Using a Conversational Framework in Mobile Game Based Learning - Assessment and Evaluation

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Abstract. Mobile language learning games usually only focus on spelling or out of context meaning for the entire dictionary, ignoring the role of an authentic environment. ‘Detective Alavi’ is an educational mobile game that provides a shared space for students to work collaboratively towards language learning in a narrative rich environment. This game motivates and preserves a conversation between learners and their teachers, and also between learners and learners, whilst being immersed in the story of the game. A seamless self-assessment scoring system in the game structure provides a less dominating environment for students to expose their weaknesses, and at the same time assists students to judge what skills they have learned and how much. This game has produced improvement in different cognitive processes and a deeper level of learning during the collaborative game play.

Keywords: Mobile Learning, Mobile Games, Game Based Learning, Conversational Framework, Educational Assessment, Self-Assessment.

1 Introduction

In this article we propose a new approach to develop a conversational framework for educational games. Mobile learning provides teachers, experts and students with a unique opportunity to have a degree of presence in a number of different physical locations. Whenever the learner raises questions which cannot immediately be answered by the virtual world, then teachers and experts provide supplementary information to assist the learners, and allow teachers and learners to attain a shared understanding. Lautlillard [1 and 2] has proposed a psycho-pedagogical framework for education that clearly defines the role and responsibilities of the teacher, the learners and the peers. In the first version of her model she uses Pask [3] conversation theory to represent her model. Pask believed that learning is basically a conversation between different knowledge systems (i.e. students, teacher and computers), where the system converses with itself and reflects on its actions and converses with other systems to share a description of the world. Pask believed learning is not to “transmit knowledge”, rather, they provoke participants into becoming informed of each other’s “informings” [3]. Pask made a distinction

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between knowledge of "knowing why" (cognitive, conceptual knowledge) and "knowing how" (procedural, performance knowledge) [3]. Laulliard [2] constructed her first version of a conversational framework based on learning as a conversation. The framework had two levels of action and description. In action learners converse with each other while they are experimenting or doing practical work. In the description level, they discuss what happened in the action level, they ask questions such as "why did that happen?", "what does this mean?", and they offer re-explanation of theories and by means of justification and rationalization. Then she proposes a second version of the conversational framework [1] where she combines her representation of learning as conversation with other important pedagogical theories. She extracts all the important features of instructionism, social learning, constructionism, and collaborative learning, where each is emphasizing a particular aspect of learning. She classified learning into two levels of (1) the discursive, articulating and discussing theory, ideas, concepts, and forms of representation; and (2) the experiential, acting on the world, experimenting and practicing on goal-oriented tasks [1]. The teacher is added to the framework as an important element in formal learning. Teachers and learners converse with each other with repeated iterative interaction on both levels [1]. The two levels connect with each other when the learners reflect on feedback received from teachers and other peers at a conceptual level or a practical level; teachers also reflect on the learner’s actions and adapt the practice environment accordingly.

2 A Conversation Framework for the Detective Alavi Mobile Game

The Detective game is a vocabulary learning program using a technical context to help the Iranian students to use focused, goal oriented and effective learning approach to learn vocabularies related to computer’s ‘Central processing Unit’. The game can access a rich instruction set and provides continuous cognitive assessment, where a reasonable amount of time is spent on each word such as its meaning, spelling and form. Moreover it uses Laulliard [1] conversational framework in a natural, simple manner while players converse with real experts and virtual characters throughout the game. A series of puzzles are used to deliberately assess different aspects of vocabulary, while taking advantage of the communicative nature of implicit learning. The game strategies make the best possible use of implicit and explicit processes to achieve specific learning goals while learners consciously apply metacognitive strategies in acquiring new vocabularies. Figure 1 displays the main character of the game, ‘Detective Alavi’, while searching for clues to help players to solve a cryptogram. A clear sequence of dialogues was planned amongst virtual game characters according to the progress of cognitive processes to help students in their analytic journey. Progressing from one cognitive development to the next and increasing the complexity of the levels benefits the individual in their intellectual growth and matures and deepens their thought process [4]. The dialogues were accessible only in hierarchal order. This ‘linearization’ was set as a starting goal for solving each puzzle and for students to stay in the right track while having a free form of conversation. At the start solving puzzles could be extracted and inferred directly
from the dialogues but gradually limited information could be found in the dialogues. Students need to analyse, compare and make choice from studying and discussing different resources and collaborate with each other and the teacher.

Puzzles and mini games were designed using QR tags printed on pieces of paper. These visual tags contain information that could be accessed via a mobile phone camera using the ‘Camera’ option the game’s option menu (see Figure 1). QR codes are two dimensional bar codes that are read on camera phones using QR reader software. Once they are accessed, they allow players to complete an action. QR codes launch and redirect a phone’s browser to an embedded URL, or initiate a phone call, or send an SMS or simply present some text. This technique helps the learners to collect data from puzzles and transfer them to their own game virtual space for further analysis. These tags can also activate access to mobile space and cyberspace, and act as a dynamic hub for accessing further help and learning resources.

Fig. 1. (a) Print screens from the Detective Alavi’s Main Play Environment (b) Detective Game’s Option menu

There are different clues distributed in QR puzzles to solve a cryptogram. At different stages during the game play, the player is asked to find the necessary clue. The player captures the clues by the camera and then the player uses ‘check clues’ option to check if he/she has captured the right clue (see Figure 2).

The puzzles were flexible, and the teacher could easily change the puzzles and produce new QR tags. There was both flexibility in content and connections, and challenges were provided by both virtual and real space information. Teachers had a game framework that they could easily customise without needing technical knowledge. It met the teacher’s needs by motivating and assessing students continuously. Teacher could use the skills that were familiar to her like managing discussions and guiding students to customise the game framework for the classroom.
Distance experts were encouraged to take part in students' discussion whenever called. This was carried out by pointing out the problem, providing interesting examples and posing provoking questions within the story's theme. They encouraged students to learn from each other and did not give the answers directly. At the same time they kept the conversations short and to the point because the game was still part of the classroom space.

3 Game's Assessment

Similar to any educational programs educational games' incorporation in education requires assessment and evaluation. Thirteen students from the third year of
Computing Engineering in an Iranian university were selected. At first the electronic concepts of the computer’s central processing unit was taught in English via a comprehension in normal classroom. Then a test was taken to investigate students’ knowledge of technical vocabulary, considering ‘vocabulary meaning’, ‘spelling’, ‘word form’ and ‘electronic knowledge’ in English. These skills were examined at different cognitive levels; the questions were designed according to the Bloom’s taxonomy of learning objectives. After this, the participants took part in playing the ‘Detective Alavi’s game that were intended for improving the students’ technical vocabulary within the boundary of the previously taught comprehension. The game sessions lasted 2 hours for six weeks during November to December 2010. The game was played privately in a classroom. The teacher integrated the game as part of a lesson, letting students play one level of the game at each session for them to become familiar with the CPU structure, its functions and key technical vocabularies. Puzzles were printed by the teacher and supplied to the students. Students were typically free to move around, as long as they did not exceed a 10 metre distance between their devices (to ensure Bluetooth wireless communication stays connected). The game was also extended to the different rooms of the university building with computer rooms. Puzzles were distributed throughout the building in different locations in each room. During the execution, rooms were chosen to show as close a resemblance to a room in the CPU complex’s virtual space as possible, with a label such as ‘Level 2-Room 2’. Puzzles were hidden in different locations in each room. Players could find them using guidance from the virtual space’s characters. People from the real world such as university staff and other students could also become part of the game, making conversation with the players or providing extra assistance. Players needed to note that in this mode the Bluetooth connection of the game will be lost when they became more than 10 metres apart. When the game sessions’ period ended, a post-test was taken by the students. It was then analysed to see whether there had been any differences between the pre-test scores and the post-test scores. The paired t-test was used to compare and analyse each student’s pre and post-test. Some students developed more and others improved less. But on average there was a substantial improvement.

Detective Game has improved different skills. The ‘Electronic Skill’ by 53.25%, the ‘Word Meaning Skill’ by 34.8%, the ‘Word Form skill’ by 24.69% and the ‘Spelling Skill’ by 19.23%. The two-tailed P value for all skills was 0.000 which was less than 0.05. This difference was considered to be statistically significant.

The detective Game has improved the students’ reporting skills gradually during level 1 to 5. It has increased the ‘Reporting skill’ at level 1 by 1.53%, at level 2 by 10.76%, at level 3 by 32.30%, at level 4 by 41.53% and at level 5 by 61.53%. The two-tailed P value in level 1 and 2 were 0.337 and 0.068 which were more than 0.05. At these two level students still lacked the necessary reporting skills. At level 3, 4 and 5 the two-tailed P value was .000 which was less than 0.05 which means a statistically significant improvement on reporting skill.

This game has improved all cognitive processes. It has increased the ‘Remembering’ cognitive process by 43.58%, the ‘Understanding’ cognitive process by 21.97%, the ‘Applying’ cognitive process by 30.76%, the ‘Analysis’ cognitive process by 20.51% and the ‘Evaluation’ cognitive process by 56.15%. This improvement was especially evident when the students utilized the game for the
critical thinking in level 5. The improvement was lower in level 2, 3 and 4 that they more focused on spelling or word forms. This game was more suitable to improve student's electronic skills and word meaning skills by encouraging them to think deeply and collaborate with their peers and teachers. However the two-tailed P value at all levels was .000 and less than 0.05 which means a statistically significant improvement has took place at all levels.

All students (denoted by Sts) experienced an increase in their test results. The rise in the test scores amongst different groups was Group 1 (St 1, 2, 3 and 4) by 32.19%, Group 2 (St 5, 6 and 7) by 37.28%, Group 3 (St 8, 9 and 10) by 22.87% and Group 4 (St 11, 12 and 13) by 32.19%. The more advanced students helped students with lower language skills to improve. If the team scored higher in the game as a group, they achieved higher test results compared to the groups with a lower gaming score.

The Pearson correlation test was performed regarding the students' game score with their post test results. The correlation coefficient was 0.731 which was positive and it indicated that there is a direct relationship between the total game score and the test result. The relationship was strong because it was more than 70% of its possible value (i.e. the coefficient maximum value is 1 or -1). The game scoring that was achieved in the game play appears to be an important predictor of the students' individual test results. Our sample accurately reflects the relationship between the game scoring and the students' results from which the sample was drawn (labelled as Sig. (2-tailed)). The probability value was 0.004 which was well below the conventional threshold of \( p < .05 \). Thus, our hypothesis was supported.

4 Students' Learning Processes during the Classroom Observations

Students have been normally passive and quiet in English classes and rarely engaged in discussions. When the game sessions first started students felt reluctant to work collaboratively but gradually they succeeded in integrating the appropriate skills with the aid of game narrative, graphics, QR puzzles, distance experts and their teacher.

4.1 Remembering Level

Their communication at level 1 was in monologue form where each member spoke their ideas by remembering important vocabularies, recognising and listing embedded facts. They retrieved and searched for further information in the game's virtual space with the help of the on-site teacher. Signs of 'surface level processing' were present in some learners where they only focused on guessing the right answer or asking the teacher for the answer. However the teacher encouraged them to further research the game environment to make them think further by exploring the full capacity of the game. The following dialogues are extracted from students' conversations in level 1:

St1: Ms what does 'manipulate' mean in Farsi? (Asking the on-site teacher)

Teacher: You have already seen this word!
St2: I remember the word 'manipulate' from puzzle one. I am sure A is the wrong answer.

St3: Just by looking at the answers it tells you which one is correct! I go for option C (surface level processing)

Si3: Oh it is wrong!

Teacher: Why do you think option C was wrong?

St1: Ms what is 'binary system'? I can't find it in the 'Language Academy'! (asking the on-site teacher).

Teacher: Try 'Intel Corporation'!

St1: No I can't find it there.

Teacher: Let's see we can find it by trying this link; you have to go to the camera and take a shot of this QR code.

St3: Oh camera failed!

Teacher: Let me try, don't shake your hands, it needs good exposure to light..., now it is opening the website.

St2: I have never worked with mobile web...

Teacher: It is not much different; this is how it works.....

St1: Here it says: 'Binary system is ......'.

St2: Oh I know it is our 'dodoi' (in farsi) 0 and 1 system!

4.2 Understanding Level

In level 2 the on-site teacher has stepped in and acted as a member of the group, and she encouraged students to talk to each other by asking questions. Students practiced the meaning and spelling of the vocabularies. However when they were asked to choose the correct order of operation in the CPU Complex in puzzle 9, most conversations were evoked. They became involved in explaining, interpreting, summarising, paraphrasing and classifying the facts. The following dialogues are extracted from students’ conversations in level 2:

St1: I can't fully understand 'when it finds a mopo ready to process, the unit executes it'.

Teacher: Can you help us with this sentence St2?
St2: In other words the ‘dispatch/execute unit’ temporarily stores the results of executions.

St3: Execution of microoperations....

Teacher: So you are saying that....

4.3 Applying Level

In level 3, communication gradually turned into dialogue and students managed to maintain a group conversation. A Bingo like game was incorporated which required deducing the correct vocabularies’ synonyms. They also had to choose an option which associated the appropriate processors components to their correspondence operations. At this stage they used the game resources automatically. They shared concepts and opinions by exchanging ideas, asking questions, giving the correct direction, encouraging or supporting each other, elaborating other member’s explanations, relating to the previously learned materials and using the tables and diagrams. The following dialogues are extracted from students’ conversations in level 3:

St2: How we have to approach this puzzle?

St1: Let’s see what the Dr Athlon has to tell us....

St3: We work through this logically; he provided us with this diagram....The decoder converts instruction to macrobytes.

St2: And Mr ‘Register’ explained how the ROB manages the execution and management of macrobytes.

St3: Well done!

St2: But what about FPU 3D?

St3: I don’t know! But let’s keep working!

St1: I think it has something to so with multimedia.

St3: Sounds right!

St1: I suggest we hold off making a decision until we have examined all our options. If we look at this link we visited last week we will get a better idea.

St2 – Let’s see what we have missed?

4.4 Analysing Level

In level 4, Students practiced the word forms through a QR board game. Then they utilized tables from different processors’ specifications to discover processors’
capabilities. Their dialogue turned into comparing, organising and deconstructing information from different resources to help them analyse different problems. The following dialogues are extracted from students’ conversations in level 4:

St1: Ms is it possible to tell us a brief history of the microprocessor? (Asking the on-site teacher)

Teacher: You can ask the Intel CPU’s expert by making a phone call!

St1: Let’s call the ‘Intel’ expert to give us a brief history of the microprocessors.

St3: What is the actual question here?

St2: We want to know about clock speed and MIPS.

St2: Could you please tell us more about the clock speed and MIPS… (talking)

‘Intel’ expert: Dr Intel suggests if you look at the table, you can compare 8088, 80386 and 80486 MIPS values…

St1: Let’s see what are our facts?

St3: 80286’s value is 1.

St2: Why did you make this choice?

St3: 3 and 4 are too big!

4.5 Evaluating Level

Finally in level 5, students made decisions based on in-depth reflection, criticism and assessment about word forms and complex CPU operations. The communication became dialectic where they started to manage cognitive conflicts by criticising and evaluating each other’s ideas, integrating different opinions and participating in debates and enquiries. Students expressed their views, listened to others, asked relevant questions purposefully and judged group’s understanding. The following dialogues are extracted from the students’ conversations in level 5:

St3: Let’s get moving! Detective Alavi really needs this clue! Do you know how Quad compares with dual?

St2: Let’s call the expert to clarify the advantages and disadvantages of Quad and dual core.

St1: Ringing CPU expert…..talking…..Is it possible for you explain to us how the quad core of say 2.5ghz perform better than a dual core of 2.8ghz?

Expert: ‘Professor Speedfast’ has told me that you will notice quite an improved performance on a quad, especially if the software is adapted to using it.
St3: But the dual core has the higher clock speed!

Expert: In Dr Athlon’s opinion, Quad core uses resources more efficiently switching between threads and processes.

St2: Does she think we will ever see more than 2.8 GHz?

Expert: No, she says it is about cooling, not overheating the cores.

St3: Future is multicore, isn’t it true?

St2: But now it is debatable!

St2: Still I suggest to Professor ‘Multicore’ if he wants to modernise the CPU complex, it is better to buy Quad core, things change quickly.

Expert: I will pass on your message!

St1: I understand 4 cores, is doing 4 things at the same time. I core does one thing at a time. If we have a program written for 1 core surely this must execute faster in quad core?

Expert: Professor Multicore thinks it causes massive problem, each core wants to execute part of the problem, they all get kind of confused! ...(laughing not giving the answer) this is as far as I can help you guys! Mr Inspection is calling me! Bye for now!

St1: We can try the first link: it is about the ‘Intel Core 2’.

St1: The website has all the technical stuff about the dual code, but not giving anything on two CPU’s comparison.

St2: Here it says....

St1: It is kind of confusing! We can’t compare them just on one or two factors.

A deep level of understanding was present in levels 3, 4 and 5 when students worked on the puzzle with more provocative questions that examined the students’ applying, analysing and evaluating power. In these challenges students made plans to solve problems, used diagrams, suggested ideas, connected ideas logically, used their past experiences and changed or refined their opinion in the process. QR word search and board games seemed to create a more cheerful and relaxed environment. Conversations drifted to more general dialogues which represented the social development processes rather than cognitive ones. It benefited the students’ bonding rather than deep processing. During the game sessions the learners appeared to be constantly moving in and out of reality and blurring the distinction between real and
virtual. The game virtual space and the experts at a distance maintained the fantasy aspect of the game, while the websites and their previous educational or life experiences brought them back to reality. This periodic experience of realism and fantasy helped the game play to maintain the necessary control and the flow of learning in an authentic, meaningful and contextual environment.

5 Self-assessment

In the game environments players might develop wrong intuitions by haphazardly diving in the game. They do not know when their hypothesis is correct and when it should be discarded. The presence of some kind of assessment appears to be necessary. However direct surveillance of students’ work could inhibit their intrinsic motivation and reduce their sense of control. Adding a self-assessment system in game scoring could assist students to evaluate their own actions in a non-controlling environment. On the other hand, teachers need to use a continuous assessment to supply them with consistent, accurate and useful information on students’ knowledge. In normal classroom assessments, the results are collected too late and they are only used for student’s grading. During the teaching sessions teachers have no idea if students have actually learned. The end of term results, often are disappointing to teachers and there is a large gap between what is taught with what is learned. Thus the teachers and they have little or no influence on the learning process and cannot remedy the student’s gap in knowledge because they have no real-time information about this.

Self-assessment in the game was in the form of scores, skills gained and cognitive progress. Figure below shows how players could check their progress during the game. They can choose ‘Skill-Score-Cognition’ option from the game’s main menu.

Fig. 3. (a) Skills’ progress screen (b) cognitive progress screen (c) reporting progress

There are different kinds of clues that were included in each game level. Clues were categorized according to the type of skill gained during solving puzzles; ‘meaning’, ‘spelling’, ‘form’, ‘electronic’.
Each game level targets a separate cognitive level of Bloom’s learning objective taxonomy of remembering, understanding, applying, analysing and evaluating cognitive progress [4]. The total number of clues in each level provides the specific level’s degree of strength, the table below shows the process of score allocation and corresponding feedback.

Writing restructures knowledge [5], improves thinking by making ideas explicit and contributes to critical thinking [6]. At the end of each game level the ‘Read Report’ item could be selected from the game menu which represents bloom’s sixth level of cognitive progress i.e. ‘Creating’. This option involves students’ writing a report of all their game experiences according to the game’s learning objectives and a description of each clue. A list of ‘Learning objectives is presented from the main menu’s ‘Learning Objectives’ item. The actual account of each learning object is narrated by dialogues that are carried out amongst the virtual characters and between teachers and students. When the players select the ‘Read Report’ a phone call is activated to a teacher at distance and a secret code will be provided according to the players’ broadness in understanding of the topic. These codes represents any of six feedbacks : ‘very low’, ‘low’, ‘moderate’, ‘good’, ‘very good’ and ‘excellent’. Each feedback assigns its specific gain in ‘Reporting Skill’.

6 Game’s Self-assessment User Experiences

In Detective game, the teacher believed to be empowered in examining at any stage during the game: (a) how students were responding to the learning environment? (b) how students were doing at initial or intermediate stages? (c) what were the students’ current abilities or gaps in knowledge? (d) how to help students with early appropriate feedbacks? (e) how to improve next level of game and provide more information on skills that were yet unsatisfactory (f) to build an on-going communication loop to students providing them with appropriate feedback (g) to save time on collecting the responses and analysing them. Self-assessment had also assisted students to discover their weaknesses and strengths continuously during the learning session anonymously in a stress free environment. They were encouraged to take the responsibility to work on correcting themselves and adjusting themselves to the syllabus standards. The on-site teacher has observed the following statements usually when students checked their progress:

I think our ‘spelling’ is good!

We seem to be confused about the meaning of technical words.

I think it is necessary to improve our electronic knowledge. It is useful to visit this web site.

We need to learn more about the word ‘form’. We have to play that board game again.

I am going to spend more time studying word meanings.

Look! Our analysis power has increased!
The self-assessment increased the metacognition behaviours amongst the learners. Students monitored and evaluated their progress towards certain educational goals regularly. They also planned specific steps and strategies to improve their weaknesses, correcting their cognitive process and enhancing their performance. The use of metacognition strategies by the students has been mentioned by many researchers as an important variable during thinking processes [8 and 9]. Halpern [10] has mentioned the metacognition process as a crucial element during the critical thinking.

7 Detective Alavi's Cost Efficiency versus Conventional Method

For a class of 30 students the cost of Detective game is 251552 Rials (15.2 GBP). If the students use university’s WiFi the price decreases to 123552 Rials (7.46 GBP) for a group of 30 students. These costs compared to the cost of lecturers that often travel from Tehran (capital city) to smaller cities is very small. Lecturers have to travel by plane which a return ticket costs 72.53 GBP, and they normally charge the university 40% more than normal lecturers. Detective Alavi when using GPRS is 80% more cost effective than normal lectures and when using WiFi is 90% more efficient.

8 Discussions and Conclusion

In constructive learning, the learner constructs knowledge by discovery and enquiry [11], [12] and [13]. Direct instruction is not acceptable; however students need some instruction at the beginning. They have to slowly build up knowledge and be able to experiment with their ideas in real world. On the other hand, if the learner has difficulties with a problem, it is more effective to provide some direct instruction rather than allow the learner to waste valuable time by trial and error. This mode of learning often results in covering only a small amount of content, which makes it difficult to address the extensive curriculum of formal education.

The Conversational framework combines different modes of learning into one overall learning approach. Considering the unique nature of mobile learning we have designed the game’s architecture using the conversational framework. To begin with students were unable to fully implement the constructivist philosophy of the conversational learning. Students focused on the content of virtual character’s dialogues and approached puzzles as a memory task. They depended on teacher’s authority and required explicit approval to move to the next task. However as the game sessions continued, students started sharing the authority with the teacher and mediating their own learning. This new authority transformed to a shared responsibility, fully exploring the potentials of the game, paying attention to the material and having active role on their learning. A continuous interaction between students, teachers, context and the learning material was shaped. This interaction was in conversation format and in its most productive nature led to a shared point of view over the curriculum objectives that were embedded in the game story.

On the other hand constructivists pay less attention to standard evaluations and their belief is students themselves must judge if they have learned [11] and [13].
Only careful analysis of the student’s work will determine how much they have actually learned and what the next step in their education should be. In our game the essence of meta-cognition (i.e. self-monitoring and evaluation) was planned, which has been realized. The game fully implemented the hierarchy of learning objectives in the game structure. The cognitive process hierarchy was implemented fully and sequentially using five game levels. This structure motivated students to master the basic level first and take part in assessment and evaluation. The game challenges stimulated the recall of prior knowledge by new challenges referring back to things learned in previous levels. This enhanced retention and transfer of knowledge, challenges were graduated initially could be handled individually to the final performance level needing collaborative work.

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