Mobile Devices in Interactive Lectures

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Abstract
In this article we investigate and compare the usefulness of different mobile, wireless devices for use in interactive classroom sessions. Conventional lectures, especially in large lecture halls, face fundamental didactic problems: There is a lack of interaction, it is difficult for the lecturer to deal with individual questions, and it is not easy to maintain a high level of attention. In order to improve interactivity and thus increase attention and learning success, the students can be equipped with mobile, wireless devices, in particular notebook PCs, PDAs or tablet PCs. In this paper we focus on the advantages and disadvantages of these different devices in the Interactive Lecture scenario. We present the results of two case studies carried out at the University of Mannheim. We also review similar projects and public opinion polls from elsewhere. In conclusion we provide the reader with recommendations as to which device is most appropriate for which circumstances.

1 Introduction

In universities worldwide, large lectures with several hundred students are quite frequent. A fundamental didactic problem in this learning scenario is: the lack of interactivity, which leads to a low level of attention and motivation, and thus to only moderate learning success. The new generation of mobile, wireless devices, such as Personal Digital Assistants (PDAs), notebook PCs and tablet PCs, enables new modes of interaction between the teacher and the students, and between the students themselves: Interactivity enables the learner to exchange his/her role as a passive recipient for active participation in the communicative information process. An active inclusion of the learner has a positive effect on the learning motivation [1].

In order to enable this new kind of interactivity, teacher and students are equipped with mobile devices. Typical interactive phases in a lecture are short quizzes, online feedback to the teacher or call-in questions, entered by the students as text.

The aims of this paper are:

• to describe possible uses of mobile devices in large classrooms,
• to present our own technology for the Interactive Lecture at the University of Mannheim, the WILD tools, and
• to discuss the results of two detailed case studies conducted among graduate students, focusing on the comparison of the use of PDAs versus the use of notebook PCs concerning the acceptance (by the students), the differences in their uses, and their advantages and disadvantages, and put them in perspective with regard to similar case studies elsewhere.
2 Use of Mobile Devices in Learning Scenarios

We now give a brief overview of ongoing and earlier work on the use of mobile devices in teaching and learning scenarios. We begin with two general observations on their usefulness.

A project of Microsoft Corporation dealing with the general use of laptops in schools is Anytime Anywhere Learning [2] [3]. More than 400 teachers were asked about their main usages of their notebook PC. It is remarkable that learning-software applications accounted for 43%. “Laptop students” spent more than twice the time in collaborative work than students without laptops. Furthermore, most teachers believed that the students benefited from using the notebooks. A high degree of enthusiasm was observed on the parts of both teachers and students.

An interesting result of the TechDis project concerning the usability of mobile computers is that as primary computing tool a PDA is frustrating and inefficient [4]. The authors also state that “the use of a PDA as an assistive technology has barely been explored in the mainstream educational sector. The expertise of the operating systems or software and their accessibility features does not at present exist”. Economic reasons can be seen as a key factor here, but the market is changing quickly.

The actual usage of mobile devices in the classroom can roughly be classified as follows:

- annotations,
- online feedback,
- tests and quizzes,
- communication.

We now take a closer look at several examples.

Classstalk is a well-known Classroom Communication System by Better Education Inc. [5]. To better involve every single student, the teacher “beams” three to four Classstalk tasks per lesson to the students’ devices; these can be calculators, organizers or personal computers, and they are often owned by the students. A "task" can be anything from a simple question to a midterm exam, from a group exercise to a survey of class opinions. The results are displayed immediately on the teacher’s notebook PC; the teacher can either keep them confidential or show them to the class. The class sessions can be archived for review, and can be analyzed and compared to other sessions. Additional features include feedback (from the teacher), tests and grading.

ClassInHand from Wake Forest University turns a PDA equipped with a wireless card into a web server, a presentation controller and a quizzing and feedback device for the lecturer [6]. Its major components are the Presentation Control and Web Server for the PocketPC. The clients need only a web browser. The Presentation Control allows remote control of the Powerpoint slides on the lecturer’s PC. It also gives him/her the possibility the forward the quiz results to the class. The Web Server enables concept tests (quizzes), textual feedback, a feedback meter and easy document posting. The quiz feature enables the teacher to present a question with up to four answers and to view the results immediately on his/her PDA. These results can also be forwarded to the students’ devices. The textual feedback component allows students to send their questions directly to the teachers PDA. Finally, the feedback meter enables students to submit numeric responses (range: -10 to 10).

Frequent key clicking can cause significant distraction in a lecture hall. For this reason, the “Classroom 2000” project at Georgia Tech decided not to provide a keyboard interface for note-taking at all, in particular when the students annotated slides during a lecture, preferring instead pen-based technology [7].

The tool ToGather from the Darmstadt University of Technology uses notebook PCs to create of cooperative, digital annotations [8]. The lecturer’s PC sends live streams to the students’ notebook PCs. Besides making their private annotations, students can also form learning groups and share their annotations. After the lecture, the annotations can be post-processed and ad-hoc-synchronization is also possible.
Another annotation tool called AOF (authoring-on-the-fly) was designed and implemented at the University of Freiburg [9]. A recent extension to this established software system allows the students to annotate a running or archived lecture. The use of multiple drawing layers allows independent annotations to be kept private or shared and combined. AOF also allows annotations to be saved and re-loaded for later review.

The IVES application of the University of Hannover (interactive concept of lecture evaluation) provides a quiz tool and a feedback tool; it also offers the possibility to exchange messages with the lecturer [10].

ConcertStudeo from Fraunhofer IPSI uses an electronic blackboard combined with handheld devices [11]. It offers exercises and interactions such as multiple-choice quizzes, brainstorming sessions, estimation queries or role-plays. During a lecture, the teacher proposes the exercise, learners enter their answers into their handheld devices – collection, analysis and presentation are done by the software.

Numina II SRS (student response system) from the University of California is a web-based student response system that uses a combination of PDAs and a data projector [12]. The instructor poses a question and directs the students to a web site that generates the appropriate answer screen on the students’ computers, where they can submit their answers. A backend database stores the responses to questions.

Specifically designed for online feedback is CFS (the Classroom Feedback System) from the University of Washington [13]. It allows students to post annotations directly on lecture slides. The lecturer sees the annotations in real-time. The students use their notebook PCs to generate their feedback by clicking a location on a slide and selecting a category from a fixed menu (such as “more explanation”, “got it”, “example”). The teacher’s view shows the number of feedback requests for each slide, and at the actual presentation slide, shows the aggregated feedback with a shaded dot for each annotation. The slides depict categorical information by color (e.g., red for “more explanation”) and the slide context by location.

There are many different settings and ways to take advantage of mobile devices to improve interactivity in the lecture hall. Most of the earlier work has focussed on specific issues, such as quiz only, online feedback only or annotations only. And often, the software is designed to run only on a particular hardware device. Our WILD tools attempt to solve these problems: the same basic software architecture accommodates many different interactivity services, and the system is written in Java and portable to almost all modern mobile devices.
3 The WILD Tools

Our WILD (Wireless Interactive Learning Devices) tools, developed at the University of Mannheim, can be seen as an extensible, portable system to support all forms of interactivity in a lecture hall [14]. At the moment there are tools available for giving online feedback to the teacher and doing an online evaluation, answering quizzes, or asking questions via call-in.

3.1 The WILD System Architecture

The WILD system is designed as a classical client/server application (see Figure 1). As the central part of the architecture, the server provides the fundamental functionality: managements of connections, users and services. Connection management establishes connections to the clients upon request, processes incoming and outgoing data and monitors the registered connections for broken links. User management identifies individual users via password and stores personal information for internal and external use. Service management dynamically loads a requested number of plug-in service modules, informs clients about the availability of certain services and controls the data flow between the services, within the server structure itself and between clients.

The services provide the current functionality that is visible to the users. Services are built as independent modules that are loaded by the server at start-up time.

The client for the lecturer runs on a machine typically connected to the server via a wired network. This client is specifically designed to match the higher functionality that is needed to operate the Interactive Lecture, e.g., activating quiz rounds or answering questions asked by students. All other clients use the wireless LAN to connect to the server. They are designed as a single homogeneous software tool that is able to operate all services available in a particular scenario.

By means of an interface program it is also possible to connect a server to an external application. For example, we have conducted initial experiments to attach a shared whiteboard system to the server in order to provide both systems with a unified user interface.

3.2 The WILD Services

The quiz tool allows the teacher to pose questions (that possibly include graphics or animations) about actual lecture contents and “beam” them via WLAN to the audience. The students work on them and send their answers back to the lecturer’s computer. After a timeout, the cumulated results are presented graphically on the projector. In this way the lecturer and students gain a representative feedback on the newly acquired knowledge.

The feedback tool delivers direct and systematic feedback to the lecturer about different aspects of the lecture from all students, who can then instantly adapt his/her presentation style to the new situation.

Finally, the call-in tool forwards teachers spontaneous text questions at any time during the lecture. The tool gives the teacher the possibility to integrate (anonymous) questions and remarks from students into the lecture.

3.3 The WILD Experience

We have used the WILD tools in two graduate computer science courses at the University of Mannheim. In addition to the local presentation, the lecture was transmitted to another German university (University of Freiburg) as a tele-lecture, and students at the remote location also used the WILD tools.
Feedback questions were activated about every 20 minutes to measure and evaluate the student’s current feelings (e.g., if they were concentrated /interested/motivated). Also, there were up to three quiz rounds in each lecture, consisting mostly of three multiple-choice questions with four possible answers to each. The quiz results were discussed immediately with the class. Figure 2 shows our Interactive Lecture scenario.

In the summer term 2002, a major experimental study of the scenario was conducted. A long-term integration of the quiz service was implemented, as well as an experimental application of the call-in-service. The course was split into a traditional and an interactive phase where the WILD tools were used in eight lessons. The two teaching methods (traditional versus interactive) were compared with regard to acceptance and success in learning. With respect to acceptance, the interactive condition was evaluated significantly better than the conventional one. Concerning the learning outcome, the results for the interactive scenario were superior: The increase in learning was a higher and faster in the interactive condition. The results are reported in detail in [15].

In the summer term 2003, the entire twelve weeks lecture period was interactive and we involved as many students as possible; many of them brought their own notebooks to use them as WILDs. We integrated the feedback service for evaluation, but removed the call-in service.

In the same two experiments we explored the issue of different types of devices; this was possible because some of the students worked with the WILD tools on notebook PCs, others on PDAs, yet others on both in turn. In an on-line questionnaire the following aspects of the use of the devices were evaluated by the students on a scale of 1 (worst) to 6 (best):

- general handling and operability,
- menu guidance,
- clarity of the display,
- technical reliability,
- representation of the quiz questions on the display,
- marking of quiz answers,
- representation of the call in questions on the notebook’s display (this service did not run on PDA),
- processing speed of the device
- general assessment of the mobile computer and mean assessment of the devices, and
- preference for one device, either notebook or PDA, for use within interactive lecture scenarios.
Table 2 summarizes the results of the descriptive statistics of this investigation.

With respect to the general handling and/or operability of the two devices, the students (on the average) rated the PDA better than the notebook PC; both devices were rated well. Also the processing speed of both was rated well on both. The clarity of the notebook PC’s display was judged better than that of the PDA.

The students also rated both devices with respect to their ease of use with the quiz and call-in tools. The representation of the quiz questions was judged well on both devices. With respect to the marking possibilities of the quiz questions for the two devices (the touch panel (notebooks) and/or pen (PDA), both received a good assessment. Regarding the representation the call-in questions, the students rated the presentation mode for this tool well on both devices.

The last question put to students was whether they would prefer to use a notebook or PDA in an interactive lecture scenario. It is remarkable that while every student clearly preferred one device or the other, half of the students preferred the PDA and the other half the notebook PC.

Table 2: Mean values and standard deviations of the two evaluations

<table>
<thead>
<tr>
<th>Variables</th>
<th>Notebook PC</th>
<th></th>
<th>PocketPC PDA</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>1st study / 2nd study</td>
<td>n = 29 / n = 15</td>
<td></td>
<td>n = 8 / n = 10</td>
<td></td>
</tr>
<tr>
<td>General handling and operability</td>
<td>4.63 / 4.73</td>
<td>1.19 / 1.10</td>
<td>5.13 / 4.90</td>
<td>0.83 / 0.88</td>
</tr>
<tr>
<td>Menu guidance</td>
<td>5.38 / 4.73</td>
<td>0.52 / 1.33</td>
<td>5.13 / 4.70</td>
<td>0.64 / 0.95</td>
</tr>
<tr>
<td>Marking of quiz answers</td>
<td>5.13 / 4.93</td>
<td>0.83 / 0.80</td>
<td>5.50 / 5.00</td>
<td>0.76 / 0.82</td>
</tr>
<tr>
<td>Display clarity</td>
<td>5.63 / 4.87</td>
<td>0.52 / 0.99</td>
<td>4.75 / 4.60</td>
<td>0.46 / 0.97</td>
</tr>
<tr>
<td>Representation of the quiz questions</td>
<td>5.50 / 4.87</td>
<td>0.76 / 0.92</td>
<td>5.38 / 4.60</td>
<td>0.74 / 0.70</td>
</tr>
<tr>
<td>Technical reliability</td>
<td>4.88 / 3.73</td>
<td>0.83 / 1.67</td>
<td>5.00 / 3.70</td>
<td>0.76 / 0.82</td>
</tr>
<tr>
<td>Representation of the call-in questions (1st study only)</td>
<td>5.38 / -----</td>
<td>0.52 / -----</td>
<td>----- / -----</td>
<td>----- / -----</td>
</tr>
<tr>
<td>Design of the GUI (2nd study)</td>
<td>----- / 4.40</td>
<td>----- / 1.24</td>
<td>----- / 4.80</td>
<td>----- / 0.42</td>
</tr>
<tr>
<td>Processing speed (2nd study)</td>
<td>----- / 4.93</td>
<td>----- / 1.16</td>
<td>----- / 4.90</td>
<td>----- / 0.74</td>
</tr>
<tr>
<td>General assessment</td>
<td>5.00 / 5.07</td>
<td>0.76 / 0.88</td>
<td>5.13 / 4.80</td>
<td>0.35 / 0.63</td>
</tr>
</tbody>
</table>

4 Mapping Devices to Scenarios

From the didactic lecture room scenarios and interactive services described in sections 2 and 3 and our own experiences in the last few years the following recommendations can be derived.

As far as CPU power and memory are concerned, these were not limiting factors in most of the scenarios. In other words, any modern device has enough computing power for the typical classroom use. There are special applications though, where the CPU power of the current PDAs may not suffice; these include real-time video playback and complex graphical simulations (e.g. 3D graphics).

Similarly, the storage capacity of all devices was sufficient for all mentioned scenarios. The PDA has no physical hard disk but the PocketPC operating system simulates a virtual disk drive in main memory. If more memory is needed than the PDA provides, most of these devices are easily upgradeable up to 2 GBytes.

Battery lifetime was a major surprise in our own experiments in Mannheim: We expected to PDAs to have a much longer lifetime than the notebooks. This was not the case; a high-end PocketPC with
color display and WLAN enabled does not run much longer than 90 minutes. The older notebook PCs had the same problem; there is no clear advantage to either device. The consequences are that all devices have to be recharged frequently (so big "recharging farms" have to be planned if a whole class is to be equipped) and it is not possible to use them in two consecutive lectures. However, we expect the lifetimes of both (and that of the notebook PC as well) to become longer soon, going up on a curve similar to that of mobile phones. For example, modern notebooks or tabletPCs with Centrino mobile technology can be expected to run up to 4 hours, thus more than twice as long as a typical notebook with similar load.

The fact that fewer standard applications are available for the PDA than for the notebook played no role in any of the scenarios, neither in those in the literature nor in our own. The reason is that most scenarios used either a web browser (available on all devices) or specifically developed software for quizzes, online feedback etc. We strongly favor portable software (such as our WILD software written in Java) that will run on almost any modern mobile device.

The really relevant differences are screen size, weight, and input devices: Whereas multiple choice questions and other types of simple quizzes as well as a feedback tool work very well on the small screen of the PDA, interaction by the students with high-resolution graphics or long texts requires the larger screen of a notebook or tablet PC. Annotations on transparencies always require much screen space; scrolling on the really small PDA screen proves to be cumbersome. When creating new applications for educational scenarios, user interfaces for devices with limited resolutions are usually much harder to design than those for bigger screen sizes.

As far as the model and weight are concerned, the results of our two extensive studies show that individual students have strong preferences; but we observed no clear trend. The reasons to prefer the PDA were usually:

- it is smaller and does not occupy as much table space as a notebook does (e.g. so the student can still use a printed script),
- it is lighter than a notebook, so not much extra weight has to be carried around,
- it is not as distracting as a notebook, because only limited amounts of software are available,
- you don't have to look over the screen to see the lecturer,

whereas the reasons for the notebook were:

- you can use the notebook to use and annotate electronic scripts,
- the screen space is much bigger, so the software is easier to handle (and to see, especially for students with impaired vision)
- you can use the notebook for other things beside the lectures (receive and send eMails via wireless LAN on the campus etc.)

Another major difference are the input devices of the discussed devices. Notebooks use a mouse - or a mouse-like device, e.g. touchpads - to control the user interface and a keyboard to enter text. Most PDAs neither have mouse nor keyboard, the user can draw directly on the screen with a stylus instead. While this input type is a very good replacement for the mouse, it is not for the keyboard. Entering large amounts of text on a PDA is very cumbersome, either done with a virtual keyboard displayed on (and consuming most of) the screen, by drawing each single character in a certain way (like Graffiti on PalmOS) or by trying to let the device recognize handwritten words or text pieces, which doesn't work at all for most users. The consequence is that if a lecture scenario depends on the ability of the students to enter more than a few words, PDAs should not be considered. On the other hand, PDAs are a better choice if the students are supposed to draw something (a graph or mathematical formulas) on their screen. Tablet PCs are something in between, offering both stylus-based input on the screen, mouse-like input and a keyboard.

Last but not least, there is a huge difference in costs for these devices. Notebook prices are ranged between $800 and $2000, Tablet PCs are no less than $1800 at the moment. PDAs on the other hand are sold for less than $400 including WaveLAN support.
5 Conclusion

We have investigated the usability of notebook PCs, PDAs and tablet PCs as mobile devices in lecture room scenarios, in particular with respect to improved interactivity. First we gave an overview of different educational scenarios in which mobile devices are typically used, both from the literature and from our own experience in the WILD project. Then we mapped the technical properties to the educational applications and derived concrete recommendations.

Our studies are by no means comprehensive; in particular, specifically designed experimental studies are needed to better understand which devices best fit into which scenario.

Also, the tablet PC seems to be an excellent device for learners: It combines many advantages of the notebook PC and the PDA. However, very little experience has been reported so far with regard to large-scale classroom usage, and we could not say much on scenarios specifically tailored to the tablet PC. These are ideas for future work.

References

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