Evaluation of Applications of Personal Digital Assistants in Elementary Education

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Abstract: - This study investigates the possibilities associated with elementary students using PDA Phones and built-in software in mobile learning. The participants comprised 21 6th grade students in southern Taiwan, including 12 boys and nine girls. Students participated in five experimental learning activities over 15 weeks. Furthermore, four semi-structured questionnaires, two unstructured individual interviews and two semi-structured individual interviews were conducted. The results demonstrate that students can easily use PDA Phones in learning activities. Besides, Internet, music, game, photo and phone were the most commonly used applications. This study also probes into the problems associated with students using PDA Phones.

Key-Words: - Mobile learning, wireless network, PDA (personal digital assistant), elementary education.

1 Introduction

Rapid development of information and communication technologies has profoundly impacted global education. The application of computers could be personal computers, notebooks and even PDAs. Consequently, teaching overcomes the limitations of classrooms and extends to places other than traditional classrooms and Internet environments.

Chabra & Figueiredo noted that "ubiquitous learning" refers to learning without constraints of time and place, and using numerous devices [1]. Harris stressed that "ubiquitous learning" mainly denotes learning at appropriate times and places, and utilizing appropriate materials. Learners can use the assistance from wireless communication to implement E-learning using mobile devices [2]. Hsiau, Ling, Juang, Shiu, You, and Ling, indicated that "mobile learning" describes the ability of an individual to freely obtain required knowledge content without constraints of time and place, and simultaneously or non-simultaneously, by using table PC, pocket PC, PDA or other devices that can carry digital content. Devices that support mobile learning are all called "mobile learning devices" [7].

Kynaslahti pointed out that "mobile learning" possesses three characteristics, namely convenience, expediency and immediacy. Convenience means that learning can occur whenever learners are free. Furthermore, expediency means learning activities can occur without constraints of place. Finally, immediacy means new ideas can be shared without constraints of time or that embedded photographic functions in mobile devices can be used to facilitate immediate sharing of videos or pictures with others [11].

The National Science Council of the Republic of China (ROC), in the document entitled "National Science and Technology for E-Learning", defined "mobile learning devices" as mobile computers that are fitted with wireless communication functions, are light-weight and hand-held, are easily portable, primary use hand-written input, and have battery life exceeding eight hours [15]. Besides, with the adoption of mobile learning devices in learning, students could connect to the Internet and obtain new learning skills and abilities. "Mobile learning devices" are suitable for lifelong learning. Individuals from all works of life and of all ages can use mobile learning devices at any time as tools for reading and learning. Among various mobile devices, PDAs are best suited for use in mobile learning. PDAs are easily portable and permit learners to learn outside classrooms regardless of constraints of time and space.

Kong, Lam & Kwok used PDAs as cognitive tools in math problem-solving learning groups, and demonstrated them to effectively enhance negotiations and interactivities within groups [10]. PDAs can solve problems on traditional desktop

computers, which are unsuitable for use in face-to-face interactive collaborative learning [2, 3]. Lehner, Nosekabel & Lehmann implemented the Welcome (Wireless E-Learning and Communication Environment) project in the University of Regensburg. In this research, lecture contents and lecture videos were provided and students could access these materials through PCs, PDAs or WAP mobile phones [12]. Danesh, et al. implemented the Geney project and used local elementary students as experimental subjects to simulate firm genetic patterns and teach genetic concepts and related genetic knowledge in Science subjects [5]. Fritz, Seifert, Leley, Paletta & Almer embedded a mobile picturing system to automatically retrieve photos from PDAs or camera phones to the servers. These images were used for image recognition and connected to related information. Additionally, the GPS was employed to retrieve user locations and assess information or services available in the neighborhood of these locations [6].

PDAs possess internet and filming functions and have gradually been applied in pilot studies elementary schools and colleges for viewing teacher lecture related videos, and monitoring teaching related discussions and communications. Furthermore, PDAs are possess a photography function and can be applied in daily life. Mobil technology positively influences learning are suitable for real life application. Therefore it is worth investigating whether mobile technology can be introduced to schools and incorporated in the teaching curriculum. This study considers the possibilities for school curricula to embed with mobile learning, as well as the suitability of elementary school students using PDA phones as mobile learning devices. This study examines the following issues:

(1) the functions students prefer when using PDA phones as a mobile learning device.

(2) the functions students commonly use when using PDA phones as mobile learning devices.

(3) the ability of students to use PDA phones for required learning activities.

(4) the evaluations and perspectives of students regarding common functions in PDA phones

(5) the distinctive characteristics of PDA phones (such as hand-written input, screen size and so on) and the influences of these characteristics on learning applications

(6) the potential for applying PDA phone functions to different learning criteria in schools

2 Experimental Methods and Procedures

2.1 Participants

The participants were from an elementary school located in southern Taiwan. With the approval of parents and teachers, 21 sixth-grade students, including 12 boys and nine girls, were enrolled in this investigation, which ran over 15 weeks. Eighteen of the participants had a networked computer at home; one had a computer but no Internet access, and two had no computer. All the participants had learned to use word processing, presentation, and image processing software. The students could surf the Internet and create simple web pages. One participant failed to complete the research activities owing to family reasons.

2.2 Equipment

During the investigation, each participant was provided an E-TEN M600 PDA phone with built-in 128MB ROM, 64 MB RAM, an 802.11b wireless network adaptor, and a 130 mega pixel camera. The operating system was Windows Mobile 5.0.

2.3 Learning Activities

The students used PDA phones to implement the following learning activities:

(1) ***Portrait sketching***: Each student sketched a portrait on their respective PDA phones.

(2) ***Plant recognition in campus****:* The students sought their favorite plants and used their mobile devices to record plant characteristics, sketch leaf veins and take pictures, and finally to edit a written document.

(3) ***Searching and communication:*** The students used Google for PDA to search websites of interest and that were relevant to their learning. Furthermore, the students phoned each other over Skype to share their findings.

(4) ***Collaborative Learning:*** Students worked in triads and used their mobile devices to complete a designated task, including creating a presentation.

(5) ***Application in Life:*** Each participants was issued a PDA phone during the research, and kept it at hand regardless of whether he/she was on campus).

2.4 Data Collection and Procedures

The following tools and methods were used before, during, and after the activity to collect research data:

(1) Before initiating the learning activities, students were administered semi-structured questionnaires to learn whether they had computers at home , whether they had Internet access at home, the kind of software they could use, and their preferences regarding PDA phone functions.
(2) Following the "portrayal sketching" learning activity, non-structured individual interviews were administered to students, to learn student problems and perspectives regarding the use of PDA phones, and particularly their views regarding the comparison of image processing software use between desktops and PDAs.
(3) Following the "plant recognition on campus" learning activity, non-structured individual interviews were administered to students, to learn their problems and perspectives regarding data collection using PDA phones,, especially the use of photography functions to assist in data collection.
(4) Following the "communication and searching" learning activity, semi-structured questionnaires were administered to students, to identify the PDA phone functions most commonly used by participants during the learning activity, the problems participants encountered when using Skype on PDA phones, and for surfing the Internet while outdoors, and their experiences when browsing web pages via PDA phones.
(5) Following the "Collaborative Learning" learning activity, semi-structured questionnaires related to "PDA phone functions" were administered to students, to identify the main PDA functions used by participants in the activity, the advantages and weaknesses of using PDA phones outdoors, the problem of collecting data using PDA phones outdoors, and the problems associated with small-group activities using PDA phone.
(6) Following the "Application in Life" learning activity, semi-structured individual interviews were administered to students, to clarify how participants use PDA phones for applications other than research related learning activities (whether on campus or elsewhere), the PDA functions that they commonly use, their reasons for using PDA phones, and the attitudes of their parents towards the employment of PDA phones and the reactions of non-participants towards the participants. Following the "Application in Life" activity, semi-structural individual interviews were administered to the participants to better understand the state in which pupils use and borrow PDA phones for activities other than learning activities (whether on campus or elsewhere), the PDA functions that they commonly use, their reasons for using and borrowing PDAs, the attitudes of their parents towards the use of PDA phones.
(7) Following the completion of the planned learning activities examined in this study, semi-structured questionnaires for "functions of PDA phones" were administered to students, to identify the problems participants encountered (using the PDA phone) during this research, as well as their reactions to applications involving the use of PDA phones in mobile learning, including reactions to the weight of PDA phones, handwriting recognition pens, extension functions, screen, charging, photographing, Internet access, memorandum and possible means for applying PDA phones in class learning.
(8) Following the planned learning activities conducted in this investigation, nine participants were administered semi-structured individual interviews to identify their reaction to the application of PDA phones in learning, and whether they changed their preferences regarding PDA phones before and after the learning activities.

The data above was collected through specially designed questionnaires which were administered on Moodle platform. (students also uploaded assignments relating to the learning activities to this platform). The interview contents were thus recorded and transcribed.

3 Results

3.1 Pupil favored PDA functions

This investigation found that Internet access, video games, photography, audio and communication were the five functions pupils favored in PDA phones, according to the questionnaires administered before the learning activities, the individual interviews conducted following the "Application in Life" activity and other activities (as listed in Table 1). A11 mentioned in the questionnaire and A21 mentioned in an interview that their preference regarding PDA phone Internet

access functions stemmed from the fact that such functions helped solve problems in real time. A01 observed that subjects who favored music, namely the audio, video game, and photography functions of PDA phones, did so because of the applicability of such functions for leisure purposes. Furthermore, A18 stated that subjects favored photography functions of PDA phones because they could use these functions to take pictures while communicating with others.

… To solve a problem rapidly or help others how to use the functions, I need to access the Internet. (from the questionnaire of A11).

… because I want to learn more, it is helpful for me surf the Internet to find answers to whatever questions I have. (from the interview records of A21)

… I can listen to music when hanging out with friends, play games and take photographs when I am bored. (from the interview records of A01)

… because I can simultaneously communicate, and take photographs and recordings while learning with friends (from the interview records of A18)

Table 1. Statistics of functions of PDA phones favored by pupils

Order	1	2	3	4	5
Before learning activities	Internet access	Video game	Photographing	audio	Communication
After "Application in Life" activity	Internet access	Audio	Video game	Photographing	Communication
After learning activities	Internet access	Audio	photographing	Video game	Communication

3.2 Functions of PDA phones commonly used by Pupils

Questionnaires conducted as part of this study, following the questionnaires on "Portrait Sketching" and "Plant Recognition on Campus", shows that Internet access, video games, photography, listening to music, and communication are the functions most commonly used by pupils (as shown in Fig. 1). This result was identical to previous results of the five PDA function most favored by pupils. The functions of Internet access and communication were especially crucial to participating in the "Communication and Searching" learning activity. Meanwhile, the functions of word processing, photographing and Internet access were crucial for participation in the "collaborative Learning" activity. With the exception of photography, pupils did not alter their habits with regard to common functions of PDA phones.

For example, subjects listened to or downloaded music using PDA phone, both A02 and A05 expressed that they had begun surfing the Internet following] completing the assignment. A03 and A05 also expressed that they listened to music when they were bored or stressed.

… After "struggling" on the Internet for a while, I am finally able to download songs. Since a lot of music-related websites have been closed, it is becoming increasingly difficult to find sites for downloading music. It seems like that my skill in using PDA phones to surf the Internet is improving. (from the questionnaire of A02).

… I am happy and excited to surf the Internet outdoors. After completing my assignments, I like to surf the Internet and I find this is a good way to make me relax. I can lie in a peaceful meadow, then quietly go online and enjoy myself. (from the questionnaire of A05).

… I enjoy listening to music when I feel bored. (from the questionnaire of A03).

… I can release stress by listening to music. (from the questionnaire of A05).

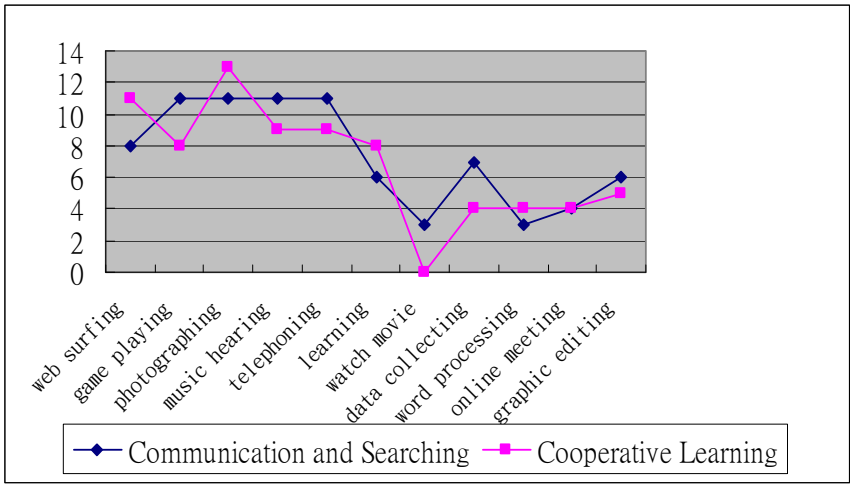

Fig.1 Statistics of commonly used functions of PDA phones

3.3 The situation after pupils completed the profile of completion of learning activities

Pupils participated in the following four mobile learning activities: "Portrait Skeching", "On Campus Plant Recognition", "Communication and Searching" and "Collaborative Learning". Students had to upload their completed work to the Mobile platform within a limited time period. The circumstances in which pupils had to turn in their works are listed in Table 2. The activity completion rate exceeded 80% in all cases, except for that of Collaborative Learning.

The individual interviews and questionnaires conducted following the learning activities demonstrated that pupils generally did not experience any difficulty applying PDA phones for learning. For example, A9 and A14 expressed that the PDA function of image processing is the same as in the case of desktops; moreover, A11 expressed that they had encountered no difficulties during the process; finally, A15 commented on it being "nice and easy" to upload files.

Table 2 Statistics profile of completion of each learning activity

Completion / Action learning	Pupils involved	Completed in time Persons involved	Not completed in time Persons involved	Completion rate
Portrait painting	20	19	1	95%
Plants Recognition In Campus	20	18	2	90%
Internet access	20	19	1	95%
Communications (Skype)	20	16	4	80%
Cooperative Learning	6 groups	2 groups	4 groups	33%

… Image processing using PDA phones is almost identical to that using desktops. (interview with A9)

… I feel drawing on PDA phones is just as fast and satisfactory as drawing on desktops. (questionnaire of A14)

… Learning outdoors enables me to experience pleasure in learning, and even to experience learning in pleasure. I find learning no problem at all! (questionnaire of A11)

… I can easily upload files when online.(questionnaire of A15)

The reason for the unsatisfactory completion rate in "Collaborative Learning" may arises not from the usability of PDA Phone function but the design of activity itself. For example, A07 expressed the ignorance of the division of labor regarding the questionnaires; moreover, A08 expressed that no one wants to be the team leader; finally, A02 expressed that he had to stop halfway through a task because of the battery running down.

… Everyone has numerous different opinions and initially we do not know how to distribute jobs fairly. (from the questionnaire of A7)

… No one is willing to lead the group, because no one wants to assume the associated responsibility. (from the questionnaire of A08)

… I was forced to abandon my share of the work for the task when the batteries of my PDA phone died. (from the questionnaire of A02)

3.4 Pupil assessments of common functions of PDA phones

Following 15 weeks of learning with the assistance of PDA phone, pupils expressed in the interviews that the main function of PDA phone in mobile learning is Internet access. All pupils expressed that Internet access was an important function. Moreover, both A02 and A12 were concerned with wireless network instability. A15 also noticed that Internet access was restricted to on campus

… PDA phones are unable to access the Internet and the error message appears. (interview with A02)

… The wireless network signal is instable, so I have to connect to and log into my accounts several times to get online. (interview with A12)

… The PDA phone Internet access is restricted to on campus, and is useless in places where one cannot connect to the web. (interview with A15)

Based on the photographic function of PDA phones, the pupils expressed during the interviews that the photographic functions of PDA phones can be used in learning and entertainment regardless of age and environment. 95% of pupils observed that they cared about whether they could use the photographic function in PDA phones. During the learning activities, A01, A02 and A06 expressed that PDA phones fulfilled both photographing and word processing functions and thus were convenient. Nevertheless, they also noted that some significant photographic problems associated with PDA phones needed to be examined. For example, A17 noted that the PDA screen became hard to view in bright sunlight A07 also observed that the lens changed color under sunlight.

… It offers both photography and word processing functions so I can take notes on photos and remind myself. It's convenient.(interview with A01)

… I use photos to supplement my recorded data, which is really useful! (interview with A02)

… Using PDA phones to take a photograph is really fun. Besides, to write down my opinions is handy after taking pictures. (interview with A06)

… The screen was difficult to view when taking shots under strong sunlight! (interview with A17)

… Under strong sunlight, the screen blurred and turned bluish green. Almost everyone had similar experiences and sometimes the whole screen blackened. (interview with A07)

Given the music functions of PDA phones, the pupils expressed during the interviews that the music functions of PDA phones can be used for both leisure and learning, but are mostly used for leisure. Approximately 95% of pupils expressed that they cared about their ability to use music functions of PDA phones. Pupils were generally concerned with the problem of whether sufficient memory was required to use the music functions of PDA phones. For example, A01, A08, A11, and A12 mentioned that memory capacity influenced the use of music function.

… The memory capacity for PDA phones is inadequate for downloading many songs. (interview with A01)

… Insufficient memory capacity limits PDA phone function. (interview with A08)

… The memory capacity is insufficient for me to download songs successfully. (interview with A11)

… I can only download one more song .It makes me feel limited and a little uncomfortable. (interview with A12)

Given the communication function fulfilled by PDA phones (Skype), pupils expressed in the interview that communication functions of PDA phones can be discussed while learning. Some 70% of pupils expressed in the questionnaires that they cared about whether they were able to use the communication function of PDA phones. During the learning activities, A03 and A06 mentioned that log in was required for both wireless networks and Skype, and it was too complicated to input the account names with whom one was speaking while trying to use the communication function.

… The main input method used by PDA phones is via a handwriting recognition pen; it's time-consuming to type the account if it contains many letters (interview with A03)

… When I want to call someone, it is troublesome to enter long numbers. Therefore, personally I think these drawbacks need to be improved by shortening the numbers improving Internet surfing ability and so on. (interview with A06)

Regarding the video game function of PDA phones, pupils expressed in interviews that this function can be used for entertainment. Notably, 85% of pupils expressed that they cared about their ability to use the video game function of PDA phones. In learning activities, A02, A03, A15, and A08 expressed that they used PDA phones to play games.

… I play computer games using PDA phones (questionnaire of A02)

… I love playing games using PDA phones. (questionnaire of A03)

… I sometimes secretly play games before going to bed. (interview with A15)

… I play games whenever I want to take a break. (interview with A08)

3.5 Influences of PDA characteristics on learning applications

Pupils saw handwriting recognition pen as a major and major input method for use in drawing. For example, A02, A16, and A18 expressed in the

interview that handwriting recognition input resembled drawing on paper with a pen, with it being possible to draw whatever comes to mind; However, pupils felt it was easy to make mistakes when inputting words. For example, A02 and A11 expressed that problems can easily occur as a result of incorrect word recognition or choice. Besides, A15 and A18 worried about scraping the screen. A16 suggested attaching a keyboard for them to use in entry.

… I think entry with a handwriting recognition pen is freer than other methods. (interview with A02)

… Use a handwriting recognition pen to draw pictures is just like drawing with a pen on paper. (interview with A16)

… One can draw whatever comes to mind when using handwriting recognition pens together with PDA phones. (interview with A18)

… PDA phones can easily recognize errors when using handwriting recognition pens with PDA phones. (interview with A02)

… The sensor zone of each letter on PDA screen is too cramped, it makes me type wrong letter unwittingly. (interview with A11)

… The handwriting recognition pen can scratch the screen. (interview with A15)

… using a handwriting recognition pen to tap and enter words directly can damage the screen of PDA phones. (interview with A18)

… Besides the touch-screen input, a set of keyboards can be included to choose from. (interview with A06)

Pupils have different views regarding PDA phone screens. Some students considered small screens to be highly portable, as pupils A02 and A08 mentioned in interviews that smaller screens are convenient to use and carry. Some believed that the small screens affected the eyesight, with A07 and A18 mentioning in the interview that smaller screens were tiring to stare at and led to sore eyes. Moreover, A05 and A14 suggested that one should take a break when feeling ill. Observation of learning activities demonstrated that pupils should take a break if using PDA phones for longer than 20 minutes.

… PDA phone has a smaller screen than a desktop and is convenient to operate and carry. (interview with A02)

… PDA phone has a smaller screen and is more easily portable. (interview with A08)

… Because the screen is too small, it consumes enormous energy to stare at the screen and leads to sore eyes. (interview with A18)

… PDA phone has a small screen, making it necessary to rest to avoid sore eyes and nearsightedness. (interview with A05)

… Because of the small screen, I need to take a rest when my eyes feel uneasy. I don't want to get myopia. (interview with A14)

Given the battery capacity of PDA phones, A07 and A11 expressed in interviews that battery death was troublesome, while A05 and A09 observed that battery life could be sustained provided the battery was kept fully charged. The results presented by Corlett. Sharples, Bull, & Chan's also demonstrated that problems of battery capacity needed to be solved [2]. Nevertheless the PDA phones used in this investigation had ten hours of battery usage time, enough for outdoor activities. According to observations of learning activities, pupils generally did not consider the problem of battery capacity until the last minute when engaged in outdoor learning activities. Though the battery capacity has been reminded to be concerned, student's awareness were still delicate. Hence, problems associated with PDA phone battery capacity were associated with recharging habits. A01 and A16 expressed in interviews that there was nowhere to conduct recharging. Currently, school classrooms typically have just one or two power sockets, insufficient to solve recharging problems. More sockets will be required in future.

… My PDA phone's battery continually dies when outside, which is very troublesome. (interview with A07)

… My PDA phone battery is flat again! I have to borrow one from somebody else, and this is really troublesome! (interview with A11)

… The battery capacity is reasonable, and it can be used for a long time when fully recharged. (A05)

… I can use it for a long time after fully charged! (interview with A09)

… PDA phones cannot be recharged outdoors. (interview with A01)

… There is nowhere to recharge my PDA phone in the classroom. (interview with A16)

Owing to the difficulties of carrying PDA phones, pupils expressed in the interviews that they loved to carry their PDA phones around, which enabled them use them whenever they required. During the research, 14 parents approved of their pupils borrowing PDA phones and carrying them all the time, while 6 parents opposed it. Based on pupil interviews, A07 and A14 recounted conversations in which their parents expressed concern that they would lose their PDA phones. Moreover, A18 and A14 were worried that it would affect their academic performance. Furthermore, A11 and A15 expressed that take PDA phone along as a learning instrument is yet not convenient enough.

Consequently, PDA phones are small, but hard work is required to make them suitable mobile learning devices.

… None of the family are careful enough, so what will happen if the phone disappears or is broken? We do not have money to pay for it! (conversation with parents recounted by A7)

… My father said that he was afraid that I would lose or break it. (conversation with parents recounted by A14)

… I play with my PDA phone until late at night, affecting my sleep and studies. (interview with A18)

… I am afraid I will play with the PDA for too long and forget to write my homework. (interview with A14)

… It is troublesome to carry the PDA around on campus? (interview with A1)

… Where shall I put my PDA during PE or swimming classes? (interview with A15)

Given network bandwidth and system crashes, A01, A05, and A06 expressed that accessing the Internet was extremely time consuming. During this research, the network interface card for PDA phone support 802.11b wireless technology but the network bandwidth did not reach expectations. A12, A13, and A17 expressed in questionnaires that PDA phones sometimes crashed. The crashing of PDA phones during this study influenced learning, and system stability should also be considered.

… Surfing the Internet is too time consuming. (interview with A01)

… I hope PDA phones can accelerate the surfing speed. (interview with A05)

… The surfing is so slow; it's not easy to download (interview with A06)

… My PDA phone crashes several times. (questionnaires of A12, A13, A17)

3.6 Possible applications of PDA phone in various learning fields

Following five uses of PDA phones in learning activities, pupils expressed that PDA phones can be used in various learning fields. In the light of language course such as Chinese and English, A02, A14 and A18 expressed that PDA phones can be used to make inquiries regarding new words. Furthermore, A02 and A11 expressed that PDA phone can be used to record lecture contents.

… In Mandarin class, I can use PDA to assist in consulting new words, and associated phonics, as well as assisting in sentence creation. (questionnaire of A02)

… During Mandarin class, I can immediately look up words or expressions that I do not recognize. (questionnaire of A14)

… I can look up words in English class at any time. (questionnaire of A18)

… During English class, I can record text as the teacher reads it and listen to it again after class. (questionnaire of A02)

… In Mandarin class, I can record content written by the teacher on the blackboard. (questionnaire of A11)

Regarding the math course, pupils (for example A14 and A18) considered PDA phones useful for calculation, A14 expressed that PDA phones can be used to look up symbols.

… During math class, I can look up symbols I do not recognize, or perform arithmetic involving large numbers. (description of A14 in the questionnaire)

… In a math class, I can easily find out the solution to a difficult problem by using a PDA Phone.(questionnaire of A18)

Regarding the science course, pupils see PDA phones as supporting diverse activities. For example, A06 mentioned that one can surf the Internet to explore related information. A02 and A05 thought that PDA phones can be used in ecological observations; moreover, A11 and A20 thought PDA phones can be used to film teacher demonstrations for purposes of experiments.

… In science class, I can immediately look up related data that I do not understand. (questionnaire of A6)

… In science class, I can record my ecological observations using PDA phones. (questionnaire of A02)

… In science class, PDA can be used for ecological observations and scientific discussions. (questionnaire of A05)

… In science class, I can film the teacher experiments and watch them again. (questionnaire of A11)

… In science class, I can record the experimental methods used by the teacher. (questionnaire of A20)

Regarding social science course, pupils considered that PDA phones can be used to consult all the course-related information, including social circumstances, and almanac about history A11 mentioned that one can consult the data on countries all around the world. Furthermore, A15 also mentioned that PDA phones can record key points from teacher lectures.

… In social science class, I can instantly obtain information on main cultures around the world. (questionnaire of A11)

… In social science class, I can record what teachers said in real time. (questionnaire of A15)

Regarding music course, pupils considered that PDA phones can be used to instantly access information on musicians and listen to their music. A09 mentioned that PDA phones can be used for recording, A01 even considered creating compositions in class.

… In music class, one can simultaneously compose and listen to tunes, and immediately revise them. (questionnaire of A01)

… In music class, one can record songs demonstrated by the teacher, and tunes the teacher plays on different musical instruments. One can then practice these at home. (questionnaire of A2)

Regarding the art course, pupils saw PDA phones as suitable for application to drafting. A02 mentioned that PDA phones can be used to record teacher demonstrations as facilitation while drawing. A05 noted that PDA phone can be used to download films related to artists.

… In art class, I want to photograph the pictures drawn by the teacher on the blackboard. I can consult them while drawing. (questionnaire of A02)

… I want to download art-related films during art class

and show them to my classmates. (questionnaire of A05)

Regarding PE courses, pupils think that PDA phone can be used to obtain information on athleticism and health. Furthermore, A02, A07, and A16 expressed that PDA phone can be used to film demonstration movements, for reference during subsequent practice at home.

… In PE class, I want to record the movements of the teacher during gymnastics, and practice them later at home. (questionnaire of A02 and A07)

… During PE class, I can shoot the movements of teachers while swimming and learn them afterwards at home. (questionnaire of A16)

In conclusion, pupils considered the main application of PDA phones to be web surfing, instantaneously accessing information, photography (including filming), word processing and audio recording (including natural phenomena and classes). However, negative applications should also be noted; for example, A01, A02, and A13 all thought that PDAs could be used to cheat in tests.

… During the test, PDA phones can be used to search for answers in cases where the correct answer is not known; [restated OR that is, these devices can be used for cheating. (from the questionnaires of A02, A02, A13)

4 Discussions

(1) The learners favored and commonly used the following five functions: Internet surfing, playing games, photography, listening to music (multimedia functions), and telephoning (Internet telephony function) before and after the learning activity, Demand for Internet surfing, listening to music, photography and gaming was particularly high. Research from market research consultant InsightXplorer Limited consistently showed that the most popular Mobile phones were those capable of web surfing, game playing, photography (including video) and music playing functions [9]. The analytical results presented in this study can provide a reference for future curricular design in elementary school education.

(2) During the learning activities, three learners spent 60% more time than average on learning PDA phone operation. Moreover, 4 learners spent 40% less time on learning than average, and moreover displayed higher interest in learning the new technology. Furthermore, these four learners were all familiar with the self-management of PDA, system use, applications of network resources and memory expansion. This result was consistent with the findings of research conducted by Ilomaki & Rantanen, which pointed out that there exists some kind of gap between learners when using new technology [8]. Therefore, in future, when the new technologies are introduced, more time must be devoted to individuals with lower learning abilities who wish to learn more complex applications. Such an approach could bridge the gaps made by new technology.

(3) The most popular locations for using PDAs (to be identified in the individual interviews conducted after the learners used PDAs) were, in order: inside the school, at home, outdoors, in cars and in libraries. Schools and families occupied first and second places, respectively, and the family members of learners also learned to use PDA phones. It is consistent with the study of Whyley et al., which mentioned that mobile learning extends learning in schools to the family, and thus has the potential to extent learning to the family or even the community [16].

(4) The most suitable timing for the use of PDAs (as identified in individual interviews conducted following learner use of PDAs) , in order, was: in hiking (entertainment), during class (assisted learning), when bored (to kill time), in emergencies (for communication) and during learning (self-learning). Hiking and lecturing occupied the first and second places, respectively. Lecturing and learning, which occupied the second and fifth places, respectively, were both related to the teaching application showing that learners still hoped that PDA Phones could be used as tools to assist in learning. In the future, when PDA phones are introduced to teaching activities, the teaching modules in traditional classrooms will be changed, for example by integrating the functions of computer classrooms into traditional classrooms. Students will be able to use PDA phones to assist their learning, and it will also change teaching modules thus also significantly changing teaching modules.

(5) When PDA phones were introduced to curricular teaching in elementary school, learners hoped that Internet surfing would be provided at any time, thus enhancing the functions of PDA phones. To enhance the functions, the most important functions included the following: longer battery lifetime, faster execution speed, and lighter weight, the ability to watch films, unlimited expansion capacity, and the addition of USB ports. Because of the incomplete internet environment, students suffered inconvenience in using PDA phones. Besides, battery charging, execution speed, weight and expansion all needed to be improved before the introduction of PDA phones for use in teaching in elementary schools.

(6) PDAs were initially designed for use as a personal digital assistant, fulfilling functions such as

calendar, contact, memos and reminders. However, for learners in elementary school, these functions were less important. During the research, the learners did not use these basic functions. Even during the interviews, learners mentioned that they did not require these functions. This differed from the initial concept.

(7) During the learning activities, the learners could not directly upload their learning outcomes on the Moodle platform because of the limitations of the Internet browser installed on the PDA phones. Information had to be processed on the computer before being uploaded to the Moodle platform. Operating the PDA thus was complicated, and mobility was reduced. Therefore, in future PDA phone operating system needs to be enhanced, and learning platform design and selection must be reconsidered to motivate learners.

(8) The learners mentioned in the application of various discipline that the PDAs could act as a Chinese dictionary for immediately looking up new words, phrases and sentences. PDAs could also act as an English dictionary for looking up the new words and Standard English pronunciations. Furthermore, PDAs could serve as foreign language dictionaries, and learners encountering unfamiliar words could look them up, listen to and learn them immediately. Furthermore, PDAs could be used as encyclopedias for enhancing personal knowledge. Consequently, learners hoped that the PDA phones could act as references to assist them in learning. This study thus suggested that in future more foreign language dictionaries should support PDA phones to enhance applications relate to teaching.

(9) The learners hoped that PDA phones would be able to record the process used by teachers to solve mathematical problems during math classes, experimental operations during science class, teacher demonstrations of swimming styles during swimming classes, sketching techniques in art classes and generally to record teaching processes as a reference for self-learning. Clearly, learners have a need to record digital classes and using PDA phones in digital learning. In the future, PDA phones need to develop better functions in digital video taking and recording to meet future learning needs.

(10) The learners hoped to be able to use PDA phones to surf online immediately or access curriculum-related knowledge on encountering problems during class; for example, they wanted to be able to access demonstrations of exercises (including swimming) and health-related information (for example, human organs or physical health maintenance). In Art classes, learners could consult information on painters, download art-related videos, and so on. Moreover, the learners wished to be composed and write lyrics spontaneously during the music lessons, or to observe natural ecosystems, collect experimental data and so on. The learners displayed strong demand to use PDA phones as assisted tools for learning, and hoped to be able to improve these functions in future.

5 Conclusion

From the practical application of PDA phones for learning among students in an elementary school, this study found that PDA phones can assist in mobile learning. The functions of web surfing, music hearing, gaming, picture taking and telephoning offered by the PDA phones were highly attractive to the students. Students could learn to operate the devices easily, and thus they were frequently used. PDA phones could be applied to different learning activities for different curricula, and most students could fulfill the regulatory requirements. Although students identified problems with the PDAs in the areas of Input System, screen size and recharging, these problems appeared not to influence the process of mobile learning activities, including collaborative learning and so on. For the sake of practical implementation, it is recommended that designs related to assignments may need to be improved and the responsibilities of members may need to be articulated.

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