A Teacher Exploration of Educational Affordances of PDA Technology

By Daniel Churchill and Natalia Churchill

ABSTRACT

This paper reports on a qualitative study of the thinking of an exemplary technology-using teacher with a technical education background, as he explored the educational affordances of PDA technology. The goal of the study was to generate an understanding of how this teacher perceives educational affordances and to explore the preconceptions that underlie those perceptions. The study also intended to explore how the perceptions changed as the device was acquired and explored. Understanding teacher thinking is important in the context of effective intervention strategy supportive of integration of PDA technology in teaching and learning. The final outcome of the study is a set of recommendations for readers to consider for possible application in their own contexts.

PDA Technology, Affordances and Teacher Thinking

A Portable Digital Assistant, or PDA, is a hand-held device equipped with computer capabilities. Nowadays, PDAs include wireless network connectivity, a mobile phone, a camera and a variety of add-on hardware extensions. This set of tools potentially create a spectrum of educational affordances. Wills (2001 in Csete, Wong, & Vogel, 2004) refers to this convergence as “the newest technological revolution”, while Attewell (2005) suggests that as the number of devices globally available increases, this technology will become “digital life” for many people.

PDA technology will potentially assist individuals to learn any time, anywhere, by empowering them “to access internet resources and run experiments in the field, capture, store and manage everyday events as images and sounds, and communicate and share the material with colleagues and experts throughout the world” (Sharple, Corlett & Westmancott, 2002, p. 222). For Luchini, Quintana and Soloway (2004), the key benefit of PDAs is that they can be powerful personal devices that “provide access to tools and information within the context of learning activities” (p.135). Studies reported a variety of contexts for the use of PDAs: during classes, enabling teachers and students to share files (Ray, 2002) and allowing students to ask anonymous questions, answer polls, and give teachers feedback (Ratto, Shapiro, Truong & Griswold, 2003); for delivery of courseware and quizzes and as an intelligent tutoring system (Kazi, 2005); for dissemination of information and collection of data during field trips (So, 2004); as a tool that supports students’ inquiries (Sharple, Corlett & Westmancott, 2002; Clyde, 2004); in computer-supported collaborative learning (Roschelle & Pea, 2002; Zurita & Nussbaum, 2004); as personal technology for lifelong learning (Sharple, 2000); and for disadvantaged young adults to improve literacy and numeracy skills (Attewell, 2005).

How PDAs will be used in teaching and learning depends largely on teacher perceptions of the educational affordances of this technology (Klopfer & Squire, 2005). Norman (1988) defines affordances as “the perceived and actual properties of the thing, primarily those fundamental properties that determine just how the thing could possibly be used” (p.9). Barnes (2000) writes that the key issue with affordances is “how and when ICT is an appropriate medium that enhances the learning process or learning outcomes, in some way” (p.238). Understanding educational affordances is important because “many of the tools we use in Education are
borrowed from other areas and these technologies may not be the most appropriate for enhancing learning” (Barnes, 2000, p. 239). Klopfer and Squire (2005) write that affordances of handheld technologies for education have been rarely explored. Klopfer and Squire describe five potential educational affordances: (a) portability, as handhelds can be taken to different locations; (b) social interactivity, as handhelds can be used to collaborate with other people; (c) context sensitivity, as handhelds can be used to gather real or simulated data; (d) connectivity, as handhelds enable connection to data collection devices, other handhelds, and to a network, and (e) individuality, as handhelds can provide scaffolding to the learners’ approaches to investigation. However, current understanding of educational affordances of PDA in literature is in the conceptual stage, based on authors’ subjective interpretations. The studies must attempt to extend understanding of affordances as they emerge from classroom practitioners’ efforts to utilize this technology.

Perceptions of affordances of PDA are likely to be influenced by preconceptions held by teachers. For Norma (1988), perceived affordances result from “the mental interpretation of things, based on our past knowledge and experience applied to our perception of the things about us” (p. 219). Barnes (2000) suggests that the integration by a teacher of new technology into teaching and learning is carried out with a belief that this technology will afford learning to occur in some way (preconceptions about learning). Previous studies inform that the manner in which technology is integrated in learning depends on what teachers think (see Churchill, 2005; Moallem, 1998; Pierson, 1999). For Pierson (1999), similar preconceptions underline teacher instructional decisions for lessons with or without the use of technology. A teacher’s instructional planning is largely influenced by epistemology - that is, is the nature of knowledge and how students learn effectively (Howard, McGee, Schwartz & Purcell, 1990). In contrast, Lovat and Smith (1990) suggest that the most important influences on teacher instructional decision-making are preconceptions about students. It is possible that perceptions of affordances of technology for learning (including those of PDA technology) might also be based upon preconceptions about learning or students. Previous study by Churchill (2005) suggests that teacher decisions for technology integration in particular, in addition to thinking about learning and students, might also be based upon preconceptions about the technology itself.

Understanding of perceptions of affordances and underlining preconceptions might provide useful information for planning of intervention strategies to support teacher change and implementation of new technologies in line with contemporary pedagogical models. Support of technology integration would be more effective if based upon understanding of teacher thinking (Churchill, 2005; Moallem, 1998; Pierson, 1999). In the context of contemporary relevant educational practices that emphasize learner-centered pedagogical approaches, teacher perceptions of educational affordances of technology should be based upon constructivist epistemology (Howard, McGee, Schwartz & Purcell, 1990).

**Methodology**

This qualitative case study explored how an exemplary technology-using teacher from a technical education institution perceives educational affordances of PDA technology. The study explored this teacher’s preconceptions as a basis for gaining understanding of the perceived affordances. An exemplary technology-using teacher was selected based on the assumption that such teacher thinking about educational affordances would not be blocked by unexpected complications due to limited technical competency. The researchers further attempted to understand how the participant’s perceptions of the educational affordances of PDAs developed as he explored uses of this new technology.
Critics might question the validity of a study with a single participant. For Merriam (1988), a researcher selects a case study because he or she “wishes to understand the particular in depth, not because one wants to know what is generally true of many.” A study of a single case is not an unusual practice in the educational research community. For example, Moallem (1998) studied a single teacher’s instructional planning and compared it to instructional design models. A small qualitative study of one teacher might not be able to generate a universal list of affordances for a mobile-enabled PDA device for learning. However, such a study might present some useful recommendations towards the effective integration of this kind of technology. It is the reader who finally decides whether such recommendations may apply to other contexts.

The Participant
In this paper, the authors use the name “Jack” for this participant to protect his identity. Jack is a 50-year-old technical education teacher with 25 years of teaching experience in the engineering field. His institute includes ten campuses, with about 1,500 teaching staff, 30 major courses and tens of thousands of students. Most of Jack’s full-time students are 16-19 years old. Some of his students study part-time. These are adults seeking to upgrade their qualification.

Jack’s institute is the key technical training institution in his country’s knowledge-based economy. Traditionally a powerful manufacturing sector in the country, or what Jack calls “the backbone of the economy”, in recent times has been challenged by the emergence of more economical labor forces and cheaper technologies from the countries such as China. The Government recognizes these challenges and provides significant attention to the uplift of technical education in order to maintain its competitive advantage. Over the last several years, the institute has received significant funding to modernize educational processes, and in particular, to integrate technology into its mainstream teaching and learning. This is very evident across the institution, where new computer classrooms have emerged over the last few years, the majority of staff have been provided with notebook computers, new networked infrastructure has been put in place, and new training and professional development initiatives undertaken. According to Jack, however, effective integration of technology has been slowed down by teacher thinking and a lack of readiness on the part of management to support reforms initiated by external demands.

Prior to this study, Jack lobbied unsuccessfully to acquire financial assistance to obtain a few PDA devices for his class in order to explore the educational opportunities of this technology. However, he was not discouraged. In one conversation before the study, he informed one of the researchers that he would be happy to have a PDA device and explore its uses. This was understood as an excellent opportunity to gain insight into how this exemplary technology-using teacher perceived the educational affordances of a PDA, and how these perceptions of affordances develop, and to link these perceptions to his preconceptions.

In order to obtain informed consent from Jack, one of the researchers briefed him during their initial meeting. The researcher provided Jack with a plain language statement containing information about the study, his right to withdraw, and an assurance that a pseudonym for his name and an acronym for the name of the institution would be used in any reports. He was told that he would be provided with a PDA device of his choice (to be returned at the end of the study). A few days later, Jack decided to take part in the study and signed the consent form.

Study Questions
The following questions guided data collection and analysis in this study:

i) How does an exemplary technology-using teacher perceive the educational affordances of PDA technology?

ii) What preconceptions underline the perceived affordances?
iii) How do perceptions of affordances develop as the participating teacher acquires and explores a PDA device?

**Procedure**

The data collection occurred over a period of four months, as follows:

i) Interview with Jack at the beginning of the study, focusing on preconceptions and initial perceptions of affordances.

ii) A particular PDA device was obtained based on Jack’s recommendation. Once he began to explore its uses he wrote regular reflective journal entries to document his observations, any new discoveries, and any changes in his thinking. The reflective journal was recorded using the on-line technology known as blog (see. http://www.blogger.com). The researchers set up the blog and briefed Jack how to make use of it. Eight weeks was allotted to this phase of the study to allow substantial time for Jack to explore the device, search for useful resources, examine software, design some files for testing and otherwise explore opportunities that the device might afford. The reflections were monitored on regular basis and some casual discussion with Jack took place.

iii) During this time, the researchers collected artifacts of Jack’s engagement with the PDA technology (e.g. resources that he constructed, or software that he found useful).

iv) The final discussion with Jack was aided by a matrix he completed to indicate areas of preconceptions, with particular affordances underlined.

The interview was transcribed and the units of data were taken out. These units of data represented single preconceptions and were recorded individually on paper cards. Cards were then given to the participant, who was asked to go through the collection and remove those he no longer held as valid. The sorting was conducted collaboratively by the researchers and the participant. An independent advisor was also involved. Initially, the cards were sorted according to three piles, representing the three areas of preconceptions which had been identified from the literature: preconceptions about learning (Howard, McGee, Schwartz & Purcel, 1990), students (Lovat & Smith, 1990) and technology (Churchill, 2005). Certain cards did not fit into any of these three areas of preconceptions. These unclassified cards were then sorted into emerging areas, which were subsequently labeled as preconceptions about teacher roles, and challenges. The researchers attended to these units again to extract those related to educational affordances of PDAs. Two areas of perceived affordance emerged: Access to Resources and Connectivity Tools.

When Jack was provided a PDA device several weeks later, he began documenting reflections in an on-line Blog. Blogging was selected on the assumption that it would enable the researchers to have access to Jack’s most recent reflections, while at the same time acting as an intervention tool encouraging him to reflect in a technology-mediated mode. Developments in perceptions of affordances were explored in the context of written reflections and artifacts provided by Jack. The researchers regularly monitored his reflections in search for any emerging areas of perceptions of affordances. Regular meetings were held between collaborating researchers to discuss any new observations. On a number of occasions, the researchers met with Jack to collect artifacts.

Prior to the final discussion in the study, Jack was presented with a matrix on which he was asked to indicate his areas of perceived affordances and to identify and explain any preconceptions that might have influenced them.

The study ensured validity through: (a) member checking – the researchers allowed Jack to scan interview transcripts, and the preliminary analysis and report; (b) use of multiple sources of data -
interview, reflection records and artifacts; (c) involvement of an advisor in the data analysis - content analysis, sorting of units of data and emergence of categories were assisted by an advisor, and (d) search and study of literature for theoretical validation.

Results

Jack’s Preconceptions Potentially Influencing his Technology Integration

These preconceptions appeared to emerge from five areas: Learning, Students, Technology, Teacher Roles and Challenges.

Jack indicated that his preconceptions about learning were dominated by the notion that learning is an active process whereby student use materials and engage in tasks that lead to knowledge. For Jack, learning must involve students in applying knowledge. Here are some of his preconceptions about learning:

- There are two elements in learning: facts and concepts.
- In learning it is important to reflect on experience.
- Whatever is learnt has to be applied and whatever is to be applied has to be derived from trying different approaches - theory and practice go hand-in-hand.
- Learning has to be carefully planned, sequenced and carried out by means of an activity.
- Illustrations are important helping students to visualize engineering parameters.

Jack demonstrated generally positive thinking about his students. He appeared to trust their learning abilities and was certain that they were capable of using technology for learning. He also saw them as being enthusiastic about technology as a learning tool. Here are some of the preconceptions held by Jack:

- Bringing technology into learning does not make students fearful.
- Students are enthusiastic about technology because it engages them actively.
- Students’ competencies are at a level sufficient to comfortably handle computers.

Jack was one of the first teachers at the institute to explore the use of technology in teaching. He had previously developed some courseware and tried this with his students. More recently, he had become interested in learning objects. He understood limited portability to be one of the limitations of computers when used as this kind of resource. Jack believed that PDA technology might fill this gap. Here are some of his preconceptions about technology:

- Technology brings fundamental concepts into a classroom and allows learners to work with them on the spot without need to go to a workshop.
- With technology on a screen, at the click of a mouse we are able to provide effective illustrations that can be manipulated with buttons and sliders.
- With technology, students can visualize multiple parameters and see how changing one parameter affects another.

Jack demonstrated significant interest in PDA technology and showed a desire to explore its uses. Jack exhibited two perceived affordances of PDA technology at the beginning of the study: (a) affordance to deliver educational material, and (b) affordance as a connectivity tool. Underpinning these affordances is the concept of portability, which is integral to this type of technology.

Teacher roles emerged as another area of preconception influencing perceptions of affordances of PDA technology. Here are some of Jack’s preconceptions in this area:

- A teacher has to plan learning activities for students to examine material and decide possible solutions for problems, and defend their findings.
How technology is used in learning depends on teachers themselves. A teacher has to constantly upgrade his or her knowledge of technology. Teachers have to be open to new ideas. A teacher has to be an expert in the content.

Based on the data from the interview, it was noted that a number of preconceptions addressed potential challenges to integration of technology into teaching and learning:

- We have to look at teaching from a different angle.
- I need to prove to management the effectiveness of technology.
- Phobia about technology prevents a teacher from venturing forward with its use.
- Some teachers strongly oppose the use of technology in the classroom, making various excuses to avoid its use.

These preconceptions potentially limit the participant’s decision-making space in relation to technology integration. The key challenges included the thinking of management and colleagues, and the limited resources available.

**Jack’s Perceptions of Educational Affordances**

Two perceived affordances of PDA technology were noted in the initial stage of the study: Access to Resources and Connectivity Tool. An additional three perceived affordances emerged as Jack explored the PDA device: Capture Tool, Representational Tool and Calculator. These five affordances, as perceived by Jack, are presented in this section.

**Access to Resources**

Early in the study, Jack indicated that he perceived PDAs as a potentially useful tool for delivery of resources. For Jack, the processing power of this technology appears to be almost equivalent to that of a computer. He understood that the kind of material accessible via PDAs could also be accessed through the internet. However, he was concerned with the size of the display area and the potential limitation of this constraint. He explored ways of working around this limitation. One strategy was to switch the display area to landscape mode. He realized that the same kind of files - e.g. PDF, PowerPoint, Flash - can be presented on both a computer and PDA; however, he understood that the design of the material presented must be different. In further reflections, Jack began to indicate that effective material for this kind of technology should be something interactive and visual illustrating important concepts from his field, rather than documents that require lengthy reading time on a small screen. Such effective material could be the kind of learning objects that he had previously developed for computer-based delivery and had utilized for an authentic learning activity. He saw that PDA technology offers an important advantage here, as it can actually take students away from a class location to a more authentic locale. Jack wrote:

> [Previously] I used one learning object on several occasions with my students. I set a real-life task for them where a virtual client is inviting them to propose suitable parameters and cost of producing certain metal components. Then the students used the learning object to explore parameters and discover relationships which guided their final decisions on providing the client with a proposal. Then they had to have a discussion about their approaches towards optimization of the cost… I think that a PDA might take this kind of activity to an altogether different level. Students, rather than being isolated from machines and workshops and conducting this kind of activity in a classroom environment, can actually be in the workshop or even at a client’s location and exploring the learning object on a PDA. They might try optimizing some parameters on a PDA-based learning object and then immediately examine a machine in front of...
them. Then they might SMS their quotations to a client, or even MMS photos from a workshop with the quote. My only concern is whether a PDA screen is sufficiently large to allow this kind of thing. Recently I worked on another learning object for the milling machining process. It looks OK on a computer. However, I would like to try this learning object on a PDA.

The interface of this learning object mentioned by Jack is shown in the Figure 1.

![Learning Object Interface](image)

**Figure 1:** “Milling” learning object developed by Jack in collaboration with his colleague

**Connectivity Tool**

Jack appeared to perceive PDA technology as an effective tool for students to exchange ideas, ask questions, connect to potential clients, engage in discussions, etc. Initially, he explored capabilities of PDA technology brought about by its integration with mobile phones. These included ability to talk, send SMS messages (Short Message Service) and send MMS messages (Multimedia Message Service). Jack observed that this allowed students to exchange information in multimodal formats. However, he appeared concerned to some extent about the cost of using a mobile service and began to explore an alternative: wireless network. Soon, he discovered an interesting collaboration technology for PDAs (Skype) that allows individuals to converse globally using a wireless network and at no cost to students. From Jack’s reflections, it appears that he saw this affordance of technology in two contexts: (a) as an important enabler of learning activity by allowing students to connect and exchange ideas, and (b) as a tool that leads to the development of contemporary relevant skills for his students: communication skills.

**Capture Tool**

For Jack, the capture capabilities of PDA technology are important for learning. He considered these capabilities very early in the study during the process of deciding on an appropriate PDA device to acquire. Jack wrote that capture enables students to take photos of places, mechanical equipment and parts, and pictures of interesting documents. It also allows students to capture videos of some processes or interesting learning moments, such as partners’ presentations in class. In addition, capture allows students to record audio clips. These might be recordings of their own voice reminders or sounds in a workshop. Notes can also be attached to all of these captured materials. A PDA might also be used to capture various data and media for later download to a computer: e.g. students might capture some observations while in a workshop, download this data to their computers and use it when creating a presentation.
Representational Tool

Another important affordance perceived by Jack, was that PDAs allow students to create representations of their knowledge and ideas. One way is by using mind-mapping tools such as Inspiration. These representational affordances are further enhanced when combined with capture affordance, for as Jack noted, this allows students to capture image, for example, and then to sketch on it or add some text,. Figure 2 shows a “Tool Selection” mind map created by Jack to illustrate the usefulness of Inspiration for creating representations.

Figure 2: “Tool Selection” mind map created by Jack to illustrate usefulness of Inspiration

Calculator

The final affordance perceived by Jack in the study was the ability of this technology to deliver a variety of calculators. These include standard calculators, more advanced graphic type calculators and special calculators that could be developed by Jack (e.g. using a Microsoft Excel file). Figure 3 shows a “Speed of Grinding Wheel” calculator created by Jack. Students can input values for the diameter of a grinding wheel (D) and number of rotations of a wheel (N) and automatically obtain calculated values of the speed of a grinding wheel (GW).

Figure 3: “Speed of Grinding Wheel” calculator created by Jack with MS Excel
Preconceptions that Underlie Perceived Affordances

Information about areas of Jack’s preconceptions that underlie his perceptions of affordances was acquired based on the matrix in Figure 4. Jack was provided with a list of his units of preconception from the interview for reference and an empty matrix as per Figure 4.6. He was asked to enter X’s in appropriate places in the matrix to indicate areas of preconception that underlined his perception of affordances. This was followed by a discussion during which Jack explained his choices.

<table>
<thead>
<tr>
<th>Areas of preconception</th>
<th>Connectivity Tool</th>
<th>Capture Tool</th>
<th>Representational Tool</th>
<th>Calculator</th>
<th>Access to Resources</th>
</tr>
</thead>
<tbody>
<tr>
<td>Learning</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Students</td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Technology</td>
<td>X</td>
<td>X</td>
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<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Teacher Roles</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Challenges</td>
<td></td>
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<td></td>
<td>X</td>
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</table>

Figure 4: Matrix of areas of Jack’s preconceptions that underlie his perception of affordances (as completed by Jack)

The pattern in the matrix indicated that, from Jack’s point of view, although all areas of preconceptions emerged to influence perceptions of affordances, preconceptions about learning and technology were most frequent. Central in his preconceptions about learning was his belief that learning must be an active process where students reflect on experience, link theory and practice, and solve problems. Technology can be effectively used to help students to visualize difficult engineering concepts during their activities. Preconceptions about students influenced Jack’s Connectivity Tool and Representational Tool affordances. He understood that it is important for students to be able to exchange information and learn with each other, and create representations to demonstrate their thinking and knowledge. Teacher roles appeared to influence Connectivity Tool and Access to Resources affordances. For Jack, an important teacher role is to support students. Technology would allow greater interactivity between teacher and student. He also stated that a teacher is responsible for providing quality subject matter, which influenced the Access to Resources affordance. The least dominating area of preconceptions was in relation to challenges. These, in particular, influenced Jack’s perceptions of Access to Resources affordances. Jack stated that his colleagues widely understood that technology should be used to deliver instructional material to students; thus, in order to satisfy the expectation of the institute’s teachers in this regard, subject matter resources must be provided, he believed.

When asked to indicate the area that, overall, most strongly influenced his perception of the affordances of PDA technology, Jack identified preconceptions about learning. He would like to use this kind of technology to make learning more active and engaging for students. In addition, he would like to more strongly link theory and practice, and he believed that this is where PDA technology could assist by delivering appropriate material, allowing collaboration and enabling students to create representations that demonstrate their knowledge and thinking.

Changes in Jack’s Thinking about PDA

Three areas of change in Jack’s thinking about the educational affordances of PDA technology were observed through the study: (a) from group tool to individual tool; (b) from subject-matter resource towards a tool for student use, and (c) from traditional resources (e.g. web pages, courseware and documents) towards learning objects.
Initially, Jack appeared influenced by the idea that learning is collaborative, and in this context there is no clear need to have one computer per student. One computer is usually useful for a group of students to support their collaboration. For Jack, a group of students presented with a learning task might utilize one PDA device, gathering around it and passing it to each other during a learning process. As Jack continued to use the PDA and reflect upon the affordances of this technology, he began to realize that the device is, rather, a personal tool and that he would like to see one provided for each of his students. He wrote:

"Before, I thought that a PDA device might be used with a small group of students when working together on some learning tasks. Now I think that this technology is rather personal, and that it would be much more effective if a student had his own PDA. A student could use it to organize activities, timetables and even plan learning tasks. At the same time, the student could document reflections, keep notes as a text file or as audio notes, capture interesting learning moments and photograph images from books, take short videos and so on. In this way, the PDA could help the student to collect materials that can later be transported to a computer and assembled in a digital portfolio as a demonstration of learning progress."

Initially, it appeared that Jack was paying attention to the delivery of resources and use of a PDA in a manner that resembled the use of computers. He was moving various kinds of resources over to the PDA, such as PDF documents, web sites, PowerPoint presentations, MS Word documents, e-books, video files and some interactive tutorial files created with Flash. However, during the study he began to question the usefulness of these resources given the size of a presentation area and other factors, such as students’ ability to focus on the small screen for extended periods. He began to think that perhaps PDA technology is more promising for learning when it offers students some tools to capture, save and process data and create representations. His focus appeared to be shifting away from resources and towards tools that could be used by students to demonstrated their engagements in a learning activity and thinking and knowledge. Influenced by his previous experience in developing useful educational material, Jack began once again to examine the kinds of material that could be effectively deployed over PDA devices. He wrote:

"Certainly, having a variety of useful learning objects would be very effective for learning. I searched the Internet for useful learning objects and found a lot of stuff out there, but they are not really what I mean by learning objects. A lot of stuff out there is just like web pages and those things that I call teaching machines. What I want is some powerful representation of key concepts from my teaching subjects, so that I can provide them to my students when setting learning tasks for them. In this way, students could attend to a variety of learning situations in the classroom, workshop and elsewhere, and pull out these learning objects when needed to aid their completion of tasks. More stuff like my machining parameters would be excellent."

For Jack these kinds of educational materials should not require students spending a long time reading; such material should be effectively designed for a small screen, should be visual in order to reduce the words needed to deliver ideas, and should be interactive to allow students to develop their own conceptual knowledge.

**Discussion of Results**

**Areas of Perceived Affordances**
The following five perceived affordances of PDA technology were explicated through the study:
Access to resources - a variety of multimedia resources can be delivered using this technology, such as e-books, web pages, presentations, interactive resources, audio files and video segments. These resources can be accessed any time, anywhere, by connecting to the internet using GPRS or wireless network connections, from the memory of the device or storage card if the resources were previously downloaded, or through synchronization of the device with a computer. However, the participant noted that merely moving resources from a computer to a PDA might not lead to effective learning. Resources for PDA use must be designed with certain principles in mind. A learning object consisting of a single interface, containing multimodal information that focuses on an important concept from a discipline, and which does not require long usage time, might be an effective resource for PDA technology.

Connectivity tool - PDA technology empowers students to connect to each other, facilitators and experts in the field, exchange ideas and files, collaboratively build understanding, manage activities and negotiate roles in their projects, etc. Connection might be established synchronously and asynchronously over mobile telephony and wireless networks that support voice and multimedia data transmission.

Capture tool - PDA technology is equipped with capture capabilities that include capture of video and still photographs. Students might, for example, photograph and videotape machines and people during their industry visits or photograph diagrams from a book or a catalogue. The capture affordance also includes audio capture. Students might interview experts, capture their own audio notes or capture characteristic sounds of a faulty engine. There is a possibility for specially designed extensions and consoles to be attached to a PDA and used to capture, store and process other kinds of data such as, for example, recording global positioning of certain air pollution sources.

Representational tool - PDA technology might be used by students to create representations which demonstrate their thinking and knowledge. These might be, for example, mind maps or captured and edited images.

Calculator -- a mobile-enabled PDA might be used as a calculator to aid students’ activities. These might include standard calculators, scientific and graphic calculators or specially designed calculators created by teachers.

Three of the affordances explicated in the study were also found in the literature: access to content, connectivity tools and capture tools (see Table 1).

Table 1: Literature sources that acknowledge affordances explicated in the study

<table>
<thead>
<tr>
<th>Affordance Explicated in this Study</th>
<th>Literature Acknowledging Affordance Explicated in this Study</th>
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<tbody>
<tr>
<td>Access to Resources</td>
<td>Kazi, 2005; Luchini, Quintana &amp; Soloway 2004; So, 2004; Sharples, Corlett &amp; Westmancott, 2002.</td>
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Use of technology as a tool that enables students to create representations of their thinking and knowledge is well documented in the literature dealing with learning with computers. The literature often refers to these representation tools as “mind tools” or “cognitive tools” (Jonassen & Carr 2000; Jonassen & Reeves 1996). Lately, there has been an emergence of representational tools for PDA delivery (e.g. Mind Manager, Inspiration); these tools should be given due attention, as potentially they may be very useful for learning. Calculator affordance was not found in the reviewed literature, possibly because authors and researchers might consider
calculators as just another kind of resource or learning object. The results of this study open the possibility for calculators to be categorized as an independent affordance.

Some affordances previously addressed in the literature have not been acknowledged in this report. Literature suggests that another area of affordances of PDA technology is portability and individual assistance (see Clyde, 2004; Kazi, 2005; Klopfer and Squire, 2005; Sharples, Corlett & Westmancott, 2002). All the affordances explicated in the study involve portability and enable individual activity; hence, in the context of this study, it is difficult to justify singling out these as perceived affordance. The very label of this kind of technology – PDA - incorporates the idea of portability and assistance. One more affordance of PDA technology in literature is its use by teachers as an administrative tool (Ray, 2002).

Preconceptions behind Perceptions of Affordances

Previous studies note that the manner in which technology is integrated in teaching and learning depends on teachers’ thinking (Churchill, 2005; Moallem, 1998; Pierson, 1999). Literature in the area of teacher thinking and instructional decision-making indicates that these preconceptions might range across several areas: learning (Howard, McGee, Schwartz & Purcel, 1990), students (Lovat & Smith, 1990), and technology (Churchill, 2005). These three areas of preconceptions also emerged as areas that influence this study participant’s perceptions of affordances. Two additional areas emerged: teacher roles and challenges. Moallem (1998), in the study of one teacher’s thinking and instructional design, observed that knowledge of self as a teacher influenced the subject’s technology integration. Churchill (2005) also suggests that teacher role is one of the areas influencing technology integration. Similar suggestions have also issued from Windschitl and Sahl (2002). The challenges area of preconceptions appeared to involve issues influenced by the external conditions of the context in which the participant made his decision. These issues are mainly expectations from management and influences arising from the thinking of colleagues. Previous literature did, for a long time, acknowledge that external influences determine teachers’ instructional decision-making (see Clark & Peterson, 1984; Duffy, 1977; Lovat & Smith, 1990; Windschitl and Sahl, 2002). Windschitl and Sahl (2002) suggest that the key limitation of the majority of the previous studies is that they considered individual teachers’ practice and beliefs while ignoring external challenges.

All five areas of preconceptions explicated in the study appeared, to varying degrees, to be influencing the participating teacher’s perceptions of affordances of PDA for learning activities. From the study, it emerged that preconceptions about learning most influenced perceptions of affordances. The participating teacher held certain preconceptions about learning that indicated his inclination towards constructivism. Churchill’s (2005) study of teacher thinking and design of technology-based learning suggests that when theories about learning dominate technology integration, technology integration is likely to take a student-centered form. In this current study, a similar trend was observed. This observation lead to the understanding that with different dominating area of preconceptions, potentially there may be different perceptions of affordances of PDA technology.

Changes in Perception

Previous studies indicate that the experience of integrating technology into teaching and learning transforms teachers’ epistemology towards beliefs that lead to more student-centered practices (e.g., Dwyer, Ringstaff & Sandholz, 1985-1998; Windschitl and Sahl, 2002). Teacher epistemology is understood as beliefs about the nature of knowledge and learning which influence teacher instructional decision-making (Howard, McGee, Schwartz & Purcel, 1990). This current study partially confirms these claims, as it also indicates a shift of the participant’s thinking towards more student-centered orientation. Three areas of changes in the participating
teacher’s perception of PDA technology were observed in the study: (a) a shift in perception of the PDA as a tool for assisting a group of students to a tool for the individual, (b) a shift from traditional resources supporting more direct instruction approaches towards learning objects that support more student-centered practices, such as collaborative inquiries and problem-solving and development of deep conceptual knowledge, and (c) a shift from resources transmitting a body of knowledge to tools that allow students to create representations, capture data and connect.

Summary and Recommendations

This study explicated five areas of affordances perceived by the participant: Access to Resources, Connectivity Tool, Capture Tool, Representational Tool and Calculator. Underlining these were five areas of the participant’s preconceptions: Learning, Students, Technology, Teacher Roles and Challenges. Preconceptions about learning appeared to be most influential upon the participating teacher’s perceptions of affordances. The results show that there were three shifts in the participant’s perceptions as he explored affordances: (a) a shift in perception of a PDA from a group to an individual tool, (b) a shift from traditional resources supporting more direct instruction approaches towards learning objects which support more student-centered practices, and (c) a shift from resources transmitting a body of knowledge to tools for student use. These shifts suggest a possible transformation in the participating teacher towards a more constructivist epistemology and indicate that experience in exploring the integration of technology in learning might result in a teacher examining and perhaps altering his or her preconceptions and shifting beliefs.

The results of the study might be useful to teachers, as the explicated affordances might provide useful starting possibilities for introduction of PDA technology in their practice. Further, for educational administrators, the understanding of these issues may help in more successful implementation of PDA technologies, as teacher thinking can be planned for as a part of an implementation strategy. The results suggest that providing teachers with PDA technology would contribute to their transformation towards student-centered pedagogical practice. It also appears that an institution should accumulate appropriate resources (learning objects) and tools that can be provided to teachers and students equipped with PDA technology. Providing technology alone without suitable resources and tools might under-exploit the technology. Suitable intervention strategies should be put in place to encourage use of these resources and tools to support students’ collaborative inquiries, problem-solving and other kinds of student-centered practices. The articulated set of perceived affordances could be used as an orientation for the content of such intervention strategy. The intervention strategy should possibly engage teachers in examining their preconceptions and seeking to understand how these might impede their technology integration. Intervention should also take into account the likelihood that preconceptions about learning will surface as most influential upon teacher perceptions of affordances and subsequent instructional decision-making.

This study is a relatively small inquiry, focusing on a single participant and particular context. Further studies might attempt to engage more teachers in similar inquiries. Further studies might also explore contexts other than a technical education institution. Here are some more specific areas that could potentially be addressed in further studies:

i) How perception of affordances shifts as epistemological orientation changes?
ii) How perception of affordances develops in collaboration of teachers?
iii) How different dominating areas of preconceptions lead to changes in perceptions of affordances?
iv) What is possible impact of perceptions of affordances upon students’ learning?
Learning objects as educational resources for PDA technology: how the experience of designing them transforms teacher thinking about PDAs?

These are just some of the possibilities. The PDA, especially with a mobile phone, is a new technology that is yet to make its way into teaching and learning. This technology potentially opens a spectrum of opportunities for interesting educational research in relation to both teachers and students.

Acknowledgement: Special thanks to Barbara White and Mike Grenfell, Charles Darwin University for their comments. The PDA device in this project was provided through the University of Hong Kong funded research project “Design of effective interactive learning objects for Pocket PC delivery.”

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