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ORIGINAL PAPER

Mobile Technology Use in Medical Education

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Abstract This study was undertaken to determine the PDA functionalities for a problem-based learning (PBL) medical curriculum at the Graduate School of Medicine (GSM), the University of Wollongong (UOW). The study determines the factors/aspects of incorporating PDAs, and the attitudes of stakeholders regarding the use of PDAs in such a PBL-based medical curriculum. In-depth interviews were designed and conducted with medical faculty, the medical education technology team and honorary medical academics. Four major PDA functionalities were identified, these being: clinical-log, reference, communication, and general functions. Two major aspects for the incorporation of PDAs into the PBL-medical curriculum at the UOW were determined from the interviews, these being technical and practical aspects. There is a potential for PDAs to be incorporated into the PBL-medical curricula at the UOW. However, a clear strategy needs to be defined as to how best to incorporate PDAs into PBL-medical curricula with minimal impact on students, as well as financial and resource implications for the GSM.

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Introduction

A systematic review of the use of PDAs in medical education has identified the general characteristics of PDAs, PDA platforms, the use of PDAs in the healthcare professions, and how PDAs can be deployed into medical education [1]. It is observed that PDA use has gradually increased in the healthcare professions. To effectively use PDAs in the healthcare sector, the devices should be compulsorily incorporated into healthcare organisation systems via network connections for data and resource sharing [2]. PDAs are essentially used in the healthcare professions for two major purposes: administrative tasks and direct clinical work. Doctors mostly use PDAs at the point-of-care for clinical decision support, prescribing medication, viewing lab results and accessing reference information, for example, drug information and drug interactions [3–7]. Moreover, doctors also use PDAs for recording patient information and patient logs. In addition, five major PDA functionalities for healthcare professions were identified, these being, general, referencing, organization, communication and other special functions. It was also noted that PDAs have been used in medical education and residency programs in order to enable students to provide an alternative way of studying medicine and to learn at their own pace, for instance, taking notes, looking up references and recording clinical encounters on clinical-logs [8].

However, there are several issues to consider for the use of PDAs in medical education in terms of technical aspects, for instance, loss of data, improper backup, technology

compatibility, etc. There are a number of software applications that can be used in facilitating medical study, for example, reference applications for drug information, classroom assessment systems, teaching evaluation, etc. Little is known about what PDA functionalities are most suitable and applicable for PBL medical curricula however. Nevertheless, PDAs seem to be a valuable tool in both the medical profession and medical education. However, the appropriate PDA functionalities, influence factors/aspects for incorporating PDAs and strategies for incorporating PDAs to PBL-medical curricula have yet to be evaluated and determined. Therefore a feasibility study for incorporating PDAs into a PBL-approach to medical education was undertaken within the Graduate School of Medicine (GSM) at the University of Wollongong (UOW).

The GSM started accepting medical students in 2007. The PBL-based medical curriculum, which comprises 93-clinical problems, was designed for use within the GSM. The core delivery strategy is cased-based learning by monitoring students' progress throughout their 4 years of study. The use of information technology (IT) is integrated into the course in order to assist and facilitate students in learning medicine, particularly the use of PDAs in medical education. According to the GSM curriculum, students start practicing in clinical placement from year 1 throughout year 4. The use of IT, in particular PDAs, becomes an essential component of medical study, especially when students are dispersed into clinical environments elsewhere in Australia.

Method and design

In order to identify the feasibility of incorporating PDAs into PBL medical curricula, the following major research questions were defined: (i) what are the key PDA functionalities applicable for medical study?; and (ii) what are the factors/aspects which may influence the incorporation of PDAs into PBL-medical curricula? The qualitative research (in-depth interviews) method was selected for using in this research because this method allows the researcher to gain in-depth understanding of various issues and aspects [9] for the deployment of PDAs. Semi-structured interview questions were formulated based on literature reviews and a scoping study. The 37-interview questions were categorised into three major aspects, these being PDA functionalities, IT and practical aspects towards PDA use in a PBL-medical curriculum at the GSM. To answer these questions, in-depth interviews were conducted with 15 medical school stakeholders, including GSM medical faculty members (n=8), educational technology team members (n=4), and honorary clinical academics (n=3) at Wollongong Hospital. The primary purpose of the interviews was to gather their attitudes, knowledge and experiences towards using PDAs in a PBL-based medical curriculum. The interview process provided insight into the relevant issues. The interviews were transcribed and analyzed into themes and sub-themes using the Nvivo software package version 7.

The first section aimed to identify preferences of the GSM regarding PDA functionalities for the UOW PBL-medical curriculum. Secondly, the questions in the IT aspects section were intended to capture technical considerations with regard to the incorporation of PDAs into the UOW PBL-medical curriculum. This section contains three sub-sections, namely interoperability, network connectivity, and data security and privacy. Thirdly, questions in the practical aspects section were set out to gather concerns and future plans regarding PDA use in both medical education and clinical placements. This section contains three sub-sections, these being electromagnetic interference (EI), maintenance and support, and education and training. Lastly, the questions in the attitude section aimed at gathering the perceptions of participants regarding PDA use in medical education.

All interview questions were sent to experts in medical education, educational technology and IT for validation. The interview questions were reviewed and revised for several rounds, based on the feedback received from the medical faculty, medical educational experts and IT specialists, to ensure that they were valid and reliable for conducting the interviews.

Purposive sampling or *theoretical sampling*, in the form of a criterion sampling strategy, was used in selecting interview participants. As previously mentioned, the aim of this study is to determine the feasibility of incorporating PDAs into a PBL-medical curriculum at the UOW GSM. Therefore the researcher specified the characteristics of the population of interest into three major groups, namely (i) the GSM faculty, (ii) clinical academics and (iii) educational technology specialists.

There are several reasons why the interview participants were drawn from these three groups of experts. Firstly, the medical faculty are the primary group of experts who have direct contact with students throughout their 4-years of medical study. Therefore it is essential to determine their attitudes, perceptions and experiences regarding PDA and technology use in medical education with respect to the UOW PBL-medical curriculum. Secondly, the clinical academics are also a group of experts who play an important role in educating and supervising clinical skills and practice to students while being dispersed in clinical placements elsewhere. Their attitudes, ideas, perceptions and experiences towards technology and PDA use are not only valuable for the incorporation of PDAs into the UOW PBL-medical curriculum, but also in a real clinical practice.

Lastly, the educational technology specialists are a group of experts who directly deal with all technical issues. Therefore it is important to identify their attitudes, knowledge, perceptions and experience in designing, developing, implementing, maintaining and supporting technology and PDA use in the educational sphere. Even though the sample for the interviews is relatively small, it is acceptable sample size in qualitative research [10]. Further, a list of participant contacts was obtained from the GSM. Authority to participate in this study was obtained from individual interview participants. The participants were scheduled for one-on-one interviews, and the interviews tape-recorded for subsequent data transcription. The interviews took approximately 30–45 min. The transcribed data and analysis of results were validated through emails to participants.

All 15-interivews were transcribed into 15-document cases and analysed using thematic analysis. Computer-assisted qualitative data analysis with Nvivo software application was used for data analysis. The strategies in analysing the interview data were segment coded with references to their original verbatim sources [11], sorted, organised, categorized into themes and sub-themes (Fig. 1), then annotated, noted in memo form [11, 12], discussed and reflected back to the literature and the conceptual framework.

Results

The results and findings are reported and discussed in the three following sections,—PDA functionalities, technical aspects and practical aspects. Table 1 summarises the categorisation of emerged themes, sub-themes and examples of codes according to the research questions.

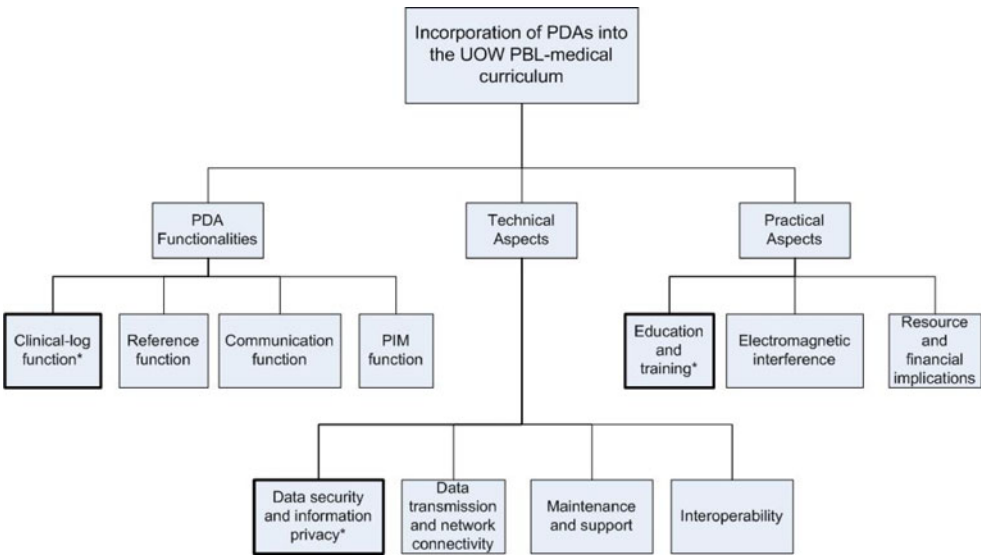

Fig. 1 Hierarchical categorization of the incorporation of PDAs into the UOW PBL-medical curriculum (Note. * represents most important function/aspect)

Figure 2 summarises the association between the four basic PDA functionalities and the UOW PBL-medical curriculum becomes readily apparent.

PDA functionalities

PDAs could assist/facilitate students in learning medicine in four major aspects. Firstly, they facilitate students in recording clinical experiences while having encounters in their clinical placements. Secondly, they facilitate students in having immediate access to reference information during clinical placements or at the bedside. Thirdly, they are a useful tool for interacting and sharing information among faculty, clinical preceptors and peers. Finally, they are a useful personal information management (PIM) tool for keeping contacts, reminders, to-do-lists and to organise daily activities and update schools' events. Therefore there are 4-major PDA functionalities found from this study, -namely clinical-log or tracking clinical experience-log, reference, communication and PIM functions.

1) *Clinical-Log Function*: This function is the most important in the context of the UOW PBL-medical curriculum (Fig. 1). According to the GSM, the curriculum essentially focuses on 93-clinical problems, therefore a clinical-log function is important for students in capturing and recording their clinical experiences and encounters based on these problems during their 4-years of medical study (Table 1). Introducing such a clinical-log function as a basic PDA function for medical study using a PBL-approach is threefold.

Firstly, students can use clinical-logs to record their clinical experiences and encounters, and to reflect upon and identify their learning needs. Incorporating this function

Table 1 Categories of emerged themes, sub-themes and example of codes according to research questions

Categories of themes	Sub-themes	Response from participants
Research question 1: What are the appropriate PDA functionalities for medical education in PBL-approach?		
A. PDA functionalities	1. Clinical-log function	*"The log is the skeleton of how the patient presented…just the basic information, how your confidence has grown using and dealing with situation, and the key feature that helps you reach an hypothesis about what was going on…that will help me grow confidence."*
		"…to make sure…student tracking patients…demonstrating themselves, their range of experiences and identify the gaps in their experiences."
	2. Reference function	*"…a lot of resources…pharmacopoeia….look up drugs, drug dosages…use them for information. …they can immediately look up information on PDA…"*
		"…having access to evidence-based materials when with patients or on the ward…that would be useful…"
	3. Communication function	*"…sharing information and allocating tasks to different members and share things together. …it can allow that interaction to happen across distance. … PDAs would help keeping the interaction that coordinate the PBL process, in tagging people (peers, clinicians and the GSM faculty)."*
	4. PIM function	*"…have them be able to use… the address books, calendars, organizers, reminders, all sort of things..."*
Research question 2: What are the aspects which may influence the incorporation of PDAs into a PBL-approach?		
B. Technical Aspects	5. Data security and information privacy	*"…there is data security. …data so it is not identified by the students' name. …a confidence grows in students over time for research purposes…a few people have access to it…by username and password. …then managed by an educational technology team to ensure… not allow any security break…"*
	6. Data transmission and network connectivity	*"…Bluetooth and Infrared might be problematic. …Bluetooth might be an option within the room…either at the lecture theatre or tutorial room. …Wi-Fi would probably be the easiest…"*
		"…we need to give them access to the server and the Internet. …if the PDA just plugs into a computer, if that is already a network then they will be automatically networking. …if not going wireless, we need to make sure that they have access to a network computer and then simply put the PDA into that. That will give them the most mobile thing with the wireless-network…"
	7. Maintenance and support	*"…provide adequate support as well as the facility. …we will have people who can determine whether that difficulty is a software or user interface problem …if it is a problem with the device, it is somebody else."*
	8. Interoperability	*"…it is cross-platform because some students already have Palms …the priority would be Windows-based, Pocket-PC. We have to look at Palm as well. …if it is web-based, that would be an issue because it would be just on the PDA browser."*
		"I much prefer to use open-standard likes "html" and "web-pages" and be agnostic about the actual platform. …the idea is to let students access through web-based, through their handheld device."
C. Practical Aspects	9. Education and training	*"…have some base level training…for everybody…specifically on knowing how to turn it on and manipulate it, how it should be used and how it benefits medical education, how the faculty or school expect it to be used. …you need drop-in sessions, extra assistance or individual assistance for people struggling with the technology…"*
		"Just giving them training session… we have already put FAQ and information sheets upon Vista for any value material…we do some distance learning modules."
		"we need to educate the community where they are to what the students are doing"
	10. Electromagnetic interference	*"…it is up to each hospital to set up the policies. …hope that students are allowed to use them because we have been discussing that it would be a very helpful thing for the students. …the hospital might set policies that they cannot use them, if that is the case."*
	11. Social acceptance	*"…it is easy to see the value of some technologies where it works very well and it is very easy to get over-enthusiastic about it and then not realize that people might not be ready to actually use that technology for whatever reasons…"*

into PDAs also encourages students to practice life-long learning (Fig. 2). This would be beneficial for students not only during their medical study but also for their professional career in the future. Secondly, a clinical-log function also facilitates students to upload and transfer their log data back to the medical school for educational purposes, for instance supervision, monitoring learning groups and learning progress, designing learning needs, etc. Finally, a

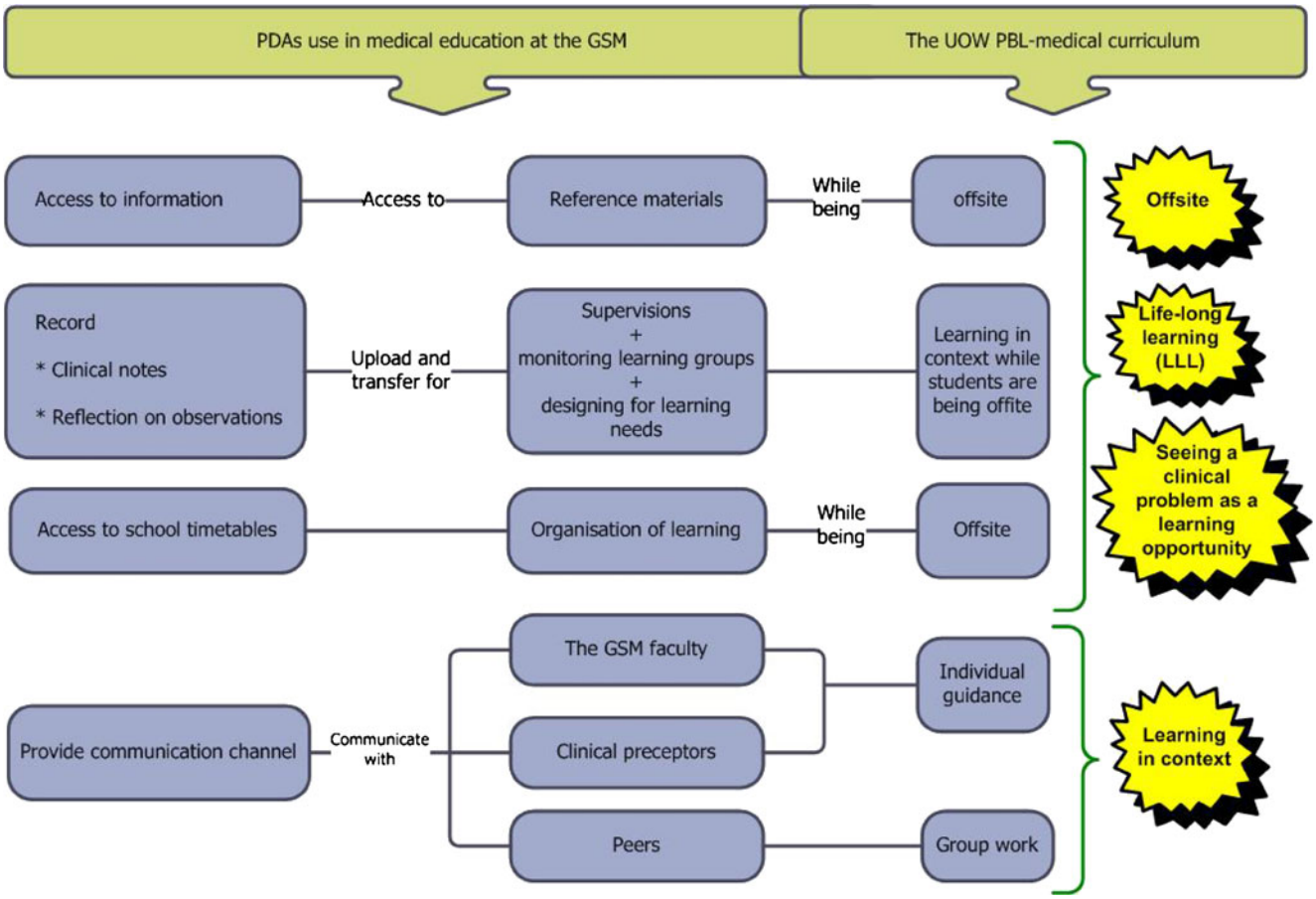

Fig. 2 The association of the four-basic PDA functionalities with the UOW PBL-medical curriculum

clinical-log function facilitates students in learning medicine, especially while offsite, as they reflect on their observations.

2) *Reference Function:* The findings indicated that a reference function is another important PDA functionality in studying medicine. The reason why this is the second most important PDA functionality (Fig. 1) is that students start having clinical experiences and encounters from year-1, as well as learning basic sciences relevant to their real clinical experiences. As a result, having access to references while offsite is essential for students, not only in accessing information at hand but also supporting their clinical reasoning, decision making and personal reflection based on the problems they encountered.

Further, incorporating PDAs with the ability to access reference resources could be more effective and efficient for studying medicine using PBL-approach. Students can at least access their resources 24/7 while offsite without waiting to come back to base. This would save time in accessing information and also encourage students to sustain their learning which would otherwise be limited to just classroom, library or on-campus environment (Fig. 2).

In addition, textbook, e-book, e-reading, third party software and evidence-based medicine (EBM) materials (Fig. 3) tend to be the most important reference resources mentioned by participants during the interviews (Table 1). On the other hand, accessing online-journals, learning environments and handbooks was the least mentioned. This is because of the difficulty of reading clinical references via PDA screens. However having access to handbooks or clinical-guidelines is possible, as students can immediately access these while they are on wards; they provide convenience in accessing references resources wherever they are.

3) *Communication Function:* The primary purpose of having a communication function is for email and internet connectivity. Moreover, it was found that having this function facilitates the use of other functionalities, such as PDA accessible clinical-logs and reference functions.

Three groups of interview participants had a similar perception of incorporating a communication function on students' PDAs (Table 1). The purpose of a communication function is twofold. Firstly, it facilitates the *accessing of*

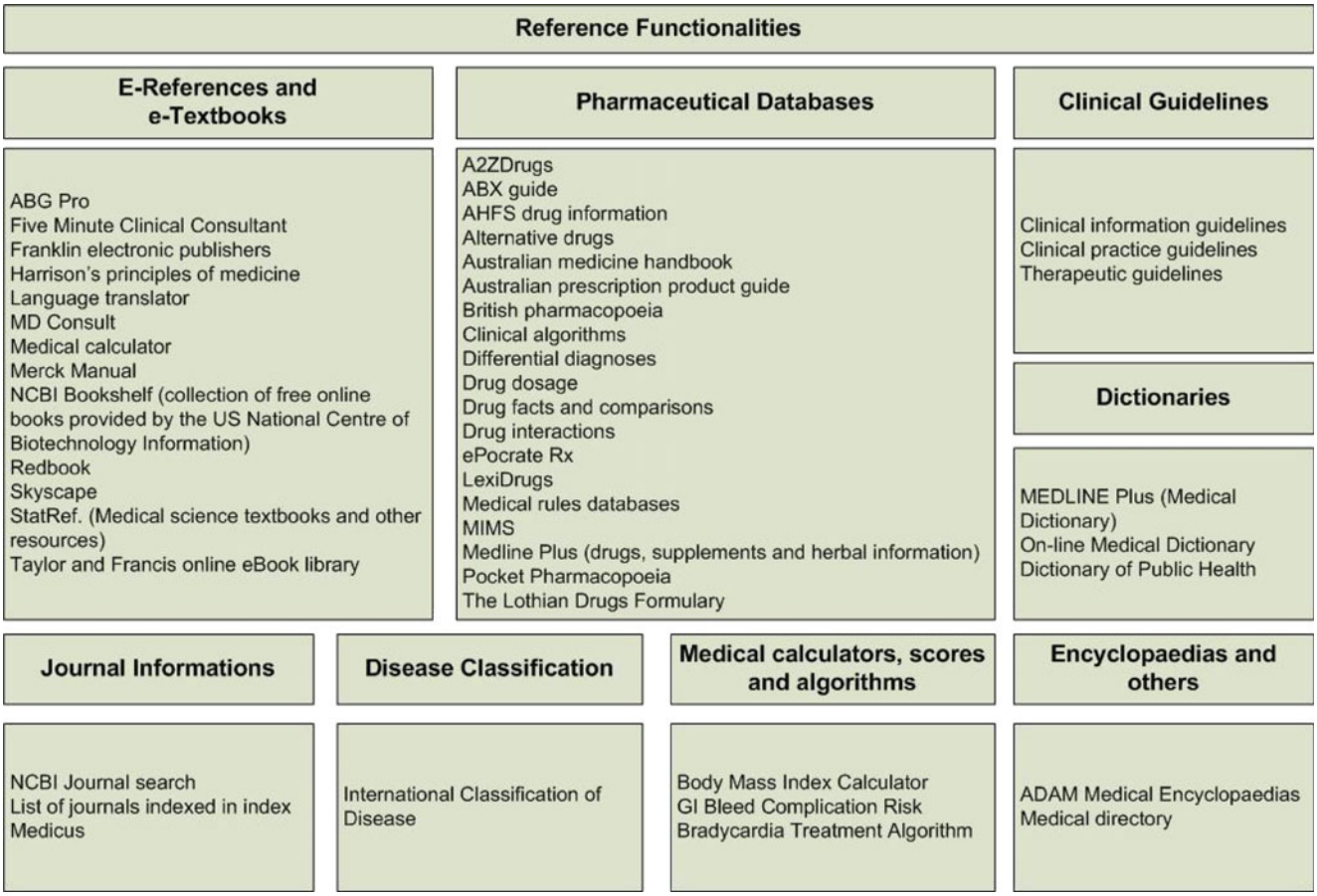

Fig. 3 PDA reference functionality

information, resources and other PDA functions through the network connectivity (Fig. 2). The use of a communication function on PDAs facilitates students in accessing online courseware, Podcasts, audio stream lectures, school events, timetables, clinical guidelines and policies, library resources, PDA-based instructional tools, additional technological simulations for medical and clinical studies, and online journals. Having the opportunity to access school timetables would be beneficial for students in organising their time and realising what they need to do during their clinical placements.

Secondly, the use of a communication function *facilitates interpersonal communication* among peers, clinical preceptors and the GSM faculty, particularly when students are offsite (Fig. 2). Moreover, this function also facilitates students in using other PDA functionalities. According to the participants' perceptions, this function improves feedback and comments on student clinical-logs from the medical faculty. Further, this function also allows students to have online group discussions and to communicate with others by using all kind of media, for instance email, text messaging, etc.

The use of a communication function enhances students to have just-in-time medical education with Internet access and network connectivity.

In summary, the purposes of incorporating communication functionality as one of the basic PDA functionalities are: (i) to access information, resources and references through available network connectivity and; (ii) to provide interpersonal communication among students, peers, clinical preceptors and the GSM faculty while offsite.

4) *PIM Function:* The honorary clinical academic, togerther with the GSM faculty and educational technology specialist have similar perceptions about using PDAs as a PIM tool, as it is a basic function of any PDA (Table 1). It is the fact that PDAs originated as electronic organisers, which comprised standard applications. Such as calendar, address book, memo, to-do-list, etc. This could be the reason why these standard functions were rarely mentioned during the interviews.

In summary, the use of a PIM function is more centred around self-organisation in relation to the school timetable. The use of this function would facilitate students to manage

their time, keep records of important contacts, to-do-lists and reminders for their medical study (Fig. 2). Moreover, there are a number of applications in relation to PIM that have been used in the medical profession, including organisers to hold appointments, access and management clinical information, and timetable organisation.

Technical aspects

Important technical aspects are data security and information privacy, data transmission and network connectivity, maintenance and support and interoperability among different PDA platforms (Fig. 1).

1) *Data Security and Information Privacy:* The GSM faculty have definite ideas regarding data security protection, in that restrictions must be applied by providing access authority only for students and some medical faculty and educational technology specialists (Table 1).

Besides having limited access for authorised people, it is possible to apply relevant security techniques to enhance the security of PDAs in order to protect from interception or hackers. These security strategies include the use of password protection, data encryption, virus protection software, identification and frequent backing up of data.

2) *Data Transmission and Network Connectivity:* There are two-types of network connectivity for students using PDAs when on-campus, these being Wi-Fi and Bluetooth. The GSM faculty and educational technology specialists indicated that they preferred students to use Wi-Fi rather than Bluetooth or infrared connectivity (Table 1). The reason is that Wi-Fi signal is much stronger than other types of connectivity. Moreover it allows PDAs to access information easier than other connectivity. There are a number of hotspots where students can use PDAs around the campus. This would provide students with an alternative in accessing information and resources on-campus besides using computers or laptops. On the other hand, the GSM faculty and educational technology specialists also commented on using Wi-Fi and syncing operations via docking stations for off-campus network connectivity (Table 1).

However, there are several reasons why a PDA docking station could be used as an alternative for network connectivity. Firstly, Wi-Fi connectivity may not be available at all places while offsite. Secondly, it is also possible that there is a restriction of using Wi-Fi at certain areas in the hospital or clinical placement therefore transfers clinical-log data via docking station to online clinical-log could be done via the PDA docking station. Finally, using hotspots for Wi-Fi connectivity is not free of charge in some places, therefore HotSync would be an alternative way to transfer data over the Internet via wired connectivity. However, students would not have the benefits on this type of network connectivity if they need to immediately access online resources while in clinical placements. On the other hand, they can use HotSync via a PDA docking station for back up purposes and transfer of data between PDA and computer.

3) *Maintenance and Support:* Maintenance and support for PDAs and the four-basic functionalities, particularly clinical-log function, is another important aspect that needs to be considered before incorporating PDAs into the UOW PBL-medical curriculum. The GSM faculty and educational technology specialists were the major groups who reflected on this aspect (Table 1). On the other hand, only a small number of honorary clinical academics reflected on this aspect as maintenance and support are an internal concern of the GSM and the university.

Generally, maintenance and support involve collaborations among different departments or units within the university. For instance, there are a number of medical nursing schools which provide direct maintenance and support by themselves in case the PDA applications or functions were directly developed and implemented by the schools. However, other support in terms of database servers, network connectivity and security are collaborations between IT units and the university. For the GSM, maintenance and support could come from three major units, including in-house support by the GSM, educational technology unit and the university's IT unit.

4) *Interoperability:* Interoperability among different PDA platforms is another aspect to be considered before incorporating PDAs into PBL-medical education, especially when the medical school has the potential to introduce the four-basic PDA functionalities for students to accommodate their medical study while in clinical placement.

The purposes of using the four-basic PDA functionalities in medical education are for capturing, recording, accessing, communicating and organising information. Therefore it is necessary for the medical school to ensure that PDAs are able to perform those functions. That is why PDA platforms and their interoperability become a technical consideration in this study.

The GSM faculty and educational technology specialists suggested possible strategies for the medical school in preparing the future use of PDAs in medical education

using (i) a particular PDA platform, (ii) a combination of different PDA platforms or (iii) other possible systems (Table 1).

There are several reasons why interoperability is important for technical issues for incorporating PDAs into the medical curriculum at the UOW. Firstly, it is essential to provide flexibility for students in selecting PDAs which suit their needs and budget. Secondly, some students already have PDAs or other mobile devices, including PDA phone, smartphone or TabletPC, therefore the likelihood of acquiring additional mobile devices with a particular platform is very slim in terms of financial implications. Lastly, the technology is rapidly changing therefore it is important to use a simple technology which is less dependent on other technology fashion and trends. The interview findings indicated that there are several strategies regarding PDA platforms and their interoperability, including *Open-standard PDA platform*, *Windows-based PDA platform* and *function-oriented PDA-platform.*

Practical aspects

The practical aspects comprise three major components, which may influence the incorporation of PDAs into the UOW PBL-medical curriculum, these being, education and training, electromagnetic interference and social acceptance, respectively (Fig. 1).

1) *Education and Training:* The honorary clinical academics, the GSM faculty and educational technology specialists reflected on how to prepare medical students to be familiar with handheld computer technology (Table 1).

The findings from these three different stakeholder groups indicated that pre-education and training regarding PDA use is essential for everyone involved in the use of PDAs in medical education at the UOW. Therefore pre-education and training should be provided during the early stage prior to students dispersing into clinical placements.

One GSM faculty member stressed that the community should be informed about the aims and objectives of students using PDAs in their medical study (Table 1).

Therefore education and training to become familiar with PDA technology is emphasised not only for providing adequate education and training for students, but also for the medical faculty. In addition the community where students have clinical encounters need to be informed about the purposes of using PDAs in medical education, as students will intensively use them in their clinical placements.

2) *Electromagnetic Interference:* PDA use in hospital and clinical placements has become a concern as the devices may generate EI to medical equipment. Alternatively, their usage could interfere with patients during medical consultations, medical treatment or during patients' rest time. The honorary clinical academic, the GSM faculty and educational technology specialists reflected on the use of PDAs in hospitals and clinical placements from the perspectives of in terms of doctor-patient interaction, EI with medical devices, and social interference (Table 1).

However concern of using such devices focuses on particular areas in hospitals, for instance, cardiac and intensive care units. Therefore use of PDAs in clinical placements or hospitals should abide by local policies and regulations in each area. Special care should be taken if using PDAs near any medical device, especially respiratory ventilators, cardio pacemakers, telemetry, or any critical life support device as not all hospitals use modern medical devices which shield their devices from EI. PDA phone or mobile phone signals could trigger such medical devices if being used less than the safe recommended distance (less than 2-metres for first generation mobile phones).

3) *Social Acceptance:* There is a contrasting view regarding the acceptance of PDA in medical education. A few of the honorary clinical academics and educational technology specialists had a similar perception that the social acceptance could be a potential limitation of incorporating PDAs into the UOW PBL-medical curriculum (Table 1), especially using the clinical-log function for recording clinical experiences and encounters in clinical placements. However, the majority indicated that this concern could be eased if the use of PDAs is well informed and the community educated regarding the purpose of using PDAs in medical education and how PDA technology would facilitate medical study and patient care.

However, the doctor and patient attitudes could be changed if appropriate education and training on using PDA devices for both medical education and the medical profession. There are a number of research studies [6, 13, 14] that prove that doctors become comfortable in using PDAs once they realise the benefits for medical education, patient care, clinical decision support and patient education. Patients could become comfortable once they are informed and educated about the purpose of using PDAs in the medical profession and the benefits of using PDAs for improving patient care. Therefore having the community informed and educated about the purposes of using PDAs as a learning tool in medical education is essential before students start having their clinical encounters and clinical experiences elsewhere in the Illawarra region.

Discussion

There are a number of medical schools that provide extensive computer facilities and network connectivity for their students. IT plays a major role in medical education as the technology facilitates both educators and learners in teaching and learning medicine effectively. Moreover a number of medical schools have developed virtual campuses on PDA-based and web-based interfaces to enhance medical teaching and learning for both educators and learners. For instance, the UCLA PDA Patient Log [15] is used during years 3 and 4 during clerkship. Further, the KNOWMOBILE PDA project at the University of Oslo [16] uses PDA devices as information gathering tool and social network tools rather than supporting PBL and evidence-based medicine in medical curriculum.

PDA devices could be integrated as part of medical education as a learning tool to facilitate students in recording clinical notes, looking up references, checking online resources and school time tabling, performing online assessment, and communicating with medical faculty, clinical preceptors and peers while offsite. However there are potential barriers, which medical schools should aware of in using PDAs, for instance hardware or software failure, security and privacy protection.

In addition, there are potential risks of using IT and mobile technology in medical education, these being the technical failure of information systems, insufficient education and training on the use of technology, and poor user interfaces. However, these concerns are directly related to the perception of the medical school stakeholders regarding the use of PDAs in the UOW PBL-medical curriculum. Therefore, it is essential to overcome such resistance by providing sufficient education and training, maintenance and support for medical educators, learners and staff.

Limitations and future work

This study was conducted at the very beginning of the GSM, therefore medical students were excluded from the participant sampling. A Qualitative research method was used for this study. Wider community involvement and quantitative analysis though involving international medical academics, clinicians and IT specialists will reinforce the applicability of the results of this study medical education.

Conclusions

The incorporation of PDAs into the UOW PBL-medical curriculum needs to consider three major aspects, namely (i) PDA functionalities, (ii) technical issues, and (iii) practical issues. These aspects have been reported and discussed in detail in the previous sections. It is essential to identify the four-basic PDA functionalities, which are suitable for the UOW PBL-medical curriculum, then gradually consider other technical issues, including data security and information privacy, ethical and clinical aspects, data transmission and network connectivity, systems maintenance and support, and interoperability of different PDA platforms and other mobile technology devices.

PDAs enable students to have immediate access to clinical resources and information on-the-spot while offsite. Secondly, PDAs enable students to record and update their clinical experiences and encounters via a PDA-based/web-based clinical-log function, which allows them to update their experiences while offsite. Thirdly, PDAs enable them to communicate among peers, clinical preceptors, the GSM faculty while offsite. Lastly, PDAs enable students to organise and manage their daily activities based on the school timetable which can be immediately accessed while offsite. The primary benefits of PDAs are (i) the accessibility of resources, (ii) the ability to track students' clinical experiences by the clinical preceptors and the GSM faculty, (iii) the ability to communicate while offsite, and (iv) convenience in carrying such devices while having clinical encounters that other computer technology or mobile technology (e.g. laptop computers) can rarely provide due to their lack of mobility.

Another important aspect for incorporating PDAs into the UOW PBL-medical curriculum is practical issues in education and training. This aspect not only focuses on providing adequate training for students and teaching staff, but also on informing the community regarding PDA use in clinical environments and emphasising a strategy for the university and the medical school to overcome concerns regarding resources and financial implications in acquiring PDAs for students.

In conclusion, the similarity between PDA use in the medical profession and medical education centers around the use of reference, communication and PIM functions. However the differences between the use of PDAs in these two areas are dependent on the purposes of using these devices and area being used, for instance, administrative purposes (e.g. ordering clinical tests, patient management, etc.), physiotherapy, dietary management, etc. Even though PDAs have yet to be incorporated into the UOW PBL-medical curriculum, there is a tendency that students may prefer to use these devices or equivalent mobile technology devices to facilitate their 4-years of medical study.

Learning medicine is a combination of art and sciences. Culture of learning medicine not only comprises of sharing understandings and perspective of medical profession [17] but also using the technology to facilitate in learning,

practicing, diagnosing and treating patients. These four major PDA functionalities were identified to facilitate medical study in PBL-approach based on the attitudes, knowledge and experiences of the participants.

It is feasible that PDAs can be incorporated into the UOW PBL-medical curriculum. What has yet to be identified is a strategy for how to best incorporate PDAs into the UOW PBL-medical curriculum, what necessary information should be carried on PDAs, what information would be suitable for evidence-based medicine, as well as how to ensure that incorporation of PDAs provides students and medical faculty with effective learning given the attendant financial and resource implications.

References

1. Luanrattana, R., Win, K. T., and Fulcher, J., Use of personal digital assistants (PDAs) in medical education. In: Kokol, P., Podgorelec, V., Mičetić-Turk, D., Zorman, M., and Verlič, M., (Eds.), *CBMS '07. Twentieth IEEE International Symposium on Computer-Based Medical Systems; 2007 20–22 June 2007*. Maribor: IEEE Computer Society Conference Publishing Services (CPS), pp. 307–312, 2007.
2. Turner, P., Milne, G., Kubitscheck, M., Penman, I., and Turner, S., Implementing a wireless network of PDAs in a hospital setting. *Pers. Ubiquit. Comput.* 9(4):209–217, 2005.
3. Mattana, J., Charitou, M., Mills, L., Baskin, C., Steinberg, H., Tu, C., and Kerpen, H., Personal digital assistants: A review of their application in graduate medical education. *Am. J. Med. Qual.* 20 (5):262–267, 2005.
4. Jerant, A. F., Training residents in medical informatics. *Fam. Med.* 31(7):465–472, 1999.
5. Carroll, A. E., and Christakis, D. A., Paediatricians' use of and attitudes about personal digital assistants. *Pediatrics* 113(2):238–242, 2004.
6. Stroud, S. D., Erkel, E. A., and Smith, C. A., The use of personal digital assistants by nurse practitioner students and faculty. *J. Am. Acad. Nurse Pract.* 17(2):67–75, 2005.
7. Lindquist, A. M., Johansson, P. E., Petersson, G. I., Saveman, B.-I., and Nilsson, G. C., The use of the personal digital assistant (PDA) among personnel and students in health care: A review. *J. Med. Internet Res.* 10(4):e31, 2008.
8. Larkin, M., Handheld use increasing for e-learning and clinical decision making. *Lancet* 361(9351):93, 2003.
9. Mertens, D. M., *Research and evaluation in education and psychology: integrating diversity with quantitative, qualitative, and mixed methods*. SAGE: Thousand Oaks, 2005.
10. Bertaux, D., *Biography and society: the life history approach in the social sciences*. SAGE: London, 1981.
11. Lee, R. M., and Fielding, N. G., Tools for qualitative data analysis. In: Hardy, M., and Bryan, A., (Eds.), *Handbook of Data Analysis*, First Edition ed. London: SAGE, pp. 529–546, 2004.
12. Bazeley, P., and Richards, L., *The Nvivo qualitative project book*, First Edition ed. SAGE: London, 2000.
13. Kho, A., Henderson, L. E., Dressler, D. D., and Kripalani, S., Use of handheld computers in medical education. A systematic review. *J. Gen. Intern. Med.* 21(5):531–537, 2006.
14. Seago, B. L., Schlesinger, J. B., and Hampton, C. L., Using a decade of data on medical student computer literacy for strategic planning. *J. Med. Libr. Assoc.* 90(2):202–209, 2002.
15. Relan, A., Parker, N., Wali, S., Guiton, G., and Fung, C. C., Supporting handheld technologies in a medical school curriculum: lessons from three years of design, development and implementation. In: Roschelle, J., Chan, T.-W., Kinshuk, and Yang, S. J. H., (Eds.), *Proceeding of the The 2nd IEEE International Workshop on Wireless and Mobile Technologies in Education (WMTE'04); 2004 March 23–25, 2004*. JungLi: IEEE Xplore, pp. 51–58, 2004.
16. Smordal, O., and Gregory, J., Personal digital assistants in medical education and practice. *J. Comput. Assist. Learn.* 19(3):320–329, 2003.
17. Becker, H. S., Geer, B., Hughes, E. C., and Strauss, A. L., *Boys in White: student culture in medical school*, First Edition ed. Transaction: New Brunswick, 1977.