there—in order to be well-educated, intelligent, 21st-century consumers and producers of information and knowledge.

We are also a mobile society. Wireless devices can enable children to engage in flexible learning environments that permeate their daily lives (Inkpen, 1999; Soloway et al., 2001). Soloway said, “The kids these days are not digital kids. The digital kids were in the ‘90s. The kids today are mobile, and there’s a difference. Digital is the old way of thinking, mobile is the new way” (in Schuler, 2009). Traditional lab settings that typically focus on the process of students collecting data are enhanced by the use of mobile devices that encourage analysis and problem solving. Students can collect data, display, and manipulate them to test predictions using mobile devices. While these technologies have much to offer, their value is determined largely by the way teachers integrate them into the curriculum. When thoughtfully used to promote active, reflective, complex learning, Internet and mobile technologies are at their best.

NET Standards potentially engaged by inquiry activities described in this chapter:

3. Research and Information Fluency
   a. Plan strategies to guide inquiry

b. Locate, organize, analyze, evaluate, synthesize, and ethically use information from a variety of sources and media
c. Evaluate and select information sources and digital tools based on the appropriateness to specific tasks
d. Process data and report results

4. Critical Thinking, Problem Solving, and Decision Making
   a. Identify and define authentic problems and significant questions for investigation
   b. Plan and manage activities to develop a solution or complete a project
c. Collect and analyze data to identify solutions and/or make informed decisions
d. Use multiple processes and diverse perspectives to explore alternative solutions

6. Technology Operations and Concepts
   a. Understand and use technology systems

21st Century Skills potentially engaged by inquiry activities described in this chapter:

Reason Effectively
   ▪ Use various types of reasoning (inductive, deductive, etc.) as appropriate to the situation

Make Judgments and Decisions
   ▪ Effectively analyze and evaluate evidence, arguments, claims, and beliefs
   ▪ Analyze and evaluate major alternative points of view
   ▪ Synthesize and make connections between information and arguments
   ▪ Interpret information and draw conclusions based on the best analysis
   ▪ Reflect critically on learning experiences and processes

Access and Evaluate Information
   ▪ Access information efficiently (time) and effectively (sources)
   ▪ Evaluate information critically and competently

Use and Manage Information
   ▪ Use information accurately and creatively for the issue or problem at hand
   ▪ Manage the flow of information from a wide variety of sources
   ▪ Apply a fundamental understanding of the ethical/legal issues surrounding the access and use of information

Analyze Media
   ▪ Understand both how and why media messages are constructed, and for what purposes
   ▪ Examine how individuals interpret messages differently, how values and points of view are included or excluded, and how media can influence beliefs and behaviors
   ▪ Apply a fundamental understanding of the ethical/legal issues surrounding the access and use of media
Apply Technology Effectively

- Use technology as a tool to research, organize, evaluate, and communicate information
- Use digital technologies (computers, PDAs, media players, GPS, etc.), communication/networking tools and social networks appropriately to access, manage, integrate, evaluate, and create information to successfully perform a job in a knowledge economy
- Apply a fundamental understanding of the ethical/legal issues surrounding the access and use of information technologies

Things to Think About

Here are some questions to think about as you consider using Internet resources, mobile devices, and other investigative technologies with students:

1. What are the implications for teaching and learning when these tools are included in instruction?
2. What impact will (can) mobile devices have on the curriculum?
3. How can mobile devices be used to augment your existing curriculum?
4. Who will provide the funding, support, and training for use of mobile devices?
5. Some people object to students using mobile devices, arguing that these are unnecessary, frivolous, and little more than toys. How would you respond?
6. How can we evaluate the effectiveness of these devices?
7. How will we manage student use of mobile devices?
8. What will happen if a student loses or breaks a mobile device?
9. How will mobile devices be physically cared for, especially if students take them home at night?
10. What information literacy skills do my students have?
11. What do my students need to know before engaging in Internet searches?
12. Are students’ information searches conducted in a meaningful context?
13. How are students using the information they gain from Internet searches?
14. What is the Internet? Is it the computers, the programs, and multimedia documents that people store and make available, or is it the people who contribute the ideas? Or is the Internet "only minds."
15. Given the potential for students to encounter undesirable material on the Internet, what is the appropriate balance between protection and free access to information?

References
