Using Gartner's Hype Cycle as a basis to analyze research on the educational use of ubiquitous computing

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Abstract: In this paper, Gartner Group's Hype Cycle is used as the basis for categorizing and analyzing research on the educational use of ubiquitous computing. There are five stages of the Hype Cycle: technology trigger, peak of inflated expectations, trough of disillusionment, slope of enlightenment, and plateau of productivity. The first decade of research on the educational use of mobile technology is divided in this paper into four stages: (i) a period of mobility and personal digital assistants; (ii) the era of wireless Internet learning devices; (iii) the introduction of social mobile media; and (iv) a ubiquitous future. In addition, three empirical case studies are used as examples of these developmental stages. These case studies demonstrate the diversity of contexts, methods, and technologies used, ranging from workplace to nature trail, from inquiry learning to collaborative knowledge building, and from PocketPCs to smartphones.

Introduction

The evolving role of smartphones, Internet tablets, and other mobile devices in our everyday life is an example of *ubiquitous computing,* a term coined by Weiser (1991), who wrote that "the most profound technologies are those that disappear [because t]hey weave themselves into the fabric of everyday life until they are indistinguishable from it" (p. 94). Weiser is widely considered to be the father of ubiquitous computing, an environment in which the computer is integral to but embedded in the background of daily life.

In this paper, Gartner Group's Hype Cycle is used as the basis for categorizing and analyzing research on the educational use of ubiquitous computing because the Hype Cycle characterizes the typical progression of an emerging technology. As depicted (Figure 1), there are five stages of the Hype Cycle: technology trigger, peak of inflated expectations, trough of disillusionment, slope of enlightenment, and plateau of productivity. Because the technology is at different levels of development during each of the five portions of the cycle, research into the educational use of the technologies can be made in steps. These steps are not linear in the strictest sense; rather, they follow the steps of the development of research in the field. In this paper, the Hype Cycle is also used to structure an examination of the development of the general idea of mobile computer-supported learning. This is achieved by adding a layer of several megatrends in the technology-enhanced learning field on top of the Hype Cycle (shown at the top of Figure 1) (O' leary, 2008).

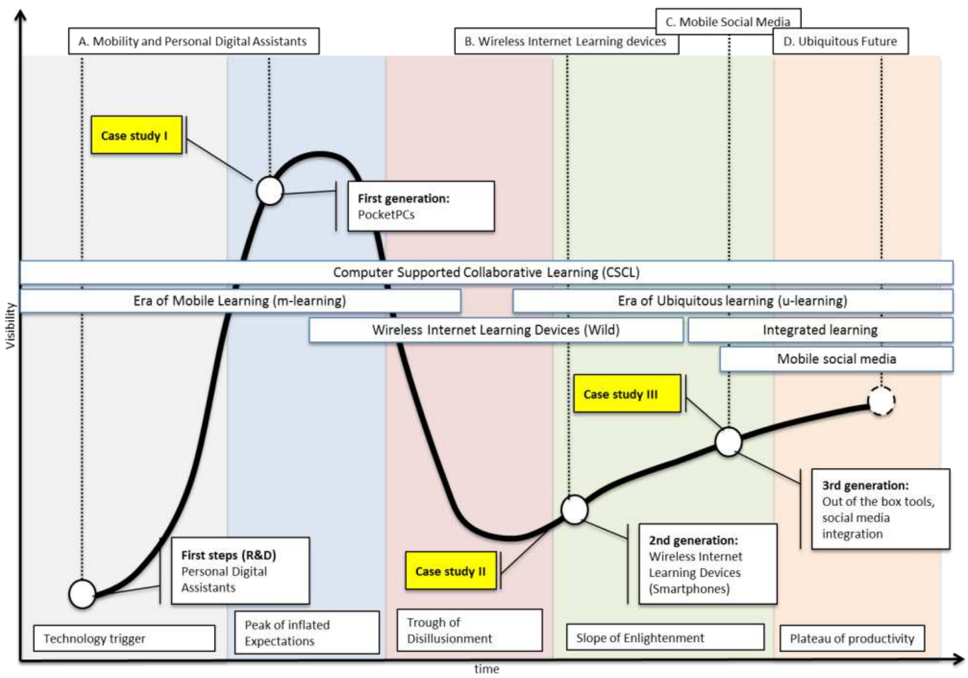

Figure 1. Gartner's Hype Cycle and educational use of ubiquitous computing

In addition to analysis of the general idea of mobile devices in education, three empirical case studies are included in this paper as examples of the developmental stages. These case studies demonstrate the diversity of contexts, methods, and technologies used, ranging from workplace to nature trail, from inquiry learning to collaborative knowledge building, and from PocketPCs to smartphones. The methodological and technological choices made in these case studies have enabled examination of the nature of social interaction in small-group settings supported with ubiquitous technologies in three different contexts with different needs for data collection and analysis.

First years of research on the educational use of ubiquitous computing: Mobility and PDA(s)

The history of the educational use of ubiquitous computing begins with the era of technology triggers (stage 1), including the product launches by Apple Newton, Palm Pilot, and Nokia Communicator in the late 1990s, followed by Microsoft's PocketPC in the early 2000s. Later devices are considered first-generation gadgets in this cycle. These early developments in ubiquitous communication led to a peak of inflated expectations (stage 2) when some scholars thought that mobile devices would revolutionize education (Trifonova, 2003). It was typical during this period to refer to the educational use of mobile devices under the terms "mobile learning" and "m-learning" (Keegan, 2005; Park, 2011; Quinn, 2000).

The idea of *mobile learning* was presented by Sharples (2000), who said that new technological affordances enabled a "new genre of educational technology—personal (handheld or wearable) computer systems that support learning from any location throughout a lifetime." The various educational affordances of wireless technologies suggested by researchers thus far (Roschelle & Pea, 2002) have paved the way for the emergence of so-called mobile learning or ubiquitous learning initiatives, such as G1:1 learning (Chan et al., 2006). While some researchers elaborate terms deeply in scientific practices, many still understand mobile devices and wireless networking technologies in education as "an extension of e-learning" (Quinn, 2000) or the mainstream, pervasive learning delivery medium. However, these simplistic views ignore the fact that modern education and pedagogy puts a high value on active, productive, creative, and collaborative learning methods that go far beyond the absorption of codified information (Hoppe, Joiner, Milrad, & Sharples, 2003).

Case study 1: Designing a new virtual master's program in the context of a distance education network

This study was conducted in realistic settings with the University Learning Center, which offers distance education on information processing sciences through several retraining programs in seven independent regional learning centers. The voluntary participants (N = 10) were split into three teams at two different locations in a northern area of Finland. The participants (nine men and one woman) comprised four project managers, a lecturer, a computer specialist, an educational designer, and three new media designers. All participants had previous experience in working together in the same distributed organization.

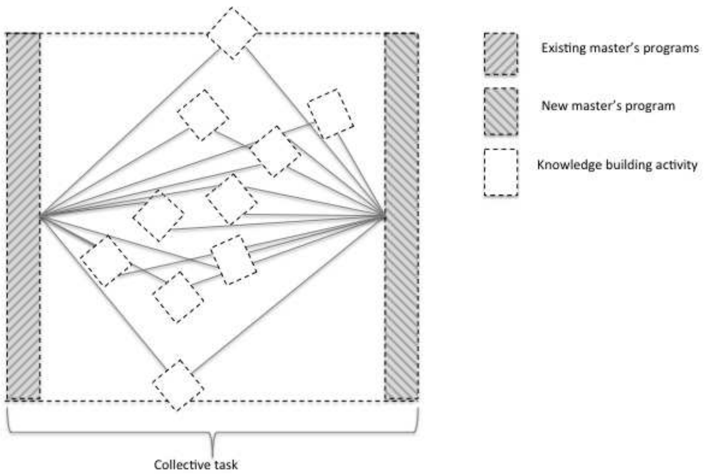

Figure 2. Instructional design of the first case study

In this case study (Laru & Järvelä, 2008), the participants shared a major problem, which was to design a new distance education master's program in a new domain (see Figure 2). The instructional design in this first case study was simplified: a knowledge-building tool was just embedded into existing practices. To design the program, participants were offered a mobilized version of collaborative technology (FLE3mobile) with a dialogue model of knowledge building at their disposal. Ideas of knowledge building and progressive inquiry learning were operationalized in sentence openers. At the pedagogical level, participants were free to collaborate as they desired while designing the program.

Appearance of first wireless Internet learning devices together with pedagogically ambitious learning goals

In the third stage, that of disillusionment, critical accounts toward technology determinism started to appear. A considerable amount of research effort in this decade was driven by technological challenges, and few studies dealt with questions of how meaningful and productive mobile technology-supported (collaborative) learning actually is (Järvelä, Näykki, Laru, & Luokkanen, 2007; Park, 2011). These concerns are explicitly enumerated in an extensive review of mobile learning projects by Frohberget et al. (2009), where the authors argue that "tool support of most projects is not pedagogically ambitious, [and] a strong minority provide tools that aim at realizing higher pedagogical goals" (p. 317).

In order to ensure engaged learners, a proper pedagogical or lesson design is needed for when enthusiasm for using the new technologies begins to wear out (Looi et al., 2009). Yet, although many scholars, most notably Roschelle and Pea (2002), have predicted tensions between traditional learning models, which are highly centralized, and emerging pedagogical ideas amplified with mobile technologies, which are naturally situated, collaborative, and distributed, educational technologists tend to create applications that are designed to work within "inherited educational ideas rather than transform them" (Squire & Dikkers, 2012). Roschelle and Pea (2002) also predicted how mobile technology might revolutionize the role of teachers by breaking contrastive teaching paradigms of "sage on the stage" (teacher-centered instruction) and "guide by side" (teacher-guided discovery). Instead, they offered the idea of "conductor of performances," which has been further developed by other scholars (Dillenbourg & Jermann, 2010) using the term "orchestration" to describe run-time adjustments in complex socio-technical designs that include multiple social planes in different contexts mediated by multiple devices.

Case Study II: Field trip to a nature park in a wilderness forest setting in the context of informal K-12 education

The participants in the second case study were primary school students (N = 22, all 12 years of age) who participated in a one-day learning project during a field trip to a nature park in a wilderness forest setting in northern Finland. The field trip activities in this case study were designed and developed by the research team in collaboration with the nature park's local expert, a biologist. The students were randomly assigned to eight groups (six triads and two dyads), and each group was provided with a mobile phone. Before the experiment, the principles and procedures of collaborative inquiry learning and argumentation were presented, and practical training for the fieldtrip was given in the classroom by the researchers and the biologist.

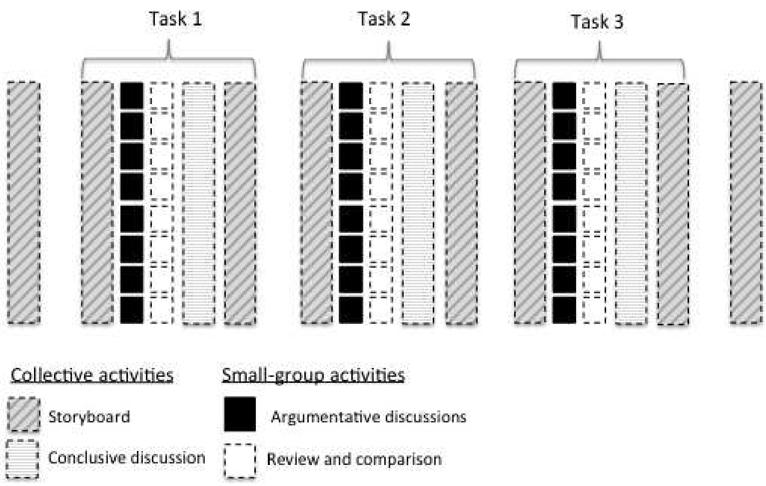

Figure 3. Instructional design of the second case study

The major problem in this study was to explore inanimate and animate traces of nature in small groups in order to create argumentative knowledge claim messages (Laru, Järvelä, & Clariana, 2012). This study is an example of a teacher-led outdoor learning activity in which students learn in groups within confined time periods, which is a subtype of "formal learning in informal settings" (Wong & Looi, 2011).

From the perspective of instructional design (see Figure 3), a collaborative core activity was aimed at scaffolding co-construction of argumentative discussions in small groups during inquiry learning. It consisted of "soft" scaffolding, provided by tutors and the nature guide, and "hard" argumentation scaffolds, provided by the messaging tool (sentence openers). In addition, the instructional design included pre-structuring activities that provided procedural scaffolding in the form of storyboard messages (Laru et al., 2012) as well as post-structuring activities that included debriefing activities such as a review and comparison phase in the collaborative and conclusive synthesis at the end of each task at the collective level.

Era of social mobile learning: Combining affordances of social software and mobile learning

The developments described for the previous phase, together with new affordances of mobile technologies, led to the Hype Cycle stage of enlightenment (Figure 1). The affordances provided by the combination of mobile devices and social software tools led us into a new phase in the evolution of technology enhanced learning, one that forges new learning spaces and continuity between pedagogical phases of the instructional design (Laru, Näykki, & Järvelä, 2012; Multisilta & Milrad, 2009; Wong & Looi, 2011). In practice, the increasing use of mobile social media in education is stitching learners' formal and informal learning contexts together and bridging individual and social learning, which leads to seamless learning.

However, most papers considered in the extensive literature review made by Wong and Looi (2011) tend to discuss or analyze personalized and social learning in their studies separately or to only focus on one of these aspects. Further, very few papers discuss the mechanisms of bridging individual and collaborative activities. The third case study in the current paper is focused on bridging individual and collaborative activities as well as face-to-face and mobile social media activities. It includes a full activity design, as suggested by Wong and Looi (2011), with multiple phases; the mobile-mediated conceptualization activity was just one phase of the instructional design. Products created in that phase can be characterized as artifacts that were used as a mediating tool for reflections, elaborations, reviews, and knowledge building (Wong & Looi, 2011).

Case Study III: Future scenarios and technologies in learning: A course in the context of higher education

For the third case study, the research participants were 21 undergraduate students in a five-year teacher education program at the Faculty of Education in the University of Finland. All students were enrolled in a required course entitled *Future Scenarios and Technologies in Learning* during the spring semester of 2009. The 21 participants comprised 16 women (76%) and 5 men (24%). The prevalence of women reflected the gender ratio of education majors at the university. The mobile phone-mediated activities in this course are an example of course-related activities outside of the normal class hours, such as artifact creation in daily life (largely incidental encounters or improvisations), which is another subtype of formal learning in informal settings (Wong & Looi, 2011).

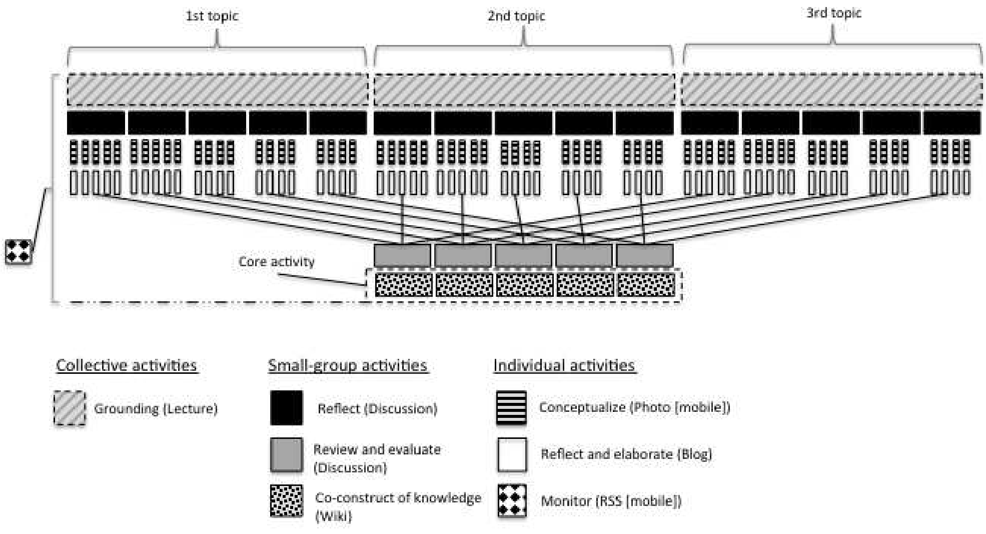

Figure 4. Instructional design of the third case study

In this case study, the same content was elaborated multiple times when students encountered multiple representations of each of the content topics (six altogether) using different analogues, examples, and metaphors. In other words, the instructional design required students to revisit "the same material, at different times, in rearranged contexts, for different purposes and from different conceptual perspectives" (Spiro, Feltovich, Jacobson, & Coulson, 1991, p. 28). From the perspective of ill-structured problems and tasks, the students split one problem into multiple smaller problem-solving tasks as phases in the instructional design proceeded.

In this experiment, the learners' core task was to integrate selected individual blog reflections and visual representations into coherent and a comprehensive wiki (see Figure 4). Although this wiki was also the main outcome of the activity (the end goal for their activities), it was not specified as such. There were also multiple individual and collective phases before the wiki activity, and the goals for these were not specified either.

The students needed to make choices in three phases concerning their learning objectives aimed at solving ill-structured problems, thus:

1. *Reflection* (collaborative): After a grounding lecture in which students discussed the lecture topic in groups and formulated a problem to be solved during the following individual learning phases;
2. *Conceptualization* (individual): Following the reflection phase, which included an activity in which students were required to conceptualize their group members' shared interests (i.e., shared problem); this task can be considered as a standalone ill-structured task that led students to qualitative modeling in order to reformulate group-level problems;
3. *Knowledge co-construction* (collaborative): An assigned task focused on integrating each group's selected blog entries and photos into a cohesive and comprehensive group wiki; this activity could not be conducted without qualitative modeling to reformulate shared learning objectives and problems, because individual activities affected the shared objectives and problems.

The instructional design of the third experiment enabled students to make comparisons between the cases. This was done both in face-to-face activities and with the help of technological tools. The activities involving comparison comprised two phases:

1. *Reflection and elaboration* (individual): After individual conceptualization, students were required to analyze photos taken using mobile phones in order to discard ideas that were not relevant to their groups' shared learning objectives; they were also required to write blog entries on selected photos, in which they further elaborated associations between the photos, group-level objectives, and students' everyday situated practices (note: students were able to see photos taken and blog entries written by other students and in other groups by monitoring their activities using an RSS reader);
2. *Review and evaluation* (collaborative): After individual reflection and elaboration, students were tasked with reviewing group members' blogs and evaluating the usefulness of blog entries in the context of their shared learning objectives.

Ubiquitous tomorrow: Learning environment consisting of an amalgam of tools around the corner

From the present perspective, this field of research is currently in the phase of the plateau of productivity. The world is entering the Age of Mobilism (Norris & Soloway, 2011). Ubiquitous computing has evolved from Weiser's initial ideas about the interplay between the human world and communication technologies with the widespread adoption of mobile devices that require proactive involvement rather than the calm computing originally suggested by Weiser. Mobile phones have grown beyond a tool for conversations, to become connected computing devices that offer a multitude of services and which currently are perceived as much more than just phones, having also developed into movie players, gaming platforms, cameras, etc. (Pea & Maldonado, 2006). Current trends are increasingly focusing on effective personal learning environments as being characterized by an amalgam of technology devices, software, and services; access to a variety of digital tools simultaneously for everyone, anywhere, anytime; and choices about which technology is most appropriate in a given situation (van't Hooft & Swan, 2007). In many techno-centric papers on context-aware technology, previous killer features—contemporary human/computer interaction paradigms (RFID tags, QR-Codes, GPS, etc.)—are fast becoming regarded as mainstream in current mobile devices. Timely, contextualized information afforded by these can serve as evidence to support partially formed ideas and misunderstandings and to trigger comparison with previously stored data on the device, as well as to support an inquiry process or dialogue in situ. Actually, these affordances are enabling the preparation of instructional designs based on the ideas suggested a decade ago (Roschelle & Pea, 2002).

Western students today may have "one or more devices per student" if needed, but the number of devices in the ubiquitous environment is quite variable. Indeed, device-to-user ratios range from the use of multiple computing devices (like sensors) by one student (10:1) to a class of students with one interactive whiteboard (1:all), and encompass the in-between usage scenarios of 1:1 (as G1:1 initiative members originally suggested), 1:2 (as in pair work sharing a device), and 1:4 (as in small-group work discussions mediated by a shared device) (Dillenbourg, 2010 in Wong & Looi, 2011). These device-user ratios set new challenges for instructional designers, because each ratio provides different dynamics of interaction and collaboration (Wong & Looi, 2011).

In other words, different device-student ratios are an example of converged cognitive tools that we unconsciously and effortlessly use for achieving the benefits of distributed intelligence (Pea & Maldonado, 2006). From an educational perspective, this is a part of an environment in which "all students have access to a variety of digital devices and services, including computers connected to the Internet and mobile computing devices, whenever and wherever they need them" (van't Hooft, Swan, & Cook, 2007, p. 6). It is also line with the tenets of constructivism insofar as it involves a learning environment in which both teachers and students are active participants in the learning processes (critically analyzing information, creating new knowledge in a variety of ways, communicating what they have learnt) mediated by tools they have chosen and that are appropriate for particular tasks (Dabbagh & Kitsantas, 2011).

Discussion

Overall, decades of research in the field of educational use of ubiquitous computing and rapid technological evolution (both described in Figure 1) illustrates the rich field of business and research opportunities. Van Lente, Spitters, and Peine (2013) have argued that hypes thrive in rich environments, where research, business, and wider social activities contribute to the creation, sharing, and refinement of expectations. This paper follows studies conducted by Järvenpää and Mäkinen (2008) and van Lente et al. (2013), which have bridged empirical measures to the Hype Cycle. Our paper represents an exploratory and empirically driven study seeking indicators in the three case study designs for the Hype Cycle in relation to the evolution of educational use of ubiquitous computing.

The Hype Cycle and case studies described here emphasize that pedagogically grounded instructional design is needed in order to put emergent technologies into effective use. The employment of mobile devices, including mobile phones and tablets, is a growing trend in education. The practice has been widely technology-driven and often justified simply by the importance of using new technology in classroom. Since we are currently living between the stages of mobile social learning and ubiquitous future, the role of mobile technologies in different learning contexts is still a challenge for researchers and practitioners. Our claim is that seamless learning can be one productive way for schools and other educational institutions to promote learning skills, namely, self-regulated learning and collaboration, and to prepare people for the 21st century learning society. To advance research on self-regulated seamless learning, we propose few design guidelines for self-regulated seamless learning.

We share the constructivist belief that students should learn in environments that deal with *"fuzzy," ill-structured problems*. Designing challenging collaborative learning tasks provides students with an opportunity for multiple strategic activities and for self-regulation and shared regulation of learning. There should not be one right way to reach a conclusion, and each solution should bring a new set of problems. These complex problems and challenging learning tasks should be embedded in authentic tasks and activities, the kinds of situations that students would face as they apply what they are learning to the real world (Needles & Knapp, 1994). Challenging learning tasks require scaffolds and support. For example, Belland (2011) has suggested the following guidelines for the creation of appropriate scaffolds: (a) Support problem reformulation through qualitative problem modeling; (b) do not give specific end goals; (c) enable students to make comparisons between cases; and (d) enable students to work collaboratively.

As suggested by Spiro et al. (1991), the same content can be *elaborated multiple times*. In practice, this means that students encounter multiple representations of content using different analogues, examples, and metaphors, for example, by using mobile tools or social software. The instructional design required then is for students to revisit the same material, at different times, in rearranged contexts, for different purposes and from different conceptual perspectives. The same content can be also elaborated with multiple individual and collaborative phases before the collective activity allowing students opportunities for self-, co-, and shared regulatory processes (Järvelä & Hadwin, 2013).

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