

## Design and Development of a Supported Tiered Software for Teaching and Learning Using a Connected Mobile Learning Application

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**Abstract:** Since the last decade, one of the fastest growing technologies is the mobile technology [1]. Mobile technology, which ranges from mobile phones, portable gaming devices to tablet computers, is getting affordable in recent years. Mobile learning should not be viewed as just a technology that provides E-Learning on mobile devices. Classic mode of mobile learning focuses in content delivery but the trend is to extend learning with the capabilities of communication and interaction as well as content capture and transfer [3]. In this paper, a discussion based on the experience of the authors in designing a mobile learning platform prototype using interconnected mobile devices and server infrastructure is presented. The prototype allows a lecturer to teach using a tablet while students learn and interact with the lecturer using their own devices. A preliminary result based on students' feedback is used to prioritize and improve the features.

### Key words:

### INTRODUCTION

Since the last decade, one of the fastest growing technologies is the mobile technology [1]. Mobile technology, which ranges from mobile phones, portable gaming devices to tablet computers, is getting affordable in recent years. Today, in some countries there are more mobile phones than fixed line telephones. The availability of mobile Internet through 3 or 4G networks has made connected devices more and more ubiquitous in many countries. This phenomenon has also brought changes to the way the society communicates with each other [1]. A prominent example is the social network – e.g. twitter and facebook.

One area that has picked up the momentum along with the emergence and growth of mobile technology is mobile learning. Bring your own devices (BYOD) is taking place more often at higher learning institutions, changing how the institutions should cope with the support as well as infrastructure. According to UNESCO, mobile learning

can be defined as education that involves the use of mobile devices to enable learning anytime and anywhere [1]. This definition challenges educators as well as institutions to develop new and innovative teaching and learning tools that will not only ride on the rapid growth of mobile technology, but also to answer the demand of the current and future learners.

Mobile learning should not be viewed as just a technology that provides E-Learning on mobile devices. Classic mode of mobile learning focuses in content delivery but the trend is to extend learning with the capabilities of communication and interaction as well as content capture and transfer [3]. At the same time, deploying learning using mobile technology also brings some “side effects”. Distractions and interruptions will be inevitable in an implementation of mobile learning [4]. The new paradigm in a mobile learning environment requires careful design and ideas that makes learning using mobile technology seamless and efficient, not sacrificing the fun factor.

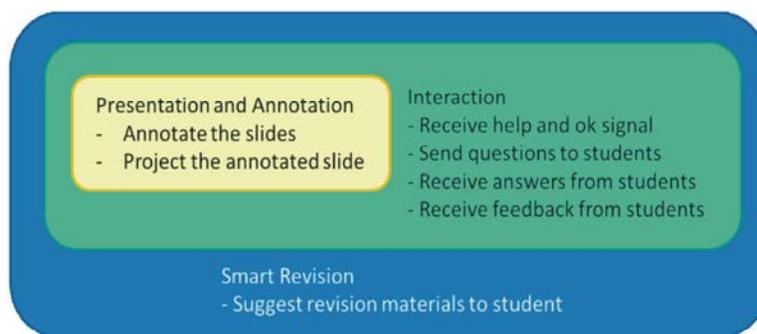


Fig. 1: The three level of features for TIApp

In this paper, a discussion based on the experience of the authors in designing a mobile learning platform prototype using interconnected mobile devices and server infrastructure is presented. The prototype allows a lecturer to teach using a tablet while students learn and interact with the lecturer using their own devices. The delivery of a lecture is a combination of features like multimodal display as well as control of contents, real time feedback and interaction, flexible annotation and automated content delivery. The paper will also discuss one area of research, which is the user interface (UI) design and improvement of the apps of this platform prototype. The design and improvements were studied and performed based on students' usage and feedback across 2 semesters at the university.

The application used by the lecturer is known as the "Teaching Instructor Application" (TIApp) and the application used by the student is the "Student Instruction Application" (SIApp). The TIApp has three levels of features (Figure 1):

- The first level covers the in class presentation and annotation, the lecturer can annotate on the PDF file and it will be projected on the screen. This allows the lecturer to move freely among the students. Apart from that, the students can also join the lecture session started by the lecturer, download the slide and follow the class using the SIApp.
- The second level covers the interaction with the SIApp. The students can send a "Help" signal if they are no longer following the class and "OK" if they are back on track. The third level covers a revision system, where the lecturer can suggest reading materials and exercises for the topics that are more challenging. The basic function for SIApp, is to be able to read the PDF file on the move. This means that the students are able to read the material while traveling to the class. The second level function is to

communicate and give feedback to the teaching instructor. The students not only can send the "Help" and "OK" signal, they can send questions to the lecturer at the end of the class.

- The third level is to have a smart assistant that would help student to revise for the course. Selected questions can be sent from the TIApp to the SIApp during the class. The SIApp will keep track of the result and propose reading materials or exercises if the student did not do well for that class.

This project started with the funding from University Kassel under the "Mobile Learning Project"[5]. The initial stage focuses on the applications that can be run on iOS platform. Therefore, this project focuses on the development of a mobile learning application for iOS platform.

### Design and Development

**Features:** There are many different applications that are able to perform each of the function individually. However, they can either do annotation, or interaction but not both. Table 1 presents the different applications surveyed and the coverage of each application. From the comment for the applications, it is observed that each application performs well within the defined function. However, there is no one "integrated" application.

The challenge of this project is to discover features that are needed. A normal "traditional" class setting comes into view when defining the basic functions needed for this project. In a traditional classroom setting, the lecturer presents the slides on the overhead projector, draws on the slides and further explains it on the board. The students, on the other hand, will follow the class, jotting notes as necessary and ask questions (when they muster enough courage to voice out). This is considered as the basic functions for both TIApp and SIApp.

Table 1: The comparison of available applications

	Presentation			Interactions			Assistance		
	Presentation	Annotation	Mobility	Send annotations	Send questions	Display feedback	Help/OK button	Revision questions	Access to library
I-Clickr	yes	no	yes	no	no	no	no	no	no
Keynote	yes	no	yes	no	no	no	no	no	no
GoodReader	yes	yes	yes	no	no	no	no	no	no
eClicker (host)	no	no	no	no	yes	yes	no	no	no
SlideJockey	yes	yes	yes	yes	yes	yes	no	no	no
iCardSort	no	no	no	no	yes	yes	no	no	no
TIApp	yes	yes	yes	yes	yes	yes	yes	yes	yes

\* compiled in December 2011

One factor that influences the class interaction is the number of students in the class. Students in large classes (more than 75 students) will have more difficulty interacting with the lecture[6]. A student in a large class environment may be shy from asking questions, as this is seen as a form of interruption. The second level functions for both TIApp and SIApp focus in overcoming this situation. Students may send “Help” signal to the lecturer when they are no longer able to follow the class. The students may press the “OK” button if they are able to follow the class again. To avoid getting false alarm, the “Help” button would only be disabled after it is pressed and would only be re-enabled when the “OK” button is pressed. The lecturer will get an indication on how many students pressed the “Help” button and if further elaboration is needed to reduce the “Help” signals. The lecturer can also send questions to the students and the students are given 5 seconds to answer the question. The feedback from the student would be projected on the board, where the real time count for each answer would be displayed. The third function that assists in the interaction is the feedback function. Students are able to send questions and feedbacks to the lecturer at the end of the class.

The third level of TIApp and SIApp focuses on the revision system. The lecturer can key in suggested readings for the questions entered in TIApp. Based on the student’s performance in answering questions sent by the TIApp, suggested readings would be proposed to the students. This would help students to specifically concentrate on the subject areas that they are having difficulties.

**Usability of SIApp:** The design of the application follows the “User Experience Guideline for OSX”[7]. Implemented guidelines for both TIApp and SIApp are

- The zooming action using two fingers to increase and decrease the PDF

- Auto full-view modus after a PDF is opened for viewing
- Eye catching red colour button for user to send the “Help” message and green colour for the “OK” button to indicate that the student is back on track
- Auto save function when making notes on the PDF
- Play button for students to auto follow the lecturer’s slide and when students flip pages on their own the auto mode is disabled.

Apart from the guideline, tests were also conducted using eye tracking movement to the area that needs to be improved for the human computer interaction. Through the eye tracing data, it is possible to take note where does most user look at when performing a certain task. This would then be most intuitive location to place the button or to detect the gesture. An example is user would tend to look at the right side of the screen to turn to the next page and the left side of the screen to turn to previous page.

As there are more users for the SIApp, the first part of the project focuses on the usability of SIApp. Two different assessments were conducted to evaluate the usability, a user test was conducted for SIApp - iPhone version and eye tracking test was conducted for the SIApp – iPad version.

**SIApp – iPhone Version:** The first survey covers the following six features as presented in Table 2. The users grade the functionality of the features using a Likert scale.

It is observed that the feature that received the best score are “reading the PDF document page by page” and “zooming in and out of the PDF document for reading”. The user interaction for this features are well known and widely implemented across different applications that have the same features. The other three features were sort of “hidden” as the full view mode for reading the PDF document was implemented. The user only “discovered” this feature after a few tries. The “taking notes in the PDF

Table 2: The intuitiveness to understand the features in SIApp – iPhone version

The intuitiveness to understand the features	Average
1 - at the first glance	
2 - after 2 to 3 tries	
3 - after more than 5 tries	
4 - after the lecturer gave some hints	
5 - did not at all understand it	
Downloading the PDF from the server	2.25
Reading the PDF document page by page	1.00
Zooming in and out the PDF document for reading	1.00
Taking notes in the PDF document	2.57
Pressing the red "Help" button	2.63
Pressing the green "OK" button	2.63
Jump to the "current" page	2.63
Connection with the server	2.75

Table 3: User preference for the interfaces in SIApp – iPhone version

Did you like the user interface	Average
1 - like it very much	
2 - like it	
3 - it is ok	
4 - it can be better	
5 - it is difficult to use	
Downloading the PDF from the server	2.50
Reading the PDF document page by page	1.25
Zooming in and out the PDF document for reading	1.75
Taking notes in the PDF document	2.75
Pressing the red "Help" button	2.00
Pressing the green "OK" button	2.00
Jump to the "current" page	2.25

document" feature, is activated when an "action" button is pressed, a new view would be pushed and the user can make notes at this new view. A better possibility is to have the note taking directly on the PDF or a more intuitive button. Pressing the red "Help" button or green "OK" button, is unique to SIApp. This instant, simple yet important, feedback from student to the lecturer was not listed on the applications surveyed in Table 3. This might be one of the reasons that the users only discovered this feature after a few tries. The participants in the survey suggested using the "like" or "unlike" thumb icon, or to use a smiley. However, all the seven participants in the survey are excited and find this feature helpful.

The user interface look and feel has much room to improve. The best score are "zooming in and out the PDF document for reading", "pressing the red Help button" and pressing the green OK button".

The user friendliness result might contrast with the intuitiveness of the feature. It might be intuitive to identify a feature, as the icon is representative, or the function is known. However, the feature might not be user-friendly. For example the "pressing the red Help

button" and "pressing the green OK button", both are features that are unknown to the users. However, it is user friendly as only by a button push the users are able to send the message to the lecturer. All the users who participated in the survey agreed that these two features are good features that should be implemented.

Through the user survey, the areas that are of importance to the users were identified. The most welcoming feature is the "PDF reading page by page" feature. The next version of the application focuses on keeping the user friendly features and improving on the features that scored poorly, especially the feature "downloading the PDF from the server".

**SIApp – iPad Version:** Although containing the same features, the layout for SIApp for the iPad version differs that of iPhone version because the device is larger. More information can be pack into the layout. The iPad version was also developed after the survey test for iPhone. The iPad version of SIApp was developed as part of a bachelor project.

Eye tracking test was conducted for this version to provide an alternative way for application testing. Eye tracking test tracks the movement of the pupil. The users are given specific tasks for example connecting to a session, downloading the PDF document, go to page 6 of the PDF document, circle the document title with blue colour, discard the annotation, re-annotate using line with different thickness, zoom in and zoom out, write a note for the PDF document, delete the Note, send feedback to the lecturer, send a "Help" signal to the lecturer and send a "OK" signal to the lecturer. The iPad layout was divided into three different areas. They are the navigation area (connection, download and slide navigation) area in green, the toolbar (annotation, insert notes and "jump to the current page") area in green and the PDF display in red (Figure 2). By observing the eye movement and the time spent in each area when doing the specified tasks, conclusions can be drawn if the design is user friendly. Ideally, the user should be spending minimal time searching and figuring out the ways to use the application and spend more time reading, making notes or annotating the PDF document instead. This translates to less time spent in the green and blue area and more time spent in the red area.

The time spent on each area is translated to heat map. Area with more time spent would be warmer colour (red) and area with less time spent with cooler colour (blue). Two examples of heat map are shown in Figure 3. The heat map from the first user is positive, with the focus in blue

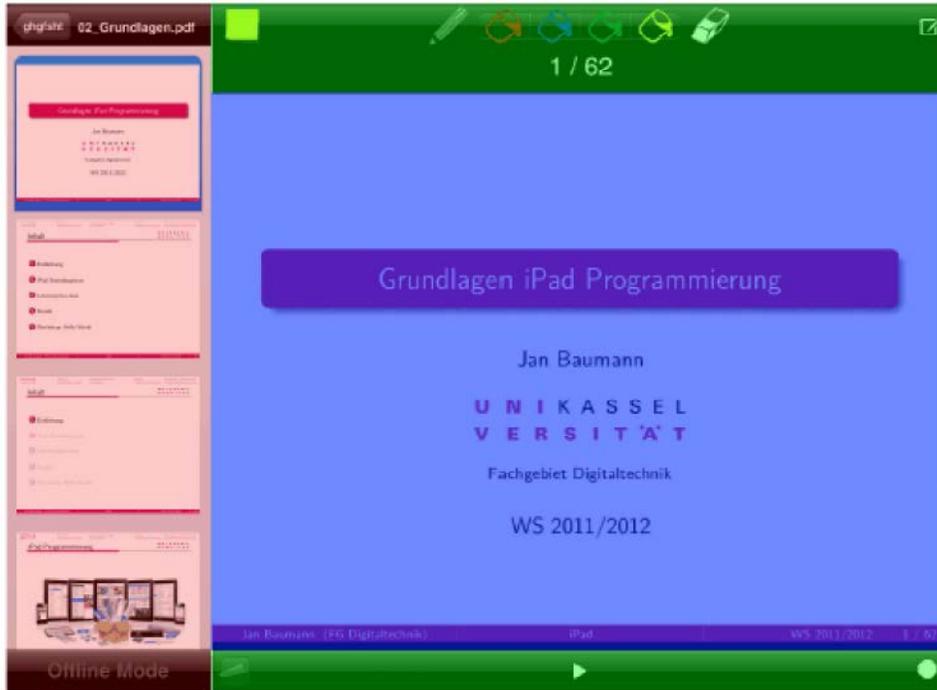


Fig. 2: The division of area for the SIApp – iPad version layout

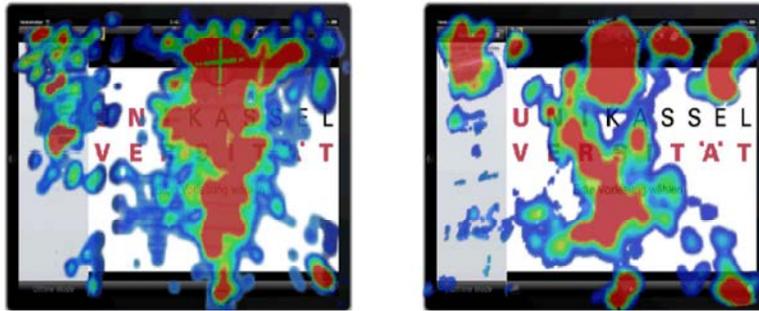


Fig. 3: Example of heat maps from users – user 1 (left map) and user 2 (right map)

area outweighing the red and green area. The heat map from the second user shows that the user was looking or searching at the bottom tool bar more than the first user. The user, which records the lowest time spent on red and green area as compared to the blue area, is a frequent user of other iOS application. The eye tracking result shows that all the students spent more time on the blue area as compared to the red and green area. Thus the layout for the application stays the same.

Feedback from the survey test is integrated in the iPad version. One major improvement in the iPad version is the feature “connection with the server”. In the iPhone version, the students are required to key in the session identification, the iPad version display a list of available sessions and the student only need to choose the appropriate session identification. The rating for this

feature in the second survey improved to 2.56 as compared to the previous 2.75 rating. Another change that did not receive much improvement was the feature “taking notes in the PDF document”. In the iPhone version, the users need to press on the note button at the tool bar and a new page with table view will be pushed and the students can type the note to it. In the iPad version, the users are required to click on a note icon and a yellow box will appear on the PDF page. The users can then key in the notes to it. The note stays on the PDF page. This would block part of the PDF document. The usability score for the iPhone version was 2.57 and the score for the iPad version was 3.48. A suggestion is to be able to close the notes and instead of viewing the notes on the PDF page as pop up, it should be displayed in a table form in another view as in the iPhone SIApp.

**TIApp:** There is only one layout for TIApp and that is the iPad version. No iPhone version was developed as the layout is small for the reading and annotation feature. Apart from that, the lecturers participating in this pilot project have an iPad for perusal. The first version of TIApp covers the first and second level of functionality as described in Figure 1.

The features in the first level are annotation and presentation. The design for TIApp to best possible mimics the good old “overhead projector” and “blackboard”. Different pen and colours are provided for the annotation purpose. The annotations can also be erased by undoing. The opacity for the lines drawn reflects the transparency pen, where the opacity decreases when a line is drawn above another. The annotation will be displayed “live” as it is being drawn. Only the PDF document view is projected. With the release of airplay mirroring feature for iPad2 and later, the lecturer has the option to display only the PDF document view or the whole TIApp layout.

The second level features include being able to send questions to the students and to display the received answer in graph form, live using the projector. Three different types of questions were considered. They were spontaneous true/false question, multiple choices question and rating scale question. The spontaneous true/false question does not require the lecturer to pre-set the questions. The lecturer will ask the question verbally and press on the spontaneous question button. The SIApp from the students the students display a view with two buttons “Yes” and “No” for the students to choose from. The multiple choices and rating scale question needs to be prepared before the class. The lecturer can then select the prepared questions to be sent to the

students. All the options for the multiple choices question will be displayed at the SIApp if this question type is sent. A sliding bar will appear if the rating scale question is sent. Currently, only one question can be sent at a time. An example of the graph result is presented in Figure 4.

The TIApp receives feedback from student. The feedbacks would not appear or popup for reading as not to distract the presentation in class. The lecturer is able to check the different feedback or questions after the class ended. Information for the feedback, red “Help” and green “OK” button are recorded with the slide number from the TIApp at the moment this information is sent from the SIApp. A slide with peak or red “Help” signal might indicate that the slide is difficult to understand or the explanation is inadequate. This would help the lecturer to review the slides and have more information to make the necessary changes.

The usability of TIApp was tested through a few lectures during the design and development phase. Among the feedbacks from the participating lecturer are:

- The control elements, namely the buttons for annotations, sending the questions, should be bigger as the lecturer is busy presenting and should not be burdened with the possibility of pressing the wrong button, or having to press a few times before the buttons react.
- The connection status with the server should be visible and reconnection should be done automatically if the connection drops.
- The annotation feature supporting different colour is helpful in explaining certain concepts to the students.
- Feedbacks from students are successfully received.



Fig. 4: SIApp showing a question being displayed and TIApp with a graph indicating the answers from the students

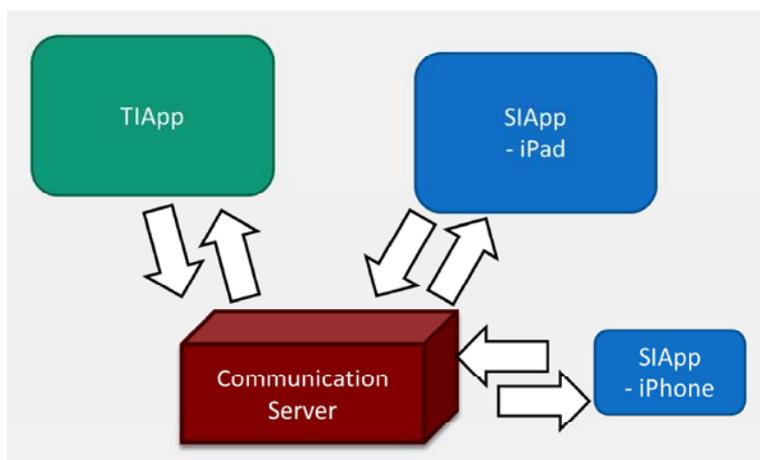


Fig. 5: The communication between TIApp and SIApp goes through a communication server

Changes were done according to the feedback received. The layout was modified to increase the button size. This is done by making the PDF view are smaller but still big enough to be read on the move.

**Communication Server:** The communication server is responsible for the communication between TIApp and SIApp (5). This is preferred over direct communication, as direct communication will burden the device where TIApp is installed with connections from different devices using SIApp. One important area in the communication is the data security. The TIApp and SIApp have secured connection with the communication server.

The lecturer uses the TIApp to start a session with the server. This will generate a unique session identification code. Students in this particular lecture need to key in this session identification code to connect to the same session. In an active session of a lecture, different types of data are sent and received by both TIApp and SIApp. For example:

- TIApp sends the current page number, questions, close question information to the server. The server pushes the respective data to all SIApps in that particular session in a real time manner. In this way, students follow the pace of the lecturer, where the SIApps change pages as the lecturer progresses in his delivery of lecture contents. Students may change to other pages than the current page of the lecturer and SIApp provides an easy switch to the current page anytime.
- SIApp sends the answers to questions, feedbacks for lecture and the red “Help” as well as the green “OK” signal to the server. The server pushes the

respective data to the TIApp, so that the lecturer can keep track of students’ feedback also in a real time manner.

The connection for sending questions and receiving answers need to be real time and continuous. The server will continue to send newly received answers from SIApp, this data will then be pushed to the TIApp and the graph reflecting students answer will be updated live. Only new data will be pushed to the TIApp or SIApp. Currently, the communication server application is written using PHP: Hypertext Preprocessor (PHP) [10, 11]. Currently, the received data from both TIApp and SIApps are stored as text files. In future versions, it will be possible to also integrate a database for data storage [12].

**Pilot Run and Result Analysis:** It is challenging to keep students active in a large class room setting. Various methods were tested and the most effective method of learning is when the students are engaged in the learning process [8]. With the help of TIApp and SIApp, the communication in large class room setting would be improved. So far, only one implementation took place and the response had been positive. A pilot run was conducted during the Winter Semester 2012. There are more than 75 students taking part in this lecture. The lecture hall has two pillars that block the view from certain seats. Therefore, the flexibility to move around is important for the lecturer. Out of the 14 lectures, TIApp and SIApp were used in at least four of the classes. After the four classes, the students filled up a survey form. 28 students with iPad loaned under the University Kassel “Mobile Learning” project took part in the survey.

From the students' survey, it is observed that the most important functionality is the PDF reading functionality; this is followed by taking notes on the PDF. Out of the 28 students, SIApp increased the motivation for 10 students to participate in the lecture, helped 9 students to understand the course content better, enabled 13 students to read the lecture notes on the move and assisted 13 students to send feedback to the lecturer. The usability of the different features rated between 2.12 to 3.48 (Following German Rating system, where 1.00 is the highest and 5.00 is the poorest). The three best scores are PDF reading (1.75), PDF zooming (2.15) and sending the red "Help" message (2.15). Taking notes on PDF had the poorest rating at 3.48. More is needed to be done to improve this feature, as it is one of graded as the third most important feature.

The lecturer who had conducted the class was well verse in using applications that run on iPad. There are various applications available to perform the different tasks. The list of applications tested and compiled by the lecturer includes i-Clickr, Who's Next? icardSort, slideJockey, etc. [9]. However, it is inconvenient to request students to change application in the course of the class. The lecturer finds the features offered by TIApp comprehensive. The TIApp features used by the lecturer are annotation and presentation, sending questions to the students and receiving feedback from the students. All these three different activities that required different applications are now integrated in TIApp. Further suggestions from the lecturer are the option to view notes during presentation, stable connection between the TIApp and SIApp as some of the students did not receive the questions sent by the lecturer and to have connections to different libraries as further reading materials for the students.

**Outlook and Future Work:** The TIApp, was developed based on the feedback of lecturers. Different ideas were gathered and new features were added based on the feedback. Two different surveys were conducted for the SIApp to find out on the importance of the different features. During the first survey, the students tested the first version of the SIApp. This survey covers the ranking of the features currently available and also the usability of the interface. Modifications were made based on the feedback. The feedback were also integrated in the development of SIApp – iPad version. Eye tracking test was conducted to ensure better usability. The second

survey, not only gathers information on the usability of SIApp, but it also gathers information on the impact of the application. Students, who used SIApp, did prepare for the classes on the move. This is the positive impact of mobile application.

Both of these applications are currently running on iOS platform. The research team is looking forward to implement both this application in other platforms. The team also intends to test the applications in more classes to investigate the effectiveness of such m-learning tools in different types of lectures.

## REFERENCES

1. Steven Vosloo, 2012. Mobile Learning and Policies: Key Issues to Consider, United Nations Educational, Scientific and Cultural Organization (UNESCO), Paris, France.
2. Klaus David, Sian Lun Lau and Bernd Niklas Klein, 2011. Social Link App, IEEE Vehicular Technology Magazine, 6(3): 80,87.
3. Clark N. Quinn, 2011. Mobile Learning: Landscape and Trends, The eLearning Guild Research, Santa Rosa, CA.
4. Mariluz Guenaga, Iratxe Mentxaka Andoni Eguiluz, Susana Romero and Javier Garcia Zubia, 2012. Smartphones and teenagers, threat or opportunity. 15<sup>th</sup> International Conference on Interactive Collaborative Learning (ICL), 2012, pp: 1,5, 26-28.
5. Projekt, 2013. Mobiles Lernen, <http://www.uni-kassel.de/einrichtungen/index.php?id=38957>, last visited 30<sup>th</sup>.
6. Tze Ying Sim and B. Vogel-Heuser, 2010. Reviews and findings on implementing active learning in a large class environment for Mechatronics and Computer Science students. Education Engineering (EDUCON), 2010 IEEE (2010): pp: 1563-1572.
7. User Experience Guidelines - Apple Developer, <https://developer.apple.com/library/mac/documentation/userexperience/conceptual/applehighguidelines/UEGuidelines/UEGuidelines.html>, last visited 30<sup>th</sup> November 2013.
8. Tze Ying Sim, 2010. Effectiveness of the methods for engineering courses in a large non-homogenous class setting With regards to the specific disciplines - Computer Science and Mechatronics in learning Embedded System. kassel university press, ISBN: 978-3-89958-970-2, 2010 URN: urn:nbn:de:0002-9711, 2010

9. Walter Blocher, In der Präsentation von Walter Blocher vorgeführte oderbeschriebene Apps, [http://cms.uni-kassel.de/unicms/fileadmin/groups/w\\_430000/Veranstaltungen/Forum\\_ProLehre/App-Liste.pdf](http://cms.uni-kassel.de/unicms/fileadmin/groups/w_430000/Veranstaltungen/Forum_ProLehre/App-Liste.pdf), last visited 30th November 2013.
10. Manimekalai Jambulingam, 2013. Behavioural Intention to Adopt Mobile Technology among Tertiary Students, *World Applied Sciences Journal* 22(9): 1262-1271.
11. Muhammad Nawaz, Fiaz Hussain and Bilal Zaka, 2013. Review of E-Learning Methodologies in Pakistan, *World Applied Sciences Journal*, 28(4): 425-439.