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## Survey of handheld computing among medical students

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### ABSTRACT

The purpose of this study was to identify trends in the utilization and acceptance of handheld computers (personal digital assistants) among medical students during preclinical and clinical training. We surveyed 366 medical students and collected information on computer expertise, current handheld computer use, predicted future use, and user acceptance. Handheld computers were primarily used for personal applications by students during their preclinical training and as drug references and clinical calculators during their clinical training. In the future, all participants predicted they would use handheld computers at significantly higher rates and on a broader range of medical applications. The adoption of handheld computing was independent of user satisfaction. Those with more clinical experience were less satisfied with handheld computers, suggesting that the expectations of the more experienced users were not met. The lack of institutional support was seen as a key limitation.

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## 1. Introduction and background

Handheld computers, also known as PDAs or personal digital assistants, are growing in popularity among physicians [1–3]. The two main varieties of these devices are the Palm computer and the Pocket PC. Both are inexpensive, lightweight, and portable. They are small enough to fit into a shirt pocket. Through a direct connection or wireless network, they can integrate seamlessly with other computers.

While the adoption of handheld computers is on the rise, the breadth of clinical applications has been limited. Recent surveys of house officers and attending physicians report that handheld computers are used primarily as reference tools and for portable computation, but rarely used to interface with electronic medical records or a wireless service [4–6]. The use of handheld computers was found to be greater among younger people, men, those at earlier stages of their medical training, and recent graduates of medical training.

Similar findings with respect to medical students have been reported [7,8]. The majority of students with handheld computers used them as reference tools and for portable computation. These surveys cited a lack of institutional support for handheld computing, which likely contributed to user dissatisfaction.

To better understand the role of handheld computers in medical training, we surveyed medical students at the George Washington University and the University of Maryland. The objective of this study was to identify trends in utilization, attitudes, and perceived limitations of this technology during both preclinical and clinical training. At the time of this study, both institutions supported a limited set of electronic medical record functions through desktop computers, wireless notebook computers, and wireless handheld computers. The computer systems provided access to laboratory data, study results, nursing notes, dictated summaries, and decision-support tools. Certain functions, like resident and medical student sign-outs, were restricted to specific computer work-

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stations. Progress notes, physician orders, and medication administration logs were essentially paper-based.

## 2. Methods

We surveyed two groups of medical students. The preclinical group consisted of students who completed their preclinical training and were just starting their third-year clinical clerkships. The clinical group included students who were just completing their third-year clinical clerkships. Eligible participants at the George Washington University were students who attended a Practice of Medicine seminar, and were asked to fill out a paper-based version of the survey. Eligible participants from the University of Maryland were requested through email to fill out an online version of the survey. Data collection took place between June and September 2004. The survey included nine questions on the utilization of desktop computers and handheld computers, predicted use of handheld computers in the future, and user satisfaction. The survey questions are located in [Appendix A](#). IRB approval was obtained through the George Washington University Medical Center.

## 3. Results

The participants provided information on usage patterns and user acceptance, which was normalized to create a utilization index (UI) and a satisfaction index (SI). These figures, shown as averages, percentages, or actual number counts, were analyzed for statistical significance using two-factor ANOVA and two-tailed paired t-tests. Linear relationships were analyzed using Pearson's correlation coefficients with two tails for the level of significance. In addition, a two-factor ANOVA was performed to show that, except as otherwise noted, the differences between participants at the George Washington University and the University of Maryland were not statistically significant.

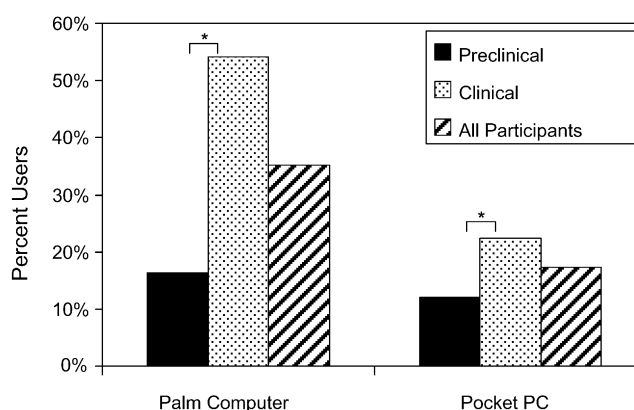
### 3.1. Response rate

Of the 559 eligible participants, 366 filled out a survey, yielding an overall response of 65%. The response rate for the George Washington University was 81% (213 out of 262), while the rate for the University of Maryland was 52% (153 out of 297). For the preclinical group, the response rate was 59% (183 out of 311), and for the clinical group was 74% (183 out of 248).

Of those that responded, the overall proportion of medical students who used a handheld computer was 52% (35% Palm, 17% Pocket PC). In the preclinical group, 28% used a handheld computer (16% Palm, 12% Pocket PC). In the clinical group, 76% used a handheld computer (54% Palm, 22% Pocket PC). See [Fig. 1](#).

### 3.2. Usage patterns

We asked the participants to describe how they used desktop computers and handheld computers, and to predict the ways they will use handheld computers in the future. They answered a series of questions to identify their usage patterns with respect to personal applications, academic resources,



**Fig. 1 – Handheld computer selection. An asterisk denotes statistical significance.**

clinical references, computational tools, and electronic medical records. We normalized their responses to create a utilization index (UI) in order to estimate how extensively the participants used these computers. The UI ranged from 0 to 1, where a higher value was indicative of greater utilization.

Desktop computers were primarily used for personal applications such as email, Internet access, and text messaging. The preclinical group used them more to access academic resources (0.589 for the preclinical group, 0.183 for the clinical group,  $p < 0.001$ ). The clinical group used them more to access electronic medical records (0.082 for the preclinical group, 0.385 for the clinical group,  $p < 0.001$ ). Overall, the preclinical group used desktop computers slightly more, although this was not significant (0.269 for the preclinical group, 0.256 for the clinical group,  $p = 0.438$ ). See [Fig. 2](#).

The preclinical group primarily used handheld computers for personal scheduling, personal task lists and address lists. The clinical group primarily used handheld computers as drug references and clinical calculators. In every area, the clinical group used handheld computers more extensively (0.048 for the preclinical group, 0.153 for the clinical group,  $p < 0.001$ ). See [Fig. 3](#).

In the future, all participants predicted they would use handheld computers at significantly higher rates and on a broader range of clinical applications (0.101 for average current use, 0.683 for future use,  $p < 0.001$ ). The differences between the preclinical group and the clinical group ( $p = 0.382$ ), and between current handheld computer users and non-users ( $p = 0.122$ ), were not significant. See [Fig. 4](#).

### 3.3. User satisfaction

Most participants felt that handheld computers were a valuable resource (88%). When asked if their views changed over the course of their training, 55% of the preclinical group and 32% of the clinical group felt more enthusiastic, while 3% of the preclinical group and 13% of the clinical group felt less enthusiastic ( $p < 0.001$ ). In comparing handheld users to non-users, 37% of users and 46% of non-users felt more enthusiastic, while 11% of users and 4% of non-users felt less enthusiastic ( $p < 0.001$ ). See [Fig. 5](#).

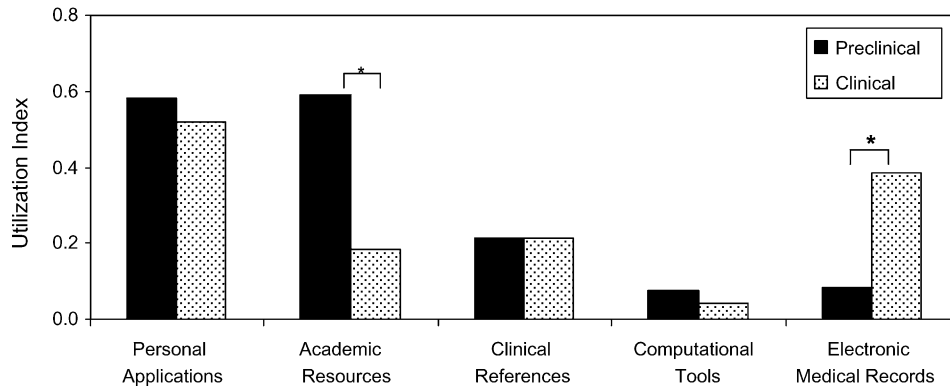


Fig. 2 – Desktop computer use. An asterisk denotes statistical significance.

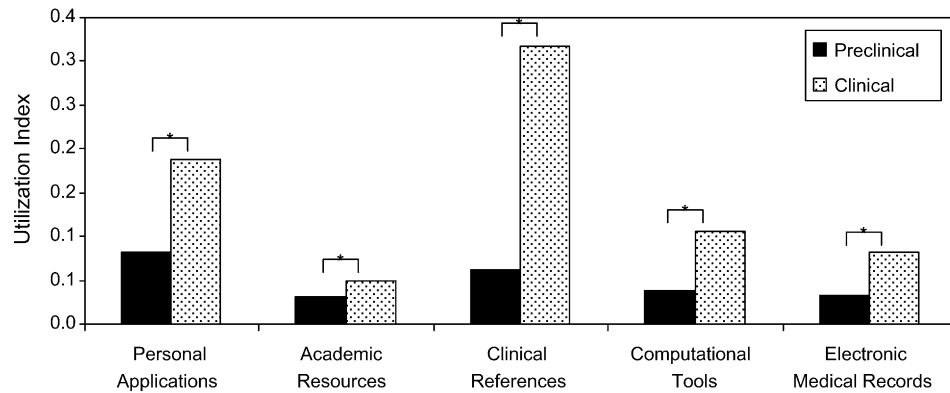


Fig. 3 – Handheld computer use. An asterisk denotes statistical significance.

A minority of the participants (30%) felt that medical students should be required to use handheld computers, including 5% who felt that they should be required to use handheld computers, even if students have to pay for them. The remaining participants felt that handheld computers should not be required at all (50%) or were unsure (20%). The differences between the preclinical and clinical groups ( $p=0.195$ ), and between current users and non-users of handheld computers ( $p=0.369$ ), were not significant. See Fig. 5.

Those using a handheld computer were asked, if they had to purchase another device, would they purchase the

same type again, or would they switch to a different type. The responses revealed that 23% of Palm users wanted to switch to the Pocket PC (30 out of 129). Also, 14% of Pocket PC users wanted to switch to the Palm (9 out of 63). The difference between the preclinical group and the clinical group was not significant ( $p=0.257$ ). However, the difference between participants from the George Washington University (46% of Palm users and 7% of Pocket PC users wanted to switch) and the University of Maryland (9% of Palm users and 71% of Pocket PC users wanted to switch) was significant ( $p<0.001$ ). See Fig. 6.

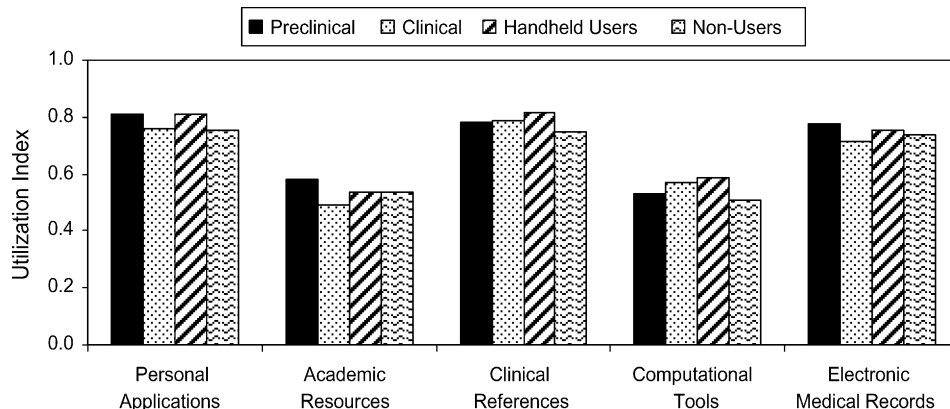


Fig. 4 – Future predicted handheld computer use.

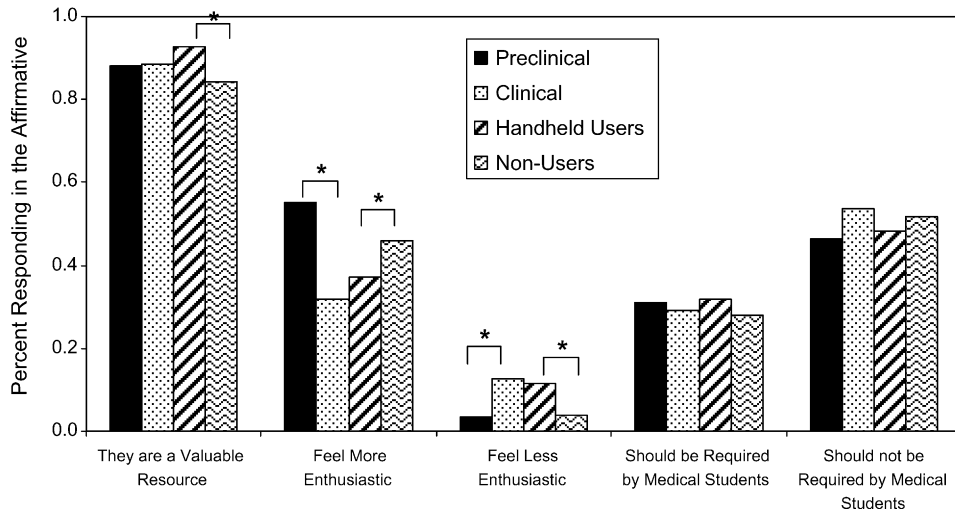


Fig. 5 – User satisfaction beliefs about handheld computers. An asterisk denotes statistical significance.

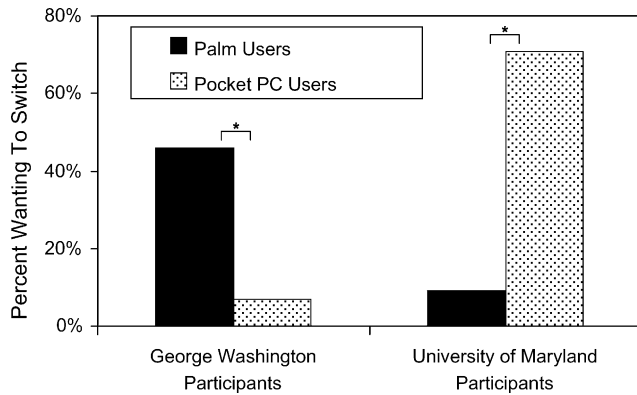


Fig. 6 – Participants wanting to switch devices. An asterisk denotes statistical significance.

The participants were asked a set of questions to estimate their views of handheld computers with respect to hardware limitations, software limitations, and institutional support. The lack of institutional support was identified as the most common area of dissatisfaction. This included concerns that

handheld computers were not integrated with their hospital information systems, that each training location had different computer requirements, and that their medical schools were not committed to using handheld computers. Other concerns regarding hardware and software limitations were secondary. We normalized their responses to create a satisfaction index (SI) as an estimate of user satisfaction with handheld computers. The AI ranged from 0 to 1, where 0.5 was neutral, and a higher value was indicative of greater acceptance. The pre-clinical group had a higher level of user satisfaction (0.556 for the preclinical group, 0.514 for the clinical group,  $p < 0.001$ ). The difference between handheld users and non-users was not significant ( $p = 0.392$ ). See Fig. 7.

#### 4. Discussion

##### 4.1. Future expectations

The participants expressed an optimism for the future of handheld computing that was not reflected by the current utilizations of these devices. Handheld computers were used for personal activities and on a limited number of clinical

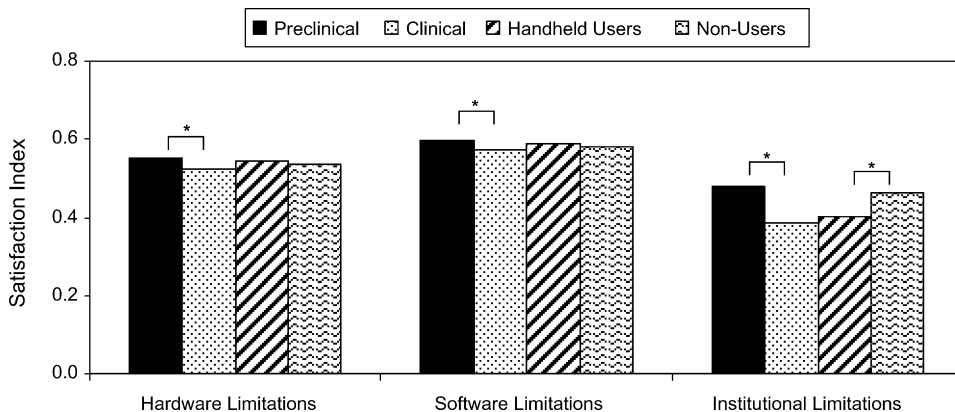


Fig. 7 – Handheld technology limitations. An asterisk denotes statistical significance.

applications. However, in the future, all participants strongly expected to use handheld computers for electronic medical records, patient tracking, clinical decision support, progress notes, lab results, and order entry.

This difference between the current role of handheld computers and future expectations suggests that medical students may not be using these devices in the ways that they would most like to. Their strong interest in this technology may be based on idealized expectations, and not necessarily on current abilities. The clinical group had more experience with clinical applications, but they had a significantly lower satisfaction index (SI). This was likely because the expectations of the more experienced users were not met. Any successful effort to incorporate handheld computers into a clinical training program should consider this gap between current abilities and desired practice.

#### 4.2. *Inherent limitations*

The lack of successful applications for clinical data management may also be related to the inherent limitations of these devices. This includes small screen size, narrow bandwidth, limited memory, handwriting recognition, battery life, and minimal processing power. Clinical systems using these devices require special consideration of both user interface design and information content [2]. A recent review of the literature identified a relatively small number of articles providing evidence-based information on the use of handheld computers in medicine [9]. Most publications consisted of reports of clinical experiences with little substantiating data. To satisfy future expectations, there is a need for further studies upon which to build an empirically based theory of mobile clinical computing. Examples of this would be to evaluate the impact of handheld computers on clinical skills development [10], outline generalized principles of mobile learning for clinical environments [11], optimize software development through human factors studies [12], develop new algorithms to share data over weakly connected wireless networks [13], and perform studies to demonstrate the benefits of handheld computing with respect to cost, patient outcome, and clinical satisfaction.

#### 4.3. *User acceptance*

No correlation was found between the use and acceptance of handheld computers. Anecdotally, one could argue that those with a more favorable view of handheld technology would be more inclined to use it. However, when comparing the utilization index (UI) to the satisfaction index (SI), no such correlation was found. This included both current use ( $r=0.043$ ,  $p>0.05$ ) and predicted future use ( $r=0.049$ ,  $p>0.05$ ). The differences between the preclinical and clinical groups were not significant. The adoption of handheld computing therefore seemed to be independent of acceptance. This suggests that the participants viewed handheld computing as an essential technology that was integral to their performance as future clinicians.

In addition, there was no correlation between computer expertise and the acceptance of handheld computers ( $r=0.063$ ,  $p>0.05$ ). There was, however, a weak but significant

correlation between computer expertise and the adoption of handheld computers ( $r=0.234$ ,  $p<0.001$ ). For the purpose of this study, we considered desktop computer utilization to be an estimate of overall computer expertise. The differences between the preclinical and clinical groups were not significant.

#### 4.4. *Institutional support*

The greatest reported limitation of handheld computing was the lack of institutional support. One of the strengths of clinical handheld computing is that the technology was initially driven by the user community, and not by healthcare informaticians. In the long run however, there needs to be a strong institutional commitment for the technology to thrive. Handheld computing, along with other information technologies, needs to become part of the professional armamentarium for which medical students are formally trained and held accountable. The lack of institutional support, along with an informal implementation of this technology, have reportedly contributed to problems with compliance, user satisfaction, unresolved technical issues, handwriting recognition, data backups, and desktop synchronization [14–16].

Institutional support for handheld computing should be implemented in a comprehensive and rational fashion that focuses on infrastructure, hardware, and software. Handheld computers need to be integrated with hospital and academic information systems. Data sharing over wireless networks, the use of synchronization ports, data backups, and other maintenance tasks should be automated and well-documented. Formal training programs should be established to ensure that all users can demonstrate the necessary proficiency. Hardware constraints such as memory requirements, processor types, and network upgrades need to be specified. Finally, a standard set of software applications needs to be purchased or developed in-house for clinical references, clinical calculations, decision support, patient tracking, computer-based physician order entry, electronic medical records, resident sign-out, academic logs, paging, and data maintenance.

Another notable finding was the impact an institutional bias can have on user satisfaction. At the George Washington University, where all medical residents are given a Pocket PC, a significant number of medical students who purchased a Palm computer wanted to switch to the Pocket PC. In contrast, at the University of Maryland, where the majority of residents use the Palm computer, a significant number of medical students wanted to switch from the Pocket PC to the Palm.

#### 4.5. *Study limitations*

The response rate of 65% creates the possibility of a response bias. The response rate from the George Washington University was higher (81% versus 52%), likely because these participants were approached in person at a Practice of Medicine seminar, while the University of Maryland participants were solicited through email. Only two medical schools participated in the survey, which may limit the ability to extrapolate these findings to all medical students. It is also important to note that the data are dependent on personal reporting and subject to recall bias.

## 5. Conclusion

We presented a survey on the use and acceptance of handheld computing among medical students from the George Washington University and the University of Maryland. The students considered handheld computing an essential technology that was integral to their performance as future clinicians. There was however, a significant difference between the current role of handheld computers and future expectations. Those with more clinical experience were less satisfied with handheld computers, suggesting that the expectations of the more experienced users were not met. The lack of institutional support was seen as a key limitation to the adoption of this technology. Further studies are needed to develop an empirically based theory of mobile clinical computing.

## Acknowledgement

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## Appendix A. Survey questions

1. During your third year of medical school, did you own or have access to a PDA? (The preclinical group was asked if they owned a PDA during their first 2 years.)
  - a. Yes, I used a Palm (or Clie or Handspring).
  - b. Yes, I used a Pocket PC.
  - c. No.
2. If you had to buy another PDA, would you purchase the same type again?
  - a. Yes, I would purchase the same type again.
  - b. No, I would purchase a different type next time.
  - c. I currently do not use a PDA.
3. Do you think PDAs are a valuable resource?
  - a. Definitely not.
  - b. Probably not.
  - c. Not sure.
  - d. Probably yes.
  - e. Definitely yes.
4. Compared to the beginning of your third year, how do you feel about PDAs now? (The preclinical group was asked to compare to the beginning of medical school.)
  - a. Less enthusiastically.
  - b. About the same.
  - c. More enthusiastically.
5. Should medical schools require students to use PDAs?
  - a. Yes, even if students have to pay for them.
  - b. Yes, but the school should pay for them.
  - c. I'm not sure.
  - d. No.
6. During your third year of medical school, how often did you use a desktop computer for the following? (The preclinical group was asked about their first two years of medical school. Possible answers were "never", "monthly", "weekly" or "daily".)
  - a. Access email, Internet, or text messages.
  - b. Calendar, addresses or task management.
  - c. Access rotation/course info (handouts, evaluations, schedules).
  - d. Take notes, do homework, or perform other academic tasks.
  - e. Access a drug reference.
  - f. Perform clinical calculations.
  - g. Access a clinical reference, dictionary, or e-textbook.
  - h. Access medical literature or abstracts.
  - i. Translate a foreign language (e.g., medical Spanish).
  - j. Record audio, video or still pictures.
  - k. Access a differential diagnosis or treatment plan.
    - l. Enter SOAP notes, patient data, or patient orders.
  - m. Track patients, access lab results or patient information.
7. How often did you use a PDA for the following?
  - a. (Same questions as item #6 were asked.)
8. In the future, what would you like to use a PDA for?
  - a. (Same questions as item #6 were asked.)
9. How do you feel about the following statements regarding PDAs? (Possible answers were "strongly disagree", "disagree", "neutral", "agree" or "strongly agree".)
  - a. PDAs are too expensive.
  - b. PDAs are too heavy or too bulky to carry around.
  - c. PDAs are too fragile and are easily broken.
  - d. I have limited computer knowledge, making PDAs hard to use.
  - e. PDAs have limited functionality.
  - f. The applications I want for my PDA are not available.
  - g. The PDA screen is too small.
  - h. It is hard to enter data using the stylus/pen on a PDA.
  - i. Protection of patient information is a problem on PDAs.
  - j. PDAs are not integrated with my hospital's computer system.
  - k. PDAs are hard to use efficiently, because each hospital I train at, or each course I've taken, has different computer requirements.
    - l. My medical school is not committed to using PDAs.

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