# USER INTERFACE DESIGN WITHIN A MOBILE EDUCATIONAL GAME

F. Fotouhi-Ghazvini[1&2], R. A. Earnshaw[1], D. Robison[1], A. Moeini[3], P. S. Excell[4]

[1]School of Informatics, Computing and Media, University of Bradford, UK
[2]Dept of Software Engineering, University of Qom, Iran
[3]University of Tehran, Informatics Center, 286 Keshavarz Blvd., Tehran, Iran
[4]Centre for Applied Internet Research, Glyndŵr University, Wrexham, UK
F.Fotouhi-Ghazvini@bradford.ac.uk , R.A.Earnshaw@bradford.ac.uk , D.Robison@bradford.ac.uk , p.excell@glyndwr.ac.uk

## ABSTRACT

*A mobile language learning system is implemented using an adventure game. The primary emphasis is upon graphical design and rich interaction with the user. A wide range of functionalities are described, and an efficient navigation system is proposed that uses contextual information, allowing the players to move seamlessly between mobile real and virtual worlds. The game environment is designed to have consistent graphics, dialogue, screens, and sequences of actions. Quick Response (QR) codes provide the necessary shortcuts for the players and Bluetooth connections automatically send and receive scores between teams. A response for every action is produced depending on the screen type, while keeping the file size manageable. Similar user tasks were kept spatially close together with a clearly designated beginning, middle and end. The main sources of error such as entering and extracting contextual data are predicted and simple error handling is provided. Unexpected events in mobile environments are tolerated and allowed. Internal locus of control is provided by 'automatic pause', 'manual pause' and 'save' commands to help players preserve their data and cognitive progress. The game environment is configurable for novice or expert players. This game is also suitable for students with auditory problems and female students are also specifically addressed.*

## KEYWORDS

*Mobile Learning, Game Based Learning, Mobile Games, User Interface Design*

## 1. INTRODUCTION

Mobile devices and desktop computers have a number of differences both in the way they operate and in the way they are perceived by users. These may be summarised as follows – mobile users operate in a varying environment with occasional connectivity problems whereas desktop users are normally in a fixed position when performing a particular computing task or application. Mobile users often use only one hand and may be multi-tasking. However, given that mobile phones cannot easily handle multiple applications on the same screen, their operation must have the capability to 'exit' an application or a menu without losing data. The mobile device hardware also has major limitations. Mobile phone screen size ranges from 2 inches to a maximum of 4.3 inches, which is still significantly smaller than 15-19 inch screens on laptops and desktop PCs. Mobile phones are normally pocket size and the phone must be easily held and operated by the hand. Mobile phones often have a small keypad to enter data where the user must press a key several times to type the desired letter or they have a touch screen which can also be cumbersome to use when entering text data. Applications such as games quickly use the device's limited battery resources and the processing power and limited memory prevents developers from utilising extensive, high resolution graphics. In addition, expensive, slow and irregular network connections such as GPRS can restrict users to accessing

the mobile internet for short amounts of time for specific purposes. In this research we describe the design principles which can overcome some of these inherent barriers of technology and provide support to resource-limited users. Different mobile language learning games can be designed which employ technologies that are widely available to most mobile phones with highly portable and adaptable results. The experimental groups in this research were chosen from Iranian University students. In a previous paper [1] an analysis of potential mobile learners in Iran was performed, as an example of a 'developing world' context. It was concluded that incorporating mobile games into lectures and students' private study time could play a significant role in increasing their motivation and enthusiasm in learning technical English.

In this paper different second language mobile learning environments were examined and their main features reviewed. This is followed by a short summary of 'Detective Alavi', a vocabulary learning program, which was constructed as part of this research. The Detective game is focused on specific learning tasks, which are goal orientated. The user can access a rich instruction set in the virtual environment, connect to the World Wide Web, or contact an expert. A reasonable amount of time is spent on each word, covering a word's meaning, spelling and form, whilst continuous cognitive assessment takes place. A series of puzzles is used to quantitatively assess different aspects of vocabulary, whilst taking advantage of the communicative nature of implicit learning. In this context, vocabularies could be learned indirectly, for example via conversations in an authentic environment. The game is analysed according to the principles of 'User Interface Design'.

## 2. MOBILE LANGUAGE LEARNING APPLICATIONS

Communicative approaches to language learning have been applied to a number of innovative mobile learning projects. In research conducted by Anderson et al [2] a mobile device connects with GPS allowing learners to annotate maps of the area with the multimedia that they create. Learners share their experiences with one another. 'GeoLearn' uses GPS to virtually tag information for real locations in a city. After initial lessons on vocabulary, learners are encouraged to travel around the city and make a conversation with local people to solve their problems [3]. PALLAS is a personalized language learning system which can be used as part of the contextualisation process in communicative learning. It introduces parameters such as defining the user profile and the location of learners [4]. Other researchers [5] have demonstrated the use of mobile Internet, Google Maps and geotagging for language acquisition, supplementing and encouraging informal learning environments through 'real life' communication. Lin [6] designed a collection of software through a Learning Management system to *'facilitate students engaging in face-to-face collaborative learning in class activities'* (p.202). Tai and Yang [7] describe a platform which allows users to edit learning materials collaboratively in a Wiki system. Here learners can study online with a handheld device. Perifanou [8] integrated micro-blogging technology with micro-gaming language activities for Italian language acquisition which, it is argued, enhanced motivation, participation, collaboration and practice among learners. Robison et al [9] describe the success of the recently completed AMICITIAS project, whereby users are encouraged to take their mobiles into six contrasting European locations, and provided with tools to enable ambient language learning. As this summary shows – there are many aspects to mobile learning, whether IT-enabled collaborative tools, location based services or multimedia aspects.

## 3. DETECTIVE ALAVI

This paper focuses specifically on the adventure format of an educational game which was developed. It is a role-playing game within which the player takes the position of a detective within a fantasy setting of the Central Processing Unit (CPU) of a personal computer. The

player is in charge of their character and is able to make the character walk in the game environment, and examine and act on things they encounter. The character is able to hold a conversation with other characters in the game. The game challenges are mostly composed of puzzles to be answered or concealed information to be discovered. Clues are provided by answering puzzles. Clues are in QR code format. When decoding the QR codes, one of the three forms of information could be revealed to the players by (1) providing them with a clue to solve a mystery, or (2) activating the web browser and referring them to a web site, or (3) activating a phone call or an SMS to a knowledgeable person. A mobile phone camera is accessed in the game play to capture and decode the QR codes by image processing techniques. Players can play in two competing teams. The game scores are communicated between the players' devices by Bluetooth. Place and context are the two most important aspects of the game. The game is built upon a series of connected physical contexts such as office rooms in the CPU complex. In each room a series of tasks needs to be accomplished.

### 3.1. The Game Flow

In reality, is not possible to see directly inside a CPU, which consists of millions of microscopic integrated circuits. In this game the CPU was designed as a large complex, with specialized staff and transistors as robot workers (see Figure 1 (a)). The robots have stopped working and a detective is called in to investigate the reason. Detective Alavi is very competent and he is invited to solve this mystery. If he does so he will be recruited into the police force with a job rank as high as 'Chief Constable'. His skill in interviewing different people in the CPU is very important and he has to pay close attention to his conversation with suspects. In the conversations he could discover clues to the puzzles distributed around the CPU complex. The source of these puzzles is a mystery; in one example a letter has been left explaining a transistor's malfunction. A complex cryptogram must be solved in order for the CPU complex to return to its normal functions. Each word in the cryptogram corresponds to each puzzle's solution. The more of the puzzle that is solved; the closer detective Alavi is to solving the cryptogram. A mysterious person has left a mobile phone, which is able to capture the clues of cryptogram, search the web, and send and receive an SMS or phone call. The mobile phone is incorporated into the design, because the use of QR codes could be easily integrated into the game and the flow of the game was preserved. The story provides appropriate metaphors for linguistic and technical learning and has a crucial role in the material to be learned. The story is relevant to the learner's knowledge at each level and slowly increases in complexity.

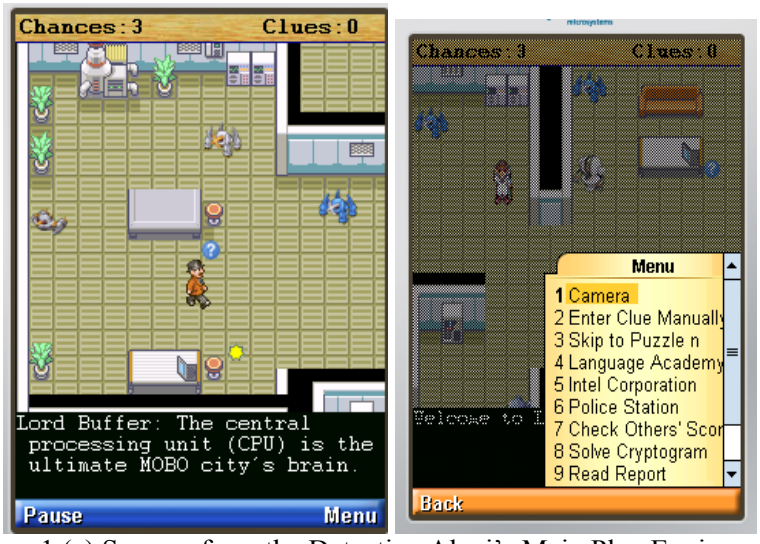


Figure 1 (a) Screens from the Detective Alavi's Main Play Environment and (b) Detective Game's Option menu.

### 3.2. Game Options

The option menu is situated at the bottom of the game canvas (see Figure 1 (b)). It contains items that can be triggered at different points in the game. The order of items is consistent with their priorities. Items are not too technical and are understandable by the player. The game environment suspends when the player chooses to use the 'Option' command. The 'Camera' option uses the phone's mobile camera to capture the clues from the QR puzzles. The player can enter the clues manually using the 'Enter Clue Manually' option if the camera fails to capture the clue. When the player is satisfied with the number of clues that they have discovered and want to solve the cryptogram, they can choose the 'Solve Cryptogram' option from the menu. A phone call will be activated to someone that has the secret code to winning the game. If the player guesses the cryptogram they will be presented with a winning screen and the game finishes. However if the player guesses incorrectly they will lose one point from their three Job Chances. By losing all three Job Chances, Detective Alavi will lose the game. Three items will help the player to move to the other sections of the game environment for further assistance. They are: 'Police Station', 'Language Academy' and 'Intel Corporation'. The 'Language Academy' and 'Intel Corporation' help players with an understanding of the game's vocabularies. In the Police Station, players are able to read the CPU complex's staff profile. These locations replace the more traditional 'Dictionary' option. Information in these three locations is in both Farsi and English. The player can use 'Read Report' when they have finished searching for all of the clues and wish to exit the level. By selecting the 'Read Reports' they activate a phone call to the 'Chief Constable' who then reads a report compiled during the playing of the game. The player is able to save the game and go to the Main Menu at any time during the game.

## 4. USER INTERFACE DESIGN FACTORS IN THE DETECTIVE GAME

This section discusses the design considerations in the Detective game. There are eight principles that have been extracted from well established user interface design guidelines that are widely used for desktop computers. Approaches are proposed with regard to how to utilize these strategies in mobile educational games. Principles summarised in 4.8 are set out in [10]; 4.1, and 4.3-4.8 are set out in [11]; nd 4.2, and 4.5-4.7 are set out in [12].

### 4.1 Consistency

An appropriate balance is maintained between the size of the game characters and the size of the background objects. Players see an overview of a scene in order to understand their position at all times. Game background, characters and text are chosen in proportion to the screen size of the phone. The foreground stands out from the background. The background is not too busy or too empty with unused blanked spaces. Dialogue, commands and the main game view are clearly distinguishable from each other and there is sufficient contrast. The game interface, graphics and characters are consistent with the physical environment within which the story is taking place, for example office rooms in a building complex. Different screens such as forms, lists and canvases have the same feel. They are all scrollable and they make it possible for the players using mobile devices with any screen size to view the screen's content. Consistent sequences of actions are required to speak with game characters and access the main menu, Bluetooth, QR, web, phone calls or SMS. Identical information is linked to the same interaction throughout the games, for example whenever the player selects 'play', he/she will be transferred to the main game canvas to play. The capitalization and fonts are kept consistent. This helps to avoid a player's confusion with regard to the meaning of different words and also makes the game easy to play and remember. The game environment depicts an office in the Detective game and these representations match the virtual world with the real world that the players experience in a real building, and follows 'real world' conventions.

## 4.2 Aesthetics and Simplicity

The interface was kept as simple as possible. The common tasks such as accessing the camera, capturing the QR tags and updating the scores in the Bluetooth menu simply require the user to select the option 'camera', 'capture' and 'update'. These words were kept natural and as short as possible. Dialogue between virtual characters did not contain irrelevant text, in order to increase the visibility of the relevant text.

## 4.3 Shortcuts

The QR codes decreased the number of operations needed to access, enter, search and activate certain actions. The use of Bluetooth for the automatic sending and receiving of the game data helped the players to concentrate on the game play while keeping an active connection with other devices. The option menu situated in the main game canvas allowed players to access the game camera, search the device's resources, check other team's scores, read a report to a distance teacher, save the game, and go back to the main menu. The player's score and cognitive progress were preserved when they moved between different screens.

## 4.4 A Response for Every Action

The player is always kept aware of their scores, language skill progress, cognitive progress and reporting skill progress. This helps the player and the teacher to remain informed and up to date about the academic progress of the player. In less powerful mobile environments, flashy graphics are avoided during the feedback to keep the size of the application manageable. However it is important that for every action there must be a response to the player to indicate that progress is being made. The game features a progress page when the game is loading and feedback is provided when the player selects to move to certain puzzles. A display assures the player that they have actually reset the game to a certain level and feedback is provided when an SMS is sent. A 'Message Send' text will be displayed on the screen, to confirm the SMS was sent. Depending on the screen type the feedback will be displayed on the same screen as the action taking place, or on a separate screen.


**Figure 2 (a) Capturing a Clue (b) The captured clue (c) Feedback on the clue.**

## 4.5 Logical Grouping of Tasks and Yielding Closure

Similar options were kept close together. In Figure 1 (b) 'Camera' and 'Enter Clue Manually' are adjacent to each other, and both are used to input the clues to the device - the first one automatically by a camera and second one by typing it manually into a text box. 'Language

Academy', 'Intel Corporation' and 'Police Station' are kept close to each other, because all of them help the player to access more information about the game. This helps the player to achieve their goals and find information more quickly. When each option is selected a series of actions takes place that contains a beginning, middle, and an end. For example, to capture a clue from QR tags and return, the series of actions are 'Camera', 'Capture', 'Check Clue' and 'Camera'. The first 'Camera' option begins the capturing process and the second one ends it and returns the player to where they started (see Figure 2 (a) and 2(b)).

### 4.6 Error Prevention and Simple Error Handling

A main source of errors and indeed tedium for mobile players is in inputting text data. The use of QR codes reduced this problem considerably. However if at certain instances it was necessary to enter data, precautions were taken such as lists being used as much as possible to enter the data. If a telephone number needed to be filled in a text box, only numbers were made available, thus avoiding the need to scroll through alphabetic characters. Mobile devices often encounter unexpected errors in the processing of applications. The devices are especially prone to errors when trying to extract contexual data from the environment. When the mobile phone was seeking to capture the QR tags it could produce a decoding error. These errors were predicted during the development process and it was explained to the player via the game environment that 'Decoding failed! Please try again' and an alternative way to enter the data was provided. In this situation, the QR content could be entered manually to the game so that the player did not feel loss of control.

### 4.7 Tolerance and Reversal of Actions

In the main game environment the player was able to jump to any puzzle by selecting 'Skip to puzzle n'. This option activated all the necessary resources to run that specific puzzle. Players had the option to capture the QR puzzle as much as they desired. Mobile devices are prone to unexpected events, such as the camera not capturing a good enough image, or the QR decoder could fail, or a telephone number could be busy, or an SMS could fail to send, or the network connectivity to the internet might fail. Restricting players too much could cause disappointment and loss of interest. If players accidentally exited the game without saving the current state, or the device encountered a crash, the teachers could enter the player's scores in 'Teacher Setting' so the player did not need to repeat all the earlier games. This option was password protected so that it could only be accessed by the teachers. These features overcame the anxiety of the players significantly.

### 4.8 Internal Locus of Control

The navigation is designed to be simple and understandable. The player always starts from the main game canvas and after executing some actions, such as solving a puzzle, they return to the main game canvas. User testing has demonstrated that the player knows at any time during the game where they are and where they can go. Different stages were implemented to help the player change focus from the game whenever they felt it was necessary. During the game if the 'Application key' on the mobile phones's surface is pressed, the application is paused automatically and switches to the background. If there is a phone call, text message or battery warning, then the game pauses automatically. Additionally, the pause command in the game interface provides the player with a control over the game environment in the case of external social interruptions. The characters stop moving, the music stops and the game no longer accepts keypad input. The 'Pause' command is changed by the 'Resume' command. Players could return to the game play by pressing the 'Play' command.

On the other hand, if it was necessary for the player to leave the game for a significant period, they could quit the game. The save capability is available, so the next time the player returns to

the game they haven't lost their data and they are able to resume from where they left off. The number of clues discovered and cognitive progress are stored in the non-volatile memory of the device. Although these features are standard to many modern computer games, achieving these within the limited capacity of the devices can be difficult. However these features are very important to ensuring continuity of user experience and to ensure learning isn't adversely affected by technical frustrations.

## 5 MOBILE EDUCATIONAL GAMES AND DIVERSITY

One of the important elements in the design of a user interface is to recognise the type of user who will be using the system. Are they novices or experts? Do they have any cognitive impairment? Do they have any disabilities? Do they have any special preferences? In desktop designs it is possible to design two sets of menus on each screen, one with extensive help and the other suggesting shortcuts. Due to the small size of mobile devices screen this approach will result in an overcrowded and confusing screen layout. One possible solution is to divide the game into different sections. In Detective Alavi the players start with an introduction that explains the game story for the novice. The game itself is divided into 5 levels starting from easy to difficult in a hierarchical manner. This structure allows the expert user to skip the easier levels quickly and concentrate on harder levels. The slow learner often benefits from deconstructing the overall tasks into smaller tasks. They can then concentrate on one task at a time. It is also possible to decrease the intensity of the challenges within each level. In a previously published mobile game i.e. MOBO city [13] it was possible to increase the initial values of the life points and decrease the number of viruses in each level to allow more time for players to consider what their next move could be. It is possible to remove the penalty when players visit the incorrect station in MOBO city in order to increase the self-confidence of slow learners. The level of feedback and detail at each location can be increased or decreased. In MOBO city, the sequence of the operation can be removed to allow players to concentrate solely on text and iconic figures.

The automatic input of data by using QR tags significantly reduces the cognitive burden of the games. Automatic assessment can help the learner to build self-awareness. The assessment of the rate of progress could be changed for each individual learner in educational games. For example, if a slow learner scores 12 clues and a fast learner scores 23, they both receive the same amount of praise from the system. Providing one to one assistance via mobile phone calls and SMS could also help learners with social difficulties.

Additionally, the Detective game can work in muted mode. Although the audio enhances the game experience, the game play does not depend on sound. Learners with auditory difficulties could significantly benefit from these games. All the communications via the mobile phone calls could be replaced by SMS. The classroom interactions with teacher and other teams could take place in a chat environment. This feature could easily be incorporated into the game play. A Bluetooth chat environment could be connected to the game interface and the learners could check any feedback from the menu option ('other team's score') in the main game canvas.

Specifically considering female players, mobile games developed in this research could introduce a friendly environment which is not time-limited nor needs previous game playing skills. This helps females to build their game play competency and confidence. In contrast to most video games where women are under represented, these games have an equal number of male and female characters. Characters do not behave in stereotyped or hyper-feminine ways with an emphasis on dependence or submissiveness. One prominent feature in Detective Alavi is social interaction between the players, and players with characters. User testing has shown this is viewed very favourably by female students.

## 6. CONCLUSIONS

This research has presented a design methodology to support the definition and implementation of a mobile educational game. The motivational factors depend on the game genre, and a good realistic story with novel characters and interesting graphics. The user interface was consistent with the use of simple language, designing appropriate responses to the actions, grouping similar tasks, and appropriate and supportive error handling and recovery. The diversity factors were also important for teachers with learners having differing abilities and capabilities. By removing time constraints, incorporating simple language, removing irrelevant information, and increasing guidance and assistance, teachers were able to involve all their students in the game-based learning process. Electronic, pedagogic, and social connectivity are the keys to success.

## REFERENCES


[1] Fotouhi-Ghazvini, F., Excell, P.S., Moeini, A. and Robison, D.J. (2008) "A Psycho-Pedagogical Approach to M-learning in a Developing World Context." *International Journal of Mobile Learning and Organisation (IJMLO)*, Vol. 2, No.1, pp 62-80.

[2] Anderson, T. A. F., Hwang, W.Y., and Hsieh, C.H. (2008) "A study of a mobile collaborative learning system for Chinese language learning." *Workshop Proceedings: Supplementary Proceedings of the 16th International Conference on Computers in Education (ICCE),* 2008, pp. 217-222.

[3] Chang-Chih T., Chun-Hung L., and Wen-Lian H. (2007) "A Mobile Environment for Chinese Language Learning" In: M.J. Smith, G. Salvendy (Eds.): Human Interface, Part II, *HCII 2007*, LNCS 4558,. Berlin Heidelberg: Springer-Verlag, pp. 485–489.

[4] Petersen S. A. and Markiewicz J. K. (2008) "PALLAS: Personalised Language Learning on Mobile Devices." *Fifth IEEE International Conference on Wireless, Mobile, and Ubiquitous Technology in Education, WMUTE*, pp. 52-59.

[5] Meyer B. and Bo-Kristensen M. (2009) Designing location aware games for mobile language learning, *International Conference on Multimedia Information and communication Technologies,* April 2009, Portugal, pp.1086-1090

[6] Lin, C. P. (2008) "A System Perspective to Establish a Mobile Collaborative Learning Environment (MCLE) - A Preliminary Study of Empirical Practice." *Fifth IEEE International Conference on Wireless, Mobile, and Ubiquitous Technology in Education (WMUTE 2008),* pp. 202-204

[7] Tai, Y. and Yang, M. (2008) "Integrated Platform for Collaborative Learning in the Mobile Environment." *In Proceedings of the 2008 international Conference on Multimedia and Ubiquitous Engineering* (April 24 - 26, 2008). MUE. IEEE Computer Society, Washington DC, 258-262.

[8] Perifanou M.A. (2009) "Language micro-gaming: fun and informal microblogging activities for language learning." In M.D.Lytras et al. (Eds.), *WSKS 2009*, CCIS 49, Springer-Verlag Berlin Heidelberg, pp.1-14.

[9] Robison, D., Earnshaw, R.A. and McClory, P (2009) "Interactive and Augmented Information Spaces to Support Learning and Dynamic Decision-Making" *Proceedings of International Conference on CyberWorlds,* IEEE Computer Society, pp 305 – 311.

[10] Nielsen, J. (1994) "Heuristic evaluation." In Nielsen, J., and Mack, R.L. (Eds.), *Usability Inspection Methods*, John Wiley and Sons, New York, NY.

[11] Shneiderman, B. (2004) (4th ed.) *Designing the User Interface: Strategies for Effective Human-Computer Interaction*, Addison-Wesley Publishers: Reading, MA.

[12] Stone, D., Jarrett, C., Woodroffe, M. and Minocha, S. (2005) *User Interface Evaluation and Design.* San Francisco, CA, Morgan Kaufmann.

[13] Fotouhi-Ghazvini, F., Earnshaw, R., Robison, D. and Excell, P. (2009) "The MOBO City: A Mobile Game Package for Technical Language Learning" *International Journal of Interactive Mobile Technologies (iJIM)*, Vol.3, No. 2, pp. 19-24.