An Assessment Tool for Out of Classroom Learning using Pervasive Computing Technologies

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Abstract. Due to the promise and proliferation of portable low-cost lightweight devices and emergent short range, low-power wireless communication networks, pervasive computing has been evolved during the last few years. Here numerous, casually accessible, often invisible, frequently mobile or embedded devices are connected to an increasingly pervasive network structure. It leads providing support in versatile areas, which include but are not limited to hospitals, smart classrooms, construction sites, stadiums, shopping malls, emergency services, convention centers, battlefields, and inhospitable physical environments. In this paper, we present an assessment tool using pervasive computing technologies, which we believe, will append a newer dimension in out of classroom learning, a very promising filed of pervasive computing.

Keywords: Assessment Tool, Pervasive Computing, Out of Classroom Learning, MARKS, Applications for Mobile devices (Pocket PCs, Laptops, Personal Digital Assistants)

1. Introduction

Pervasive computing environments focus on integrating computing and communications with the surrounding physical environment by making computing and communication transparent to

the users. Pervasive computing enlarges the usability of computers despite demanding challenges of expensive connections, frequent line disconnection, limited host bandwidth and location dependent data, to name a few examples. Despite the challenges, Persuasive computing applications are present in hospitals, smart classrooms, construction sites, stadiums, shopping malls, emergency services, convention centers, battlefields, and in hospitable physical environments.

Some works have been done on the use of pervasive computing in teaching and learning environment. For example, West Bloomfield uses pervasive computing devices to enable the children to utilize a pen reader to store text from a book into their PDA's. At Central Washington University, music students utilize PDAs to write music whenever inspiration hits them [1, 2]. Another example is from Pennsylvania State Abington [3] where the students learn French III by using their keyboarded PalmIIIx handhelds to download class notes and quizzes and receive support materials beamed to them via an infrared point within the classroom. Chen et al. have developed a system for test taking using handheld devices [4]. In Interactive Classroom [5], the students share a virtual whiteboard, electronic textbook, and access the World Wide Web over a networked environment to actively participate in class discussions. Projects that use pervasive computing technology have so far mainly focused on facilitating the note or exam-taking or student-tracking applications in a classroom. For example, Smart Kindergarten uses sensor data collected from children or toys to make a record for the instructor to review children's activities and track their learning progress [6]. Classroom 2000 captures classroom context (teaching material or student notes) to automatically generate Web-accessible multimedia class files for the instructor and students [7]. At ASU, a Smart classroom [8] is built that used pervasive computing technology to enhance collaborative learning among college students.

The mobile devices in Smart Classroom are situation-aware in the sense that they can capture different situations in a classroom dynamically from ad hoc networks to facilitate both student-student collaborations and student-instructor interactions. Although there exist some systems to improve classroom learning using various emerging computing and communication technology including pervasive computing [1, 3, 5, 9-13], few address assessment for learning among students [8, 14]. RCSM group [8] integrates mobile and handheld devices such as Personal Digital Assistants (PDAs), with fixed computing infrastructures, such as PCs, sensors, etc. in a wireless network environment inside a classroom for collaborative learning.

This paper focuses on the assessment of out of class learning using pervasive computing technologies. Chen et al. developed a system for test taking using handheld devices [4] but they do not address out of class assessment, which we believe will be a future trend of education. We

identify the characteristics of assessment for out of classroom learning and develop a working prototype using pervasive computing for that purpose.

We have developed the first prototype of our middleware named MARKS (Middleware Adaptability for Resource Discovery, Knowledge Usability and Self-healing) [15]. Besides the core ones, it supports the crucial services like Knowledge Usability [16], SAFE-RD [17], and GETS Self-healing [18]. Our developed assessment tool enjoys those services in a very transparent manner from user's perspective and in semi-transparent mode from application developer's point of view.

Pragmatic scenarios are presented in section 2 to illustrate the significance of our assessment tool for out of class learning. We describe elaborately the background and characteristics of assessment in section 3. What key features and the functional requirements are required for this tool in section 4. How MARKS helps to provide the fundamental services to this assessment tool in transparent manner is portrayed in section 5. An example, to make the utilization of this tool more articulate, is illustrated, with necessary images, in section 6. The implementation and evaluation detail along with the way to approach all the characteristics of assessment in our assessment tool are depicted in section 7. Section 8 depicts the future direction of our research regarding this.

2. Motivation

With the increase of use of mobile devices (Pocket PCs, Laptops, Personal Digital Assistants), the expectations of users' are also rising. Users like to employ the same device in diverse fields. As these devices are portable, they become a part and parcel of everyday life. In the field of education, these devices can play a vital role. Both instructors and students can be greatly benefited by the use of these smart devices.

The following scenarios are presented as typical instructional problems we believe can be efficiently addressed by our assessment tool.

Scenario 1

A group of students consisting of two freshmen, one sophomore, two juniors, and one senior student are responsible for completing a project. Though they have different schedules of classes it is essential for them to regularly work on the group project. It is impossible for them to meet at the same time to work on the group project. But they all have PDAs. A special application is running on all of their PDAs that allow each to make changes in their own copy of the project. That change is reflected to all others PDAs. So whatever change one project member makes, all others can see it in their PDAs concurrently and provide immediate or delayed feedback. This solves the schedule constraints for all of them.

Scenario 2

In this class there are five project groups. Each group consists of more than one student. The instructor wants to monitor the progress of the groups. The instructor completes the lecture and allows 50 minutes for each group to complete their project. During that time the lecture can approach any one group and have the group progress downloaded to her PDA. Immediately the instructor can assess the progress of the group, add commentary and evaluate if necessary. As the group makes changes, the instructor version of the project is updated. In this case, as the instructor discusses (electronically or in person) the project of one group, the other groups' updates are automatically transferred to her device. She can go through those in her suitable time.

Scenario 3

There is a test scheduled for next Monday; the instructor will be traveling to a conference at that time. He prepares the question while traveling and stores them in his PDA. At the exam time he sends the questions to the registered students PDAs. To complete the exam students send their answers to the instructor's PDA. Even though the instructor is attending the conference the student submissions (the exams) are individually graded because the instructor PDA has an application provision for auto-grading. Incoming student exams are graded and the results are stored for the instructor to analyze or distribute as necessary. During the exam time, the students could also write comments and send those to the instructor. The auto feedback option makes it possible to reply the students' queries even when the instructor is busy. During the whole process, the instructor is out of town but the absence does not hamper responsibilities.

Considering situations like these, it becomes apparent that intelligent systems can be designed to reduce the burden of low-level physical work of both the students and the instructors. The assessment tool is efficient because our application builds upon MARKS middleware that actually controls interactions with ad-hoc networking.

3. Background: Assessment

Assessment is a process that is used to collect information about a student's progress toward educational goals. The specifics of an assessment depend on what is being assessed and on users to whom the results of the assessment will be applied. The range of assessments can vary greatly from small-scale assessments (instructors use in the classroom to obtain day-to-day information about student's progress) to large-scale assessments (surveys in national level) [19].

3.1 Characteristics of assessment for out of the classroom learning

Assessment should be as objective and reproducible as possible. With the advancement of technology there are other needs that must be fulfilled by any assessment procedure. Some prime criteria of good assessment are described in this section.

Timely fast assessment

Timely fast assessment is beneficial not only for the instructors but also for the students. No matter how easy a topic of assessment is it creates some psychological pressure for students. Assessments are most useful to facilitate learning when the turn-around time allows the student to benefit from the assessment. Students experience a feeling of academic relief when they get the result of the assessment. Again from the instructor's point of view, fast assessment is very necessary as they have lot of other engagements besides assessing.

Variation in assessment on the fly

A change in assessment strategy to facilitate learning is frequently the result of responding to individual or collective learning styles or changes in the learning environment. An assessment variation may be necessitated because content cause or consequence changes the instructional problem. The classroom dynamic involving the students may prompt changes. For example, students join and leave in dynamic way in different scenarios of an out of classroom environment. Though the assessment need is static, the application of an assessment strategy may need to respond to the student, the environment and the problem.

Ease of creating input (use of PDA instead of pen and paper)

Instructors spend a great deal of time and energy creating questions. If they have the ability to create questions anywhere at any time then it will be very helpful for them. Instructors are also very busy with other research and personal activities. What if the instructor were to use the PDA to create exams? The instructor could design exams and presentation materials at their suitable time. Also there may be situations where instructors may want to create a questionnaire on the fly. For an example an instructor in civil engineering discipline may become inclined to construct a special survey after watching a spectacular building design. The assessment procedure based on small mobile devices such as PDA will facilitate this.

Ease in creating output and editing

Creation of output is also straightforward as the instructor can create, delete or edit any answer at any time. There is no limit on page sizes so he can change the entire format of the answer also.

Automatic comparing

Auto grading is a time-saver from the instructors' perspective. As all the answers are stored on the device, grading can be done without any intervention of the instructor. Automatic comparison of responses submitted by different students makes the entire

grading process more efficient and reliable than traditional assessment. Also there is no possibility of human errors due to fatigue or any other reason.

Both Automatic feedback and manual feedback

While creating the questionnaire the instructor can use a "judging function" to create a list of frequently asked questions and appropriate responses for those anticipated questions. The application matches the response to the question and automatically delivers feedback to the student making the inquiry. The instructor updates the responses as necessary.

If students have any question during an exam, the feedback can be sent to them automatically without the involvement of the instructor if it is included within FAQ.

Suppose a student makes an inquiry that is not part of the FAQ list? In that case the instructor is prompted to respond in the manual feedback mode. Both forms of feedbacks are necessary because it is impossible to predict what kind of question or comment a student can have. Also most of the time there are lots of common questions. This is also applicable in case of the comment/question posted by the guardian to the instructor.

Ability to communicate with heterogeneous device

This system of assessment is targeted to all kind of devices. Questions can be created in desktops or laptops and then transferred to PDAs or mobile phones and vice versa. Instructors are expected to make most content and assessment commentary in advance and on a PC. The PDA will facilitate field responses where necessary.

Individualistic assessment

Instructors have personal preferences for assessing. One instructor may like to have a variety of question types mixed whereas other instructors may prefer only one type of question presentation for the entire exam. Therefore a mobile device such as the one proposed here must have a high degree of flexibility to reflect assessment choice. The proposed PDA assessment tool assures flexibility in the use and application of true and false, multiple choice, short answer and open-ended student responses.

To support this conjecture we address these important characteristics during the trial of our first prototype.

4. Major Features and Functional Requirements of Assessment Tool: Wireless Exam Project

We designed this trial as a demonstration to make the process of examination more efficient. Right now the examinations in the classrooms are organized by the instructors and require the use of paper. First the instructor creates questions using their computers, makes copies and delivers them to students during an exam session. The assessment tool is then returned to the instructor

for analysis. Later the instructor grades the student response papers and manually enters each grade into a computer. Later, they have to file the answer sheets securely. Typically, a semester or a school year will have a few exams like these. Each time the instructor has to go through the same process. Although, this looks simple, the task can be daunting when one considers the number of tests times the number of students. We believe we can simplify this entire examination process by using smart compact devices. As the cost of compact devices comes down we believe there will be a surge of use reducing the time faculty spend grading and entering grades. This use will reduce the inventory and stationary expense to universities resulting in one of several reasons to foster the use of these devices to foster learning.

The scope of this project is to create a series of applications to help instructors create and administer exams to be delivered on mobile devices. The distribution can take place as real-time exams or can be delayed to suite instructional purposes. This simple task is non-trivial considering the limitations of these devices, with regards to reliability in communication.

Security and privacy issues are utmost important in the field of pervasive computing. The unique ad-hoc nature of network demands that high security and supreme privacy is incorporated in applications running in the "pervasive computing" environment. To protect the confidentiality of the instructor and the students devices' a simple but secure mechanism is badly needed. To incorporate the security features the system will ask for secret code to authenticate the instructor and registered students for a particular course.

Requirements from Instructor point of view

1) The system should enable the instructors to enter a certain number of questions. We assume that the instructor will be teaching other courses as well and hence may plan to create questions for the other courses concurrently. Hence, one set of questions should not overlap with others. To ensure this, all the questions for a particular course should be grouped together and stored in a data structure or database (whatever is efficient on a PDA).

2) The system should facilitate the creation of exams. It can have any number of

   a. Multiple choice
   b. True/false
   c. Short answer (fill-in) and
   d. Open ended response options.

3) The instructor should be able to create a suitable "answer key" for the questions. Ideally, an instructor will view the question and type the answer so that the answer is visible whenever the question is displayed. Teachers may want the correct answer to be sent to the student after grading is complete.

4) The system should have the capability to do the auto grading (multiple choices, fill blank, and true-false) and generate result (text, table and graphical output) of varying format.

5) The distribution of the entire exam should take place when the instructor selects the designated action.

6) The system should also provide the facility to distribute the grades to the students.

7) The instructor would be the only authorized person to specify the time limit for the students to submit their answers. The students can commit their answers to the instructor before the expiration of the given time frame. Otherwise, the system should have necessary mechanisms to deny access to the questions after the pre-defined time is over, and commit all the answers to the instructors PDA identifying the students who answered questions.

8) The instructors PDA must be able to store the data received in an efficient way. The storage constraint imposes the prime challenge in this issue.

9) The instructor will collect feedback from the students during and after any exam. The instructor can exercise the option of filtering stored feedback for repeated use.

10) This system can be easily transformed into a survey instrument. The requirements for designing, administering and collecting survey instruments are easily identifiable by the instructor.

Requirements from Student point of view

1) The system should facilitate answering of questions. They should be able to submit their answers within a pre-specified time limit.

2) Normally students get tensed up during any exam. It is very reasonable from their perspective to expect the PDAs to be reliable. The devices should not play any tantrums (like denying the students access to network, resetting in the middle of an exam, partial download of file because of unspecified reasons). An occurrence of a single event specified above will undermine the students and instructors confidence in the entire process. All these considerations obviously have to be taken care of.

3) The students should also able to submit their comments during and after the exam. While they would not be able to submit the answer outside the time limit imposed by the instructor, they can comment at any time at any topic related to the course and question.

5. Development of Assessment Tool using MARKS

The central idea of developing an assessment tool is to make the exam development, administration and result collection/distribution process more efficient and user-friendly. The

desired qualities of assessment are addressed fully in our first prototype implementation, named "wireless exam."

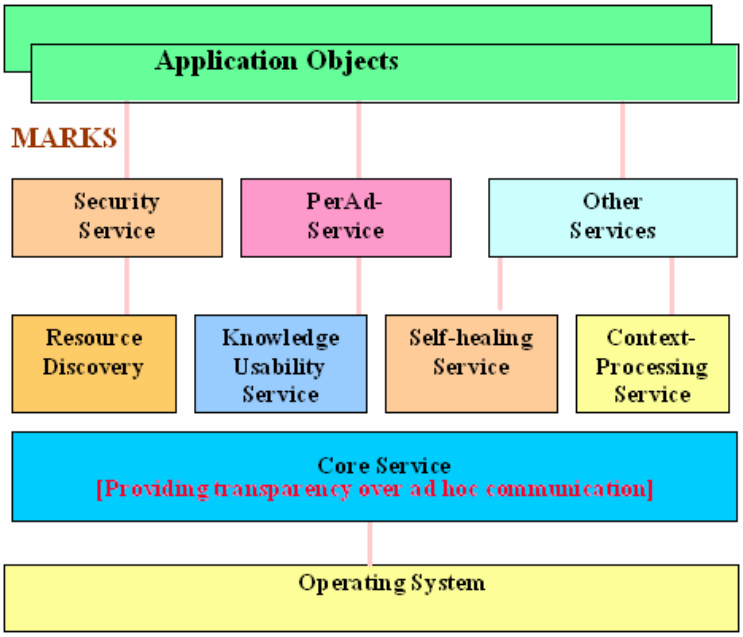


Fig. 1. MARKS Architecture [15]

At present, we are developing a middleware named MARKS for pervasive computing to facilitate the application developer to get all kinds of crucial and core services to develop their application in a very easy but semi-transparent manner. The basic architecture of MARKS is shown in figure 1. The assessment tool that we are discussing is initiated from MARKS by simply invoking the appropriate services. The IDL (Interface Definition Language) and classifier of MARKS, after converting and classifying the request, sends it to the appropriate agent which helps to drive it to the appropriate unit. For an example, to find the address of all the registered students of a course, the request of instructor's assessment tool will reach at Resource Discovery unit via IDL, Classifier, and RD agent. After performing all these functions, the corresponding unit will return the appropriate result to the assessment tool in reverse. The whole procedure is fully transparent to the user (instructor). Instructors will not know what procedures are going on in the process. Though semi-transparent to the application developer who may understand the workflow diagram they will not be annoyed with maintaining low-level activities.

Timely fast assessment is achieved through the support for auto grading. When the instructor wants to complete the grading, he just has to select the "Grading" option. This option provides the facility of not only grading but also result generation. It saves the results of each student in the

individual directories of the students and also a summary copy for the instructor at a separate directory along with the exam name.

To create an exam, the instructor types a new question or selects from a repository of exiting questions. The Repository shortens the time to create exams while providing the instructor with an opportunity to compare and consult past student performance on selected items.

Our tool makes editing real easy. To change any question in any examination, it is sufficient to modify its contents and others will remain unchanged. Instructors can modify any part of any question any time. Adjustments can be made even after distribution to some students. The modified version being sent to the remaining students.

Comparison between the responses from different students is a time-consuming procedure. The auto comparison functionality makes it possible to not only grade all the submitted answers but also generate a summary of the answers given by the students.

Our first prototype has the facility of generating both automatic and manual feedback. It is a common scenario that many students ask the same question or find it difficult to understand the same point. The instructor can store a file containing “frequently asked questions” and store the answers for those. Whenever a student asks a question that falls within the common question range an automatic feedback will be passed to the student. It saves time and energy because the instructor is freed from answering the same question repeatedly. When there is no match for the question in the stored file the instructor has a provision to give feedback manually. The instructor types and sends the student an individual response. The instructor will add the “unexpected question” to the FAQ pool of questions and responses set for future use.

The assessment tool is designed and developed considering the diversity of devices running on typical pervasive computing environment. The tool is usable in powerful devices like desktops, and laptops and also resource poor devices like PDAs and smart phones. The user interface was designed considering these facts. In our first prototype, we used desktops, laptops, and PDAs as our test devices. The same tool can run on different devices and can communicate to each other. This makes it a very powerful tool as the instructor can create the exam on his laptop or desktop and then upload the questions to his PDA as necessary.

Generality is one of the most important features of any tool. Each instructor has his own idea of making questions. The pattern of questions, type, and also number of questions vary not only from instructor to instructor but also from exam to exam. Our first implemented prototype maintains high flexibility. The instructors are free to choose any number of any kinds of question in any order.

6. An Example

An instructor and students are returning by buss after a field trip to the Michigan art and science museum. To evaluate the learning and understanding of the students (denoted as S1-S4, Da, and Ju), the instructor (labeled as Ins) makes impromptu questions for distribution to students during the ride. The instructor then “electronically” passes the questions to the students residing in the bus. This scenario is presented in the first picture of figure 2(a).

After getting the questions, each student answers. David and Julia (noted as Da and Ju), two students inside that bus, failed to understand a specific question and send a query to the instructor and subsequently received a “feedback” rapidly. Figure 2(b) portrays this scenario. Answering within the specific time, students send their answers to the instructor. The instructor, within a short period of time, distributes the grading to the students using the auto-grading option. These two situations are depicted in figure 2(c) and 2(d).

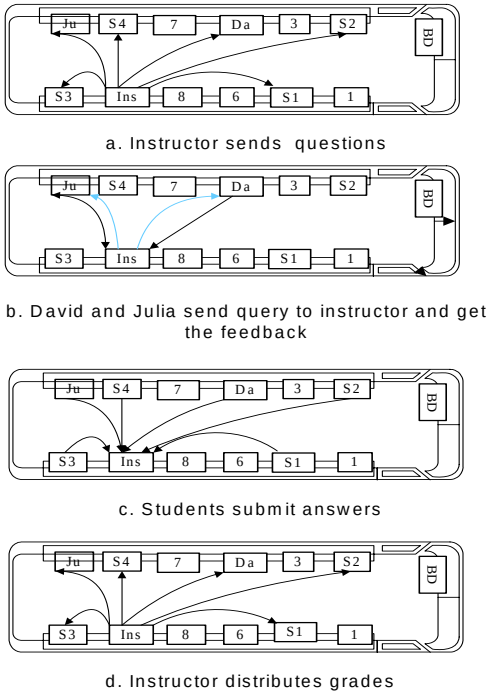


Fig. 2. Use of Assessment Tool during Traveling

7. Evaluation and Implementation

The PDA platform used to implement the wireless exam application, WinCE running on a set of Dell Axim X30 pocket PCs (Process type is Intel@PXA270, speed is 624 MHz, display is 3.5" Transflective TFT color, and weight is 4.8 oz) is used. This application is compatible to laptop and desktop. As an implementation language, we have used C# in Compact Dot Net Framework. As the underlying wireless protocol, we have used mobile ad hoc mode of IEEE 802.11.

Bluetooth is also appropriate for this communication. Socket and thread programming is used to make the entire communication scheme simple yet effective. The instructor's PDA uses one thread for each student. To manage all kind of database related things, we have used SQLCE.

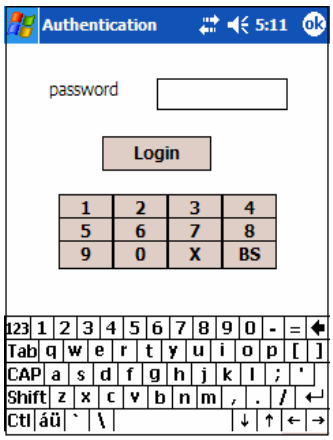


Fig. 3. Authentication

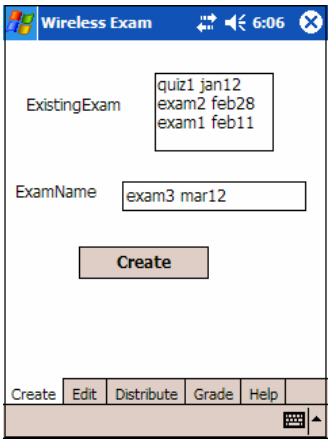
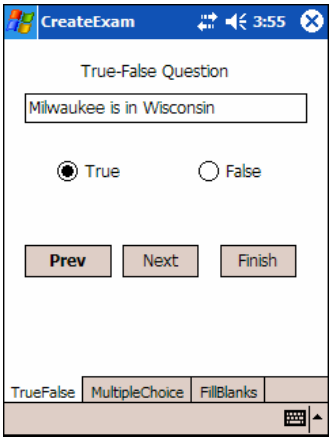


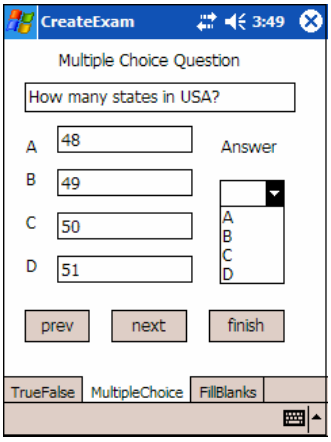
Fig. 4. Create an Exam

To commence the wireless exam application, the user, instructor or student, needs to be authenticated to ensure higher degree of security. Figure 3 shows such an authentication form.

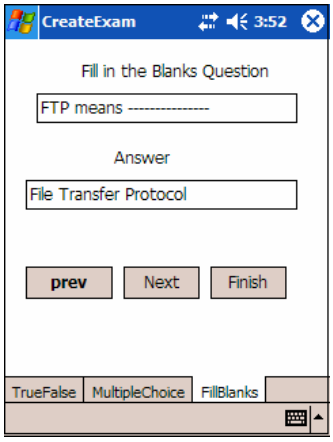
Once authenticated, an instructor can create, edit, distribute, or grade an existing exam. Figure 4 shows the common form for these actions.



(a) True-False Question



(b) Multiple Choice Question



(c) Fill Blanks Question

Fig.5. Create Exam Questions

Ease of creating input (use of PDA instead of pen and paper)

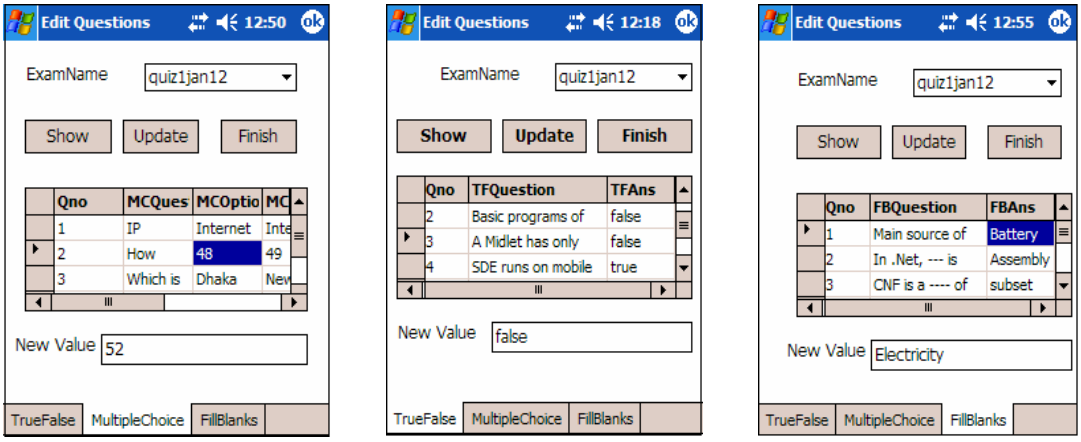
The instructor chooses the “Create” option. A window displays an existing list of names for existing exams known to the instructor. The instructor puts (writes) a new name in “Exam Name” window and taps the “Create” button to create a new exam.

After tapping the “Create” button, the instructor will reach in “CreateExam” subsection where as many questions as required can be entered. Figure 5(a) shows the form for creating a True-False question. The instructor enters not only the question but the correct answer to take advantage of auto-grading feature. The instructor can easily update any question. The “Next” button is used to create new True-False questions. Select the “Finish” button to exit the True-False question creation function.

Figure 5(b) and 5(c) show the creation template for multiple choices and fill blanks questions respectively. The instructor can choose any number of and any types of question in any order. For the instructor, the exam creation phase becomes simpler and less time consuming with experience.

Ease in editing

This tool provides the easiest way to edit an existing exam. The instructor can view all of the questions for a chosen exam and can modify any part of any question or answer. It is not necessary to alter the entire question, simply choose any part and change it. Leave the rest as it is. The change made will reflect in the database.



(a) Multiple Choice Questions (b) True False Questions (c) Fill Blanks Questions

Fig. 6. Edit Exam Questions

Before distribution to students, the instructor may want to edit some (or all) of the questions. To provide that facility, the form named “Edit Questions” has been designed. Figure 6 shows how an instructor can edit previously created multiple-choice questions. The instructor first chooses an exam by name for editing. Then select the “Show” button to look at the questions and keys that

are entered in the data gird. Next, select the specific item (question or answer) that needs to be edited, to choose that item. Then write the value in the "New Value" field. Complete the change by pressing the "Update" button. The new value will automatically be updated to the database and the data grid as well. Select the "Finish" your editing task is completed. Figure 6(a), 6(b) and 6(c) present forms used to edit multiple choice, true-false and fill in the blank questions.

Timely fast assessment

Distribution of exams among the students and quick collection of answers from them along with auto-grading contribute to timely fast assessment.

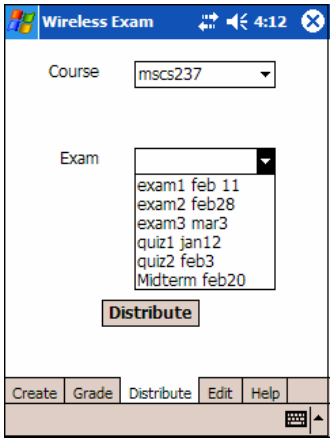


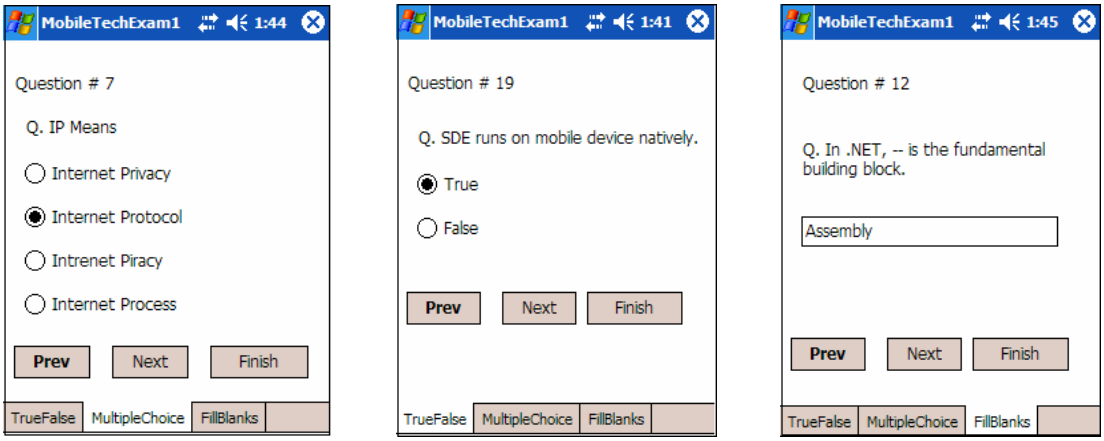
Fig.7. Distribute the Questions

After creating and editing the questions, to distribute the questions among students, the instructor needs to go back to main form (wireless Exam). After choosing the course name and exam name and pressing the "Distribute" button, the corresponding questions will automatically reach to all the registered students of that course. This scenario is presented in figure 7. A database has also been maintained in the instructor's PDA to put the addresses of the students' PDAs according to the course name.

Now the instructor's PDA will wait a specified time (duration of the exam) to get the answers from the students. All the students need to submit all their answers within that specific time like a typical paper-pencil exam.

After the distribution of the questions by the instructor's PDA wirelessly, the students will get those in their PDAs. Figure 8(c) shows the question # 12 of fill blank questions. It means the student has already given the previous 11 fill blank questions. After giving the answer, by pressing "Next" button, the student will get next question to answer. Some times the student may skip some questions or they may want to change their previous answers. "Prev" button has been

used to provide those facilities. Figure 8(a) and 8(b) show the same scenarios mentioned above but for multiple choice and true false questions respectively.



(a) Multiple Choice Questions (b) True False Questions (c) Fill Blanks Questions

Fig.8. Answering a Fill the Blank Question

By pressing "Finish" button, the students ensure that they have finished the examination and the answers are ready to send to the instructor's PDA. The instructor will get their answers automatically.

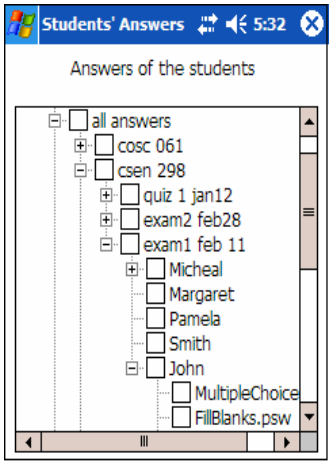


Fig.9. Student's Answer in Instructor's PDA

Since the instructor will get answers from different students, it needs to store their answers in such a systematic way so that he can easily understand which student provides which answers. Such a tree hierarchy of all the students' answers is shown in figure 9. Here for each course (e.g. cosc061, csen-298 and so on), a folder is maintained. For each exam (e.g. quiz1jan12,

exam2feb28 etc.) there are corresponding sub folders. For each student (e.g. Michael, Margaret etc.) sub-subfolder has been maintained. This application is developed in such a way that all the answers of a student for a particular course as well as for a specific exam will automatically be stored in the corresponding folder.

Automatic comparing

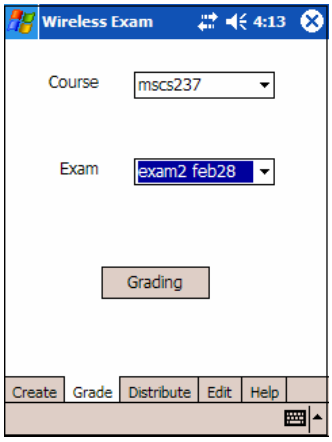
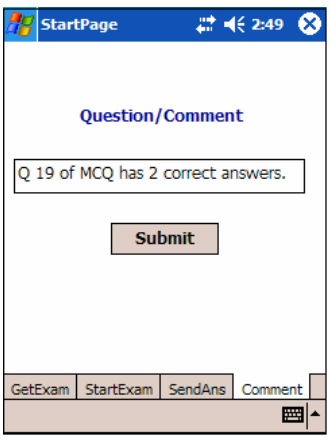
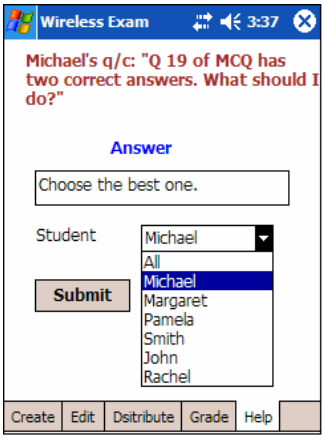


Fig.10. Auto Grading

To grade the exam the instructor first selects the course and then the exam to be graded. Press the "Grading" button located in the "Grade" section. This scenario is depicted in figure 10.

Both Automatic feedback and manual feedback





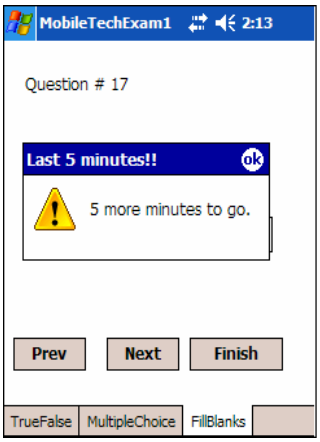


Fig.11. Comment from Student Fig.12. Instructors Feedback Fig.13. Auto-generated Message

Students and instructors can send question or comment at any time. Auto feedback facility is provided to answer common questions. The instructor also has the provision to give manual feedback when necessary. Figure 11 and 12 depict comment from a student and respective feedback from the instructor. Figure 13 shows a typical automated message that reminds the

students about the duration of the exam. The comment function is especially useful outside of the testing situation. Imagine giving the students prompts or feedback during a lab exercise or during a guest presentation to your class.

8. Discussions and Future Works

In this paper, we have presented a PDA assessment tool, facilitating assessment in an out of classroom learning environment using pervasive computing technology. The "assessment tool" is designed to improve learning for the student while providing the teacher with a reliable and efficient instrument to gauge instructional outcomes. The functions of the assessment tool and probable scenarios have been presented for consideration. The first prototype of the assessment tool has been implemented. The evaluation of the assessment tool has been illustrated in this paper.

Since developing and testing our first prototype we have added a simple yet effective security mechanism. Our continuing work includes implementing a more robust security services, voice activated exam-taking and improved grading tools. We continue our work on the design and implementation of a voice recognition function useful in a training setting. A particular goal for our continued research is to implement a sophisticated privacy and security facet on top of our existing application. We are working on making our assessment tool applicable for use not only in education but also for patient-doctor communication and distant monitoring in medical field and collaborative market research in business.

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