Twenty-first century learning: communities, interaction and ubiquitous computing

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Advanced technology makes 21st century learning, communities and interactions unique and leads people to an era of ubiquitous computing. The purpose of this article is to contribute to the discussion of learning in the 21st century. The paper will review literature on learning community, community learning, interaction, 21st century learning and ubiquitous computing. It will also present work conducted by a teacher who used a hand-held device, one of the 21st century tools, in a sixth grade classroom in the USA. The authors suggest that 21st century learning involves five types of interactions: (a) learner–content, (b) learner–teacher, (c) learner–learner, (d) learner–interface and (e) learner–community. They also recommend that professionals explore the potential of hand-held devices in education and conduct research on its effectiveness in learning.

L'apprentissage au vingt et unième siècle: les communautés, l'interaction et l'ordinateur passe-partout
La technologie avancée donne leur caractère unique à l'apprentissage, aux communautés et aux interactions et conduit les gens vers l'ère de l'ordinateur passe partout. Le but de cet article est d'apporter une contribution au débat sur l'apprentissage au 21e siècle. Cet article va passer en revue les publications sur les communautés d'apprentissage, l'apprentissage communautaire, l'interaction, l'apprentissage au 21e siècle et l'informatique passe partout. Il présente aussi les travaux menés par un enseignant qui a utilisé un ordinateur de poche, un de ces outils du 21e siècle, dans une classe de 6e aux Etats-Unis. Les auteurs pensent que l'apprentissage du 21e siècle met en jeu cinq types d'interaction différents: a) apprenant/contenu, b) apprenant/enseignant, c) apprenant/apprenant, d) apprenant/interface, et e) apprenant/communauté. Ils recommandent aussi que les professionnels étudient les possibilités des ordinateurs de poche pour l'éducation et mènent des recherches sur leur efficacité en matière d'apprentissage.

Lernen des einundzwanzigsten Jahrhunderts: Gemeinschaften, Interaktion und der allgegenwärtige Einsatz von Computern
Fortschrittliche Technologie macht das Lernen, Gemeinschaften und Interaktionen im 21. Jahrhundert einzigartig und führt die Menschen zu einer Ära allgegenwärtiger Computernutzung. Der Zweck dieses Artikels ist, zur Diskussion über das Lernen im 21. Jahrhundert beizutragen. Das Papier überprüft Literatur über Lernumgebungen, Lernen in Gemeinschaften, Interaktionen, Lernen im 21. Jahrhundert und allgegenwärtige

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Computerbenutzung. Es zeigt auch den von einem Lehrer durchgeführten Versuch, mit einem "handheld"-Gerät, einem der technischen Hilfsmittel des 21.Jahrhunderts, in einer "sixth grade class" in den USA zu arbeiten. Die Autoren behaupten, dass das Lernen in diesem 21. Jahrhundert fünf Arten von Interaktionen umfasst: (a) Lerner – Inhalt, (b) Lerner – Lehrer, (c) Lerner - Lerner, (d) Lerner – Schnittstelle und (e) Lerner - Gemeinschaft. Sie empfehlen auch, dass Fachleute das Potential von "handheld"- Geräten im Bildungsbereich untersuchen und eine Einschätzung ihrer Wirksamkeit für das Lernen abgeben.

Introduction

Twenty-first century learning is unique in history due to the rate of technological advancement. Modern technology transforms the ways 21st century citizens communicate with each other and provides 21st century learners with a variety of learning methods. Although many systems and/ or beliefs have been shifting because of technological development, the human need to interact with others and to learn in a social context has not changed.

Human beings are social creatures with an instinctive need and desire to exchange information with fellow community members. The sharing of common goals and activities reinforces the community's structure; the spreading of new ideas and knowledge helps communities evolve and expand. Throughout history community members have employed various types of technology to transmit information. Whether it was by group storytelling, by banging a drum or by sending smoke signals, people have learned to overcome time, distance and other obstacles to share thoughts, ideas and experiences.

The Smithsonian Institute points to 1837 as the dawning of the Information Age, when Samuel Morse first sent and received coded messages. The concepts underpinning this age are both the production and dissemination of information, free from the constraints of time and geography (McFarlane, 2003). The constraints have become increasingly transparent during the past decades: from communicating via a single mainframe computer, desktop and laptop computers to the current era of ubiquitous computing (Weiser, 1991), which brings human beings to the level that technology is seamlessly infused into the fabric of a person's everyday life.

The purpose of this article is to contribute to the discussion of learning in the 21st century. It begins with a review of learning community, community learning, interaction, 21st century learning and ubiquitous computing. This is followed by an exemplary case in which a teacher used a hand-held device in a sixth grade classroom in the USA. The authors do not consider the case as a research study but use it to stress the importance of a hand-held device in 21st century learning. The authors hope that the article may help educators better understand 21st century learning and generate professional dialogue about ubiquitous computing in education.

Learning, community, interaction and ubiquitous computing

When learning takes place between a group of people with common interests living together within a common location, humans participate in community learning. This is usually conducted at a physical location central to the members of the community, such as the local community recreation centre. When participants from diverse backgrounds and scattered locations organize to learn together, learning communities are formed. Until the evolution of recent digital and telecommunications technology, it was challenging to find a common physical meeting place for members of widespread communities. Virtual environments, however,

now facilitate these diverse learning communities, and ubiquitous computing further expands the communities.

Community learning

Community learning uses education to create and enhance learning opportunities in a local setting. This approach generally involves the entire community, both young and old, individuals and groups, novices and professionals, for the enrichment of the entire population. With this conviction, the Dundee City Council in Scotland approved a comprehensive community learning programme in 2000. The Community Learning Partnership, a collaboration between local government and organizations from the voluntary and statutory sectors, was developed to combat high levels of long-term unemployment and other significant poverty indicators. This partnership defined community learning as learning 'which is associated with personal development and, in the collective sense, development of the capacity of communities. Effective community learning will, therefore, impact on both the individual and the community' (*Dundee community learning strategy*, Dundee City Council, 2000, p. 10).

The partnership envisions voluntary community learning for citizens of all ages as an essential part of life-long learning, resulting in increased individual self-confidence, skills and knowledge. Community capacity expands, reflected in an improved social infrastructure, greater wealth creation, environmental improvement and a more vibrant local democracy. Learners of all ages and backgrounds participate in structured or unstructured, accredited or non-accredited, vocational or non-vocational learning experiences.

Although community learning has always been a dynamic part of the human fabric, American President George W. Bush made the 21st Century Community Learning Centers (21st CCLC) Program a key component of the *No child left behind act of 2001* (US Department of Education, 2001). This federal education policy legislation signified major changes to the American elementary and secondary education landscape by being designed to drive broad gains in student achievement and to hold states and schools more accountable for student progress.

In 2003 the US Congress appropriated $993.5 million to after-school programmes for students and their families from 6800 rural and inner city public schools in 1420 communities. This legislation provides expanded academic and social enrichment opportunities for children attending low performing schools. Community members have access to many programmes, including tutorial services, counselling, character development, drug education and violence prevention. Society as a whole benefits when community members not only access these programmes, but also various forms of technology, art, music and recreational education.

Albeit the *Dundee community learning strategy* and the 21st Century Community Learning Center Program are recent developments, the concept of using technology as the catalyst for community learning has been a goal for more than two decades. Papert (1980) first introduced the term 'technological samba schools' to describe a social concept of learning.

At samba dance schools in Brazil a community of people gathers to prepare for Carnival. Members of the school range in age from young children to elderly grandparents and in ability level from novice to professional. They dance together and, as they dance, everyone is learning and teaching as well as dancing. People go to samba schools not just to work on their presentations, but also to socialize and be with one another.

Papert envisaged learning in a technological samba school as:

- self-motivated;
- richly connected to popular culture;
- focused on personally meaningful projects;
- community based;
- an activity for people of all ages to engage in together;
- life long, experts as well as novices seeing themselves as learners;
- situated in a supportive community. (Bruckman, 1999, pp. 14–15).

Bruckman (1997) expanded on the original analogy, describing a decreasing emphasis on information and increasing emphasis on community and the social context of learning. Bruckman believed the development of technological 'virtual spaces' has the potential to make the idea of a technological samba school more feasible. While concurring with Papert's vision for a technological samba school where people of all ages gather together to work on creative projects using computers, she also envisioned virtual, not physical, places being used to create such a community. Bruckman (1997) noted 'The broader point is that the Internet can be used not just as a conduit for information, but as a context for learning through community-supported collaborative construction' (p. 4).

The MOOSE Crossing Project (Bruckman, 1999) is designed to realize that vision. Guided by the educational theory of constructivism, children construct their own projects while practicing reading, writing and programming skills. The MOOSE Crossing community provides ample support for children in the form of a knowledge resource, a sounding board for ideas and an appreciative audience.

Learning communities

Compared with community learning, the concept of a learning community is relatively new. Senge (1990) defined learning organizations as 'places where people continually expand their capacity to create the results they truly desire, where new and expansive patterns of thinking are nurtured, where collective aspiration is set free, and where people are continually learning how to learn together' (p. 3).

Although the idea of the learning organization were first embraced in corporate boardrooms, it quickly spread to school classrooms. As Senge's paradigm shift was explored by educators and shared in educational journals, the label changed to 'learning communities' (Hord, 1997). It describes an environment in which students become integrated into a group, recognizing that the new community is a valuable source for learning potential.

Communities of learners can be seen as a kind of widely distributed memory, with each of its members storing a part of the group's total memory. Distributed memory, what the group knows as a whole, is clearly more capacious than individual memories, and so the sharing of those memories makes the community more dynamic (Jonassen *et al.*, 2003).

Similarly to Jonassen *et al.* (2003), Bielaczyc and Collins (1999) define a 'learning community' as a culture of learning in which everyone is involved in collective learning. If the community encounters a problem, the entire learning community brings its collective knowledge to bear to solve the problem. It is not necessary for a member of the community to understand

everything the community knows as long as the member is able to identify who within the community has the expertise to solve the problem. This multisource concept radically departs from single source, teacher-directed schooling in which all students are expected to acquire the same knowledge at the same time from the same source.

Advanced technology has created opportunities for such learning communities. Among the most promising is the emergence of the Internet and the World Wide Web, which, in its brief life, has hosted electronic interactions between a myriad of learners across the planet, facilitating the learning process for all participants. Jonassen *et al.* (2003) described the Internet as the ultimate distributed network, linking users and institutions together, allowing interactions of all kinds to occur. They noted that 'the education future portended by the Internet, therefore, is not isolated and targeted to individuals. Rather, it is a community-centered future that accommodates each person through the workings of the larger community of learners' (p. 73).

Tapped-In (Tapped-In 2 http://ti2.sri.com) is one such successful 'online community', going online in 1997 with funding from the US government's National Science Foundation. This educational community is described as providing a response to teachers' needs for support, community and idea sharing within a virtual space that is both efficient and intuitive (Bull *et al.*, 2004). Participants are provided with powerful, dependable communication tools, meant for interaction with as small or as large a community of teacher participants as they wish to involve.

As Tapped-In evolves, more human benefits are found (Bull *et al.*, 2004). While holding class in their virtual offices, teachers direct online synchronous chats, enabling typically reticent students the opportunity to freely interact in discussions. Existing classroom experiences are enriched and expanded, while giving both students and teachers the opportunity to participate in and benefit from this electronic learning community.

Interaction

Lev Vygotsky (1978), a developmental psychologist and influential educator, noted that 'Every function in the child's cultural development appears twice: first, on the social level and, later, on the individual level; first, between people (interpsychological) and, then, inside the child (intrapsychological)' (p. 57). His ideas continue to profoundly influence educators, many of whom believe that interaction plays a fundamental role in a child's learning. Interaction is also one of the most important components of any learning experience (Dewey, 1938; Vygotsky, 1978). For distance education professionals, interaction has been identified as one of the major constructs in distance education research, serving as an essential element in online environments (Moore, 1989; Wagner, 1994; Vrasidas, 2000; Leh, 2002; Gunawardena & McIsaac, 2003; Tu & Corry, 2003).

Distance education researchers identified four types of interaction. Moore (1989) first noted that interaction included: (a) learner–content, (b) learner–teacher and (c) learner–learner. Hillman *et al.* (1994) further suggested a learner–interface interaction. They argued that to allow any of the three types of aforementioned interaction to take place, the learner has to interact with the medium used in an online environment. Their argument was supported by Ross (1996) and Tsui and Ki (1996), who found that technology skills such as using computer conferencing were important for successful participation in online environments.

Paulsen (1995) discussed interactivity in terms of a technological pedagogical technique based on four communication paradigms: one-alone techniques (the online resource paradigm); one-to-one techniques (the E-mail paradigm); one-to-many techniques (the bulletin board paradigm); many-to-many techniques (the conferencing paradigm). The first technique involves minimal interactive participation: for example, a teacher only posts online information resources, without facilitating much communication among students. At the other end of the spectrum, all students with a teacher using the last technique participate in interaction, such as through computer conferencing.

In the past two decades computer technology has enabled students to interact with the content, programme interface, the instructor and other students, both individually and in groups (Geer, 2000). At the same time, many professionals have been exploring various ways of utilizing technology to foster interaction for better learning. Palloff and Pratt (1999) and Ko and Rossen (2004) provided strategies of building effective learning communities in cyberspace and offered ideas for making connections across virtual space and time. Palloff and Pratt (1999) suggested that instructors should work with students to formulate a common goal for learning and to share responsibilities for facilitation. Instructors should also encourage expansive questions, promote feedback and foster inter-group collaboration. Ko and Rossen (2004) emphasized the importance of class participation and strongly encouraged instructors to make it and its relationship with grading criteria explicit in the syllabus.

In addition, Harvard University set a good example, creating an environment in which students may learn through interacting with the Multi-User Virtual Environment Experiential Simulator (MUVVES, http://muve.gse.harvard.edu/muvees2003/), which may aid the transfer of learning from classroom contexts into real world settings. Some Nebraska teachers demonstrated potential advantages of using hand-held devices (Teaching NOW!, n.d.). Pupils solved problems on their own, independently exploring the use of the devices, and later trained graduate students at the University of Nebraska to use Palms. These hand-held devices generated considerable interactions among pupils, between pupils and teachers and between pupils and community members, such as the graduate students.

21st century learning and ubiquitous computing

Learning for a child of the 21st century is much more complex than ever before. Modern technology has been seamlessly infused into the lives of children and their interactions with their surroundings. The Partnership for 21st Century Skills (2003), an alliance of education, business and government leaders working to fully address the educational needs and challenges of work and life in the 21st century, has identified six key elements of 21st century learning: (a) emphasizing core subjects, (b) emphasizing learning skills, (c) using 21st century tools to develop learning skills, (d) teaching and learning in a 21st century context, (e) teaching and learning 21st century content and (f) using 21st century assessments that measure 21st century skills. Since an example involving a ubiquitous computing device, one of the 21st century tools, will be presented in an upcoming section, key element number three is discussed in detail.

To address the use of 21st century tools in developing learning skills, Dede (2004) noted that three complementary interfaces would shape how people learn during the coming decade:

(a) the familiar 'world to the desktop' interface, (b) 'Alice-in-Wonderland' multi-user virtual environment interfaces and (c) interfaces for 'ubiquitous computing'. Weiser (1991), who first proposed the concept of 'ubiquitous computing', advocated:

> Ubiquitous computing names the third wave in computing, just now beginning. First were mainframes, each shared by lots of people. Now we are in the personal computing era, person and machine staring uneasily at each other across the desktop. Next comes ubiquitous computing, or the age of calm technology, when technology recedes into the background of our lives. (Weiser, 1999, Chapter 1)

A hand-held device is an example of ubiquitous computing, and many educators have been exploring the potential of using such devices in education (Harvard Graduate School of Education, 2003; Royer, 2004; Son *et al.*, 2004). While there does not exist a wealth of research documenting the use of hand-helds as an effective learning tool, admittedly there are benefits. As teachers reported, the benefits of hand-held computers include:

- improved quality of instructional activities, especially in science;
- enhanced student communication and collaboration;
- improved student organizational skills;
- enhanced student motivation;
- promotion of student autonomous learning. (Crawford & Vahey, 2002, Findings)

Some professionals believe that a hand-held device is the 'true' personal computer (Soloway, 2001), due to its distinct features. First, its small size makes it highly portable and adaptable and students may use it at anytime and anywhere (Pownell & Bailey, 2001; Shields & Poftak, 2002; Dede, 2004). As a result, students gain easy access to their personal computers.

Affordability of hand-helds is another attractive feature. Hand-helds, costing between US$200 and US$300, compare attractively with laptops ranging from US$1000 to US$2000. Desktops may cost significantly less than their laptop counterparts, but portability then becomes an issue. In his keynote presentation, Dede (2004) noted that wireless hand-held devices offer approximately 60% of the computing power of laptops of a few years ago at only about 10% of the cost of one modern laptop.

The versatility of hand-helds may be their most attractive feature, especially as an effective learning tool. In addition to the most common uses associated with hand-helds, such as the date book, contacts, etc., the devices have many more creative capabilities. For example, an abundance of free educational software allows users to write, create concept maps, take and/or draw pictures, use spreadsheets and read documents and/or books. Hand-helds allow the easy transfer of information, facilitating student collaboration. Documents can be effortlessly beamed between students and stored in computers.

Hand-helds are quickly becoming a widely used technology, especially in the business world. Many businesses use hand-helds for scheduling, contacts, tasks and document storage. If hand-helds are being commonly used in the 'real world', students should also know how to use this tool in their learning. When hand-held computers are used as a real world collaborative tool, students are offered a versatile and effective means of becoming life-long learners (Topp & Hanquist, 2002).

The use of hand-held devices: an examplery case

While many educators are exploring the potential of using hand-held devices in learning, a teacher at a Southern California elementary school is also experimenting with usage in his instruction. This section describes the teacher's experiences, participant observations and reflections.

Background

The school received 10 devices (Palm Zire 71) in 2003 through a State University sponsored grant. The school mainly serves middle and low income families, with 51% of the students receiving free and/or reduced price lunches. Although technology at the school, such as computers, is limited, several teachers maintained a strong desire to integrate technology into their instruction to help the children succeed. When these teachers became prospective hand-held device users at the school, they were unschooled and uncertain about the capabilities and usage of the devices.

Implementation

The school principal and teachers collectively decided that one Grade 6 teacher would first experiment using the devices in his class. The teacher divided the implementation into three stages: (a) setting selection criteria, (b) managing logistics and (c) integration into the curriculum.

Setting selection criteria.   The teacher selected 10 responsible group leaders who shared the devices with their group members. A permission slip/agreement form required both students' and parents' signatures. Legally, neither the students nor the parents could be held financially accountable, however, it was hoped that the formality of the procedure would heighten students' awareness and sense of responsibility.

   The teacher decided to permit student use of the hand-helds at all times during the school day. Class members were also permitted to take devices home during weekends, holidays and off-track times. Although some teachers and administrators were initially hesitant to support this widespread use, the teacher later found it to be the best course of action. Since all assignments utilizing the device were conducted at school, the students who could not bring the device home were not at a disadvantage in terms of submitting their assignments.

Managing logistics.   Once the decision was made as to who received the devices, the next task was to visualize the logistics of charging, syncing and basic maintenance for the 10 devices in a classroom with six computers. Group leaders were trained to install the software, then they trained the remainder of the students. The class followed a trainer teaching trainers model. It seemed vital, for optimal effectiveness, that all participants be able to install the software, name their device and be self-sufficient after leaving the classroom. The training was designed to facilitate successful integration into their home and effective use of the hand-helds.

   Few problems were experienced with the initial installation, due in large part to the fact that some students had prior experience of installing/uninstalling hand-held software. On at least two

different occasions the group leaders ensured that students correctly entered their own user name and continued to sync to the same computer. Several months later the process continued to run smoothly.

Integration.   Once logistical and day-to-day operational problems were solved, the teacher considered the most effective use of the devices for the current users and decided to focus on four different areas: (a) training, (b) moving toward a paperless classroom, (c) acquiring afford-able reading material and (d) utilizing task-specific applications.

The teacher trained the students to utilize applications that crossed platform boundaries instead of using only Palm-specific software. As a result, the hand-held applications could easily be incorporated into the students' favourite computer applications and be utilized in some manner that had not been previously considered. The teacher found that training students to appropriately use devices turned out to be the least time intensive component of the four areas.

Devices were set up for first use and additional software installed (e.g. Documents To Go, PalmReader, Adobe Reader). With no further teacher assistance students were then encouraged to use the remainder of the day to explore the capabilities of the devices. Students returned the following day and each, without exception, eagerly demonstrated an application that he/she learned on his/her own. Many developed an expertise using the camera function and shared numerous pictures. All had a favourite application, along with ideas on its implementation, both inside and outside the classroom. Other than encountering occasional difficult language at a random install screen, students needed little or no additional training with software installation and device navigation.

Moving towards a 'paperless' classroom was one of the project's emphases. A Weekly Home-work Assignment Sheet requiring students to write down their homework and parents to initial upon completion was transferred from Microsoft Word format to an Excel spreadsheet. A blank template was beamed to each student, thereby removing one piece of daily paperwork.

Students used the devices to track spelling lists, for crossword puzzles, for word searches, and to create/store quizzes, both of their own and others' creation. Most tasks were created in Excel, simply because of its versatile ability to cross over to both the Mac and PC platforms. Devices were readily used for note taking, brainstorming, and rough drafts. Typically, these types of documents have been created using Word, again because of its versatile nature. While all possi-bilities were certainly not exhausted, students began and continued seeking new ways to go 'paperless'.

Another major area of emphasis was providing affordable student reading material via the devices. After downloading/installing Microsoft Reader for the Palm, the digitally adept students navigated to the University of Virginia's E-Book Library (http://etext.lib.virginia.edu/ebooks/ebooklist.html). This site provided a choice of more than 50,000 titles for students at no cost, most of which can be downloaded in web version, E-book, and Palm formats. The 10 students responsible for the devices were all supplied with a wealth of appropriate grade and reading level material that would otherwise have been unavailable.

The last area of focus was providing useful, task-specific applications to students. One afore-mentioned application is Documents-To-Go. This program allows students to not only view

Microsoft Word, Excel, and PowerPoint documents on their devices, but to also use the same devices as a transportation and storage medium. Microsoft Reader proved invaluable; without it, the reading material would not be a viable resource. Picomap (GoKnow) is a beneficial concept mapping tool. Students easily and collaboratively created electronic concept maps without typing on a computer. Quizzler, a quiz compiling program, allowed students to easily and quickly create their own highly motivating assessment tools.

Observations and reflections

Since the first student users/trainers were technologically skilled, the teacher was initially concerned that they might become bored, disengaged, and perhaps disruptive. However, using these individuals as 'trainers' to assist the remainder of the hand-held users helped alleviate the aforementioned issues. In addition, using this 'super user' group to assist as facilitators in demonstrations and in trainings kept them interested and permanently connected with the 'hand-held' group as a whole. The teacher noticed that students experienced few technical problems, none of which were considered to be insurmountable. The trainer-teaching-trainers model might have contributed to the success.

The teacher noticed that nearly all students in the class reacted positively to using hand-helds. The students mentioned that using the devices made learning more fun and believed that every student should use a hand-held computer. The teacher observed that E-books in the devices motivated student reading. He was surprised about the classroom synergy that occurred: students comparing the concept maps they created using Picomap, beaming documents to one another, critiquing one another's projects, and sharing assessment tools developed using Quizzler. The devices seemed to encourage and generate considerable interactions among students.

Participating as an observer, the teacher found that:

- students of all ability levels displayed no fears or inhibitions of the hand-held and used it effectively;
- the drawing program provided a highly useful medium for creating representations across the curriculum;
- device portability enabled students to better incorporate technology into their learning experience;
- note taking integration was used effectively as support for organizing, thinking, and investigation;
- hand-held devices provided a myriad of possibilities to design and question in new and creative ways.

The teacher felt that learning was enhanced as he and his students enjoyed the active mode of solving, questioning, defining, predicting, and evaluating with these devices.

Due to the lack of scientific data to either prove or disprove the results, the teacher's positive findings were based solely on his own personal observations. Because scant literature or research was found on this subject, the teacher supports and encourages professional exploration of hand-held device potential, such as the projects conducted at the Harvard Graduate School of Education.

As previously discussed, not every student in the teacher's classroom could take a hand-held device home. The teacher envisioned the day when every student in his class would own a device and be able to use it ubiquitously. Such an environment corresponds to the 1:1 computing strongly advocated by Norris and Soloway (2004), who believe that every student should have his/her own hand-held device.

Discussion

Twenty-first century learning involves technology. Technological tools have been reshaping our communities and interactions within and between the communities over recent years. Our community is no longer defined by distance and/or time, nor is a learning community limited to a classroom setting. Technology enables full inclusion, regardless of location, into communities that foster learning. Technology also fosters the formation of a variety of communities through which learners can easily move, both into and out of. Furthermore, at any time, knowledge may exist within any individual in any community.

Communities and technology may create dynamic learning environments, but they cannot make learning happen. Interactions between (a) learner and content, (b) learner and teacher, and (c) learner and learner may facilitate learning. Distance education researchers (Moore, 1989; Hillman *et al.*, 1994;) further emphasized the importance of learner–interface interactions in learning. While the authors of this article are reviewing 21st century learning and the dynamic communities created by technology, they argue that learner–community interactions should be added and, in the 21st century, learning should include five types of interactions: (a) learner–content, (b) learner–teacher, (c) learner–learner, (d) learner–interface, and (e) learner–communities.

The 21st century puts us in the third wave in computing: ubiquitous computing (Weiser, 1999), with hand-held devices being one example. Such devices allow learners to participate in the aforementioned dynamic communities and to conduct the five types of interactions. They are comparatively inexpensive and small enough to fit in a user's pocket. Educators are beginning to realize their power and potential in learning.

Unfortunately, few professional literature sources document successful strategies for hand-held device use in education and only a limited number of research efforts report on the effectiveness of using such technology. The teacher's experience in the previous section indicated challenges that K-12 teachers encountered when using the device in the classroom. The case provides some tips and strategies that the teacher generated during his implementations. It is recommended that professionals form communities, online as well as off-line, in which educators may exchange their experiences and share best practice of using a hand-held device, and that experienced hand-held educators be invited to facilitate discussions and interactions in the communities. It is also recommended that researchers and practitioners conduct collaborativ research on their effectiveness in learning.

Conclusion

Advanced technology makes 21st century learning, communities, and interactions unique and leads people to an era of ubiquitous computing. Hand-held devices, examples of ubiquitous

computing, allow learners to participate in dynamic communities generated by modern technology and to conduct five types of interactions: (a) learner–content, (b) learner–teacher, (c) learner–learner, (d) learner–interface, and (e) learner–community. These portable and comparatively inexpensive devices have drawn considerable attention from educators who recognize their full potential and educational value, but more research is needed to confirm their effectiveness and benefits. With the utilization of technology, 21st century learning has the potential to be both exciting and inspiring, but only adept and motivated educators can make it happen.

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