Designing E-Learning Games for Rural Children in India: A Format for Balancing Learning with Fun

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ABSTRACT
Poor literacy remains a barrier to economic empowerment in the developing world. Of particular importance is fluency in a widely spoken "world language" such as English, which is typically a second language for these low-income learners. We make the case that mobile games on cellphones is an appropriate solution in the typical ecologies of developing regions. The challenge is to design e-learning games that are both educational and pleasurable for our target learners, who have limited familiarity with high technology. We propose the receptive-practice-activation cycle that could be used as the conceptual model for the designs. We then report how this format could be refined, based on our experiences in the field with three games that have collectively undergone nine rounds of iterations. In particular, it appears that maintaining a distinction between learning and fun to some extent is necessary for effective designs.

Categories and Subject Descriptors
H.5.m [**Information Interfaces & Presentation**]: Miscellaneous

K.3.1 [**Computers and Education**]: Computer Uses in Education – *Computer-assisted instruction*

General Terms
Human Factors.

Keywords
Cellphone, Developing world, Digital divide, Games, E-Learning, English as a Second Language, Language learning, Mobile games, Mobile learning, Serious games, Third world.

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1. INTRODUCTION
Low literacy remains a barrier to economic empowerment in the developing world. English is widely seen as a key to economic success [18]. English is taught in almost all schools in India: as a second language in public schools, and as a first language and the medium of instruction in most private schools. Fluency in English can almost be equated with membership in the middle and upper classes [9]. A recent article states that mastery of English is the "single most influential factor [in India] that determines access to elite educational institutions, and hence to important avenues of economic and social advancement" [17].

More broadly speaking, the literature [8], our conversations with international development professionals in Africa, Asia and Latin America, and further experiences in the field indicate that a large proportion of low-income populations in these places desire to improve their command of an appropriate "world language." English is certainly one of these, as is Mandarin and Spanish. But even in countries where such a language is an official "national language," many speakers (inevitably the least empowered) have a different native language, and many *regional* languages (let alone dialects) are often spoken. In India, Hindi and English are official "national languages," but Hindi is native to only 20% of the population; there are 18 major regional languages. Fluency in a "world language" opens the door to further education, a larger regional (or world) marketplace, to "new economy" jobs, and often improves access to government, health and legal services.

Unfortunately, public schools in developing regions face several difficulties, especially with ESL (English as a Second Language). From nation-wide surveys in India [1] and our fieldwork in the poorest state of the country, two significant factors stand out. The first is non-regular attendance in schools owing to the need for students to work for the family. The second is the qualification of ESL teachers in poor schools, who usually cannot communicate with us in English without the help of interpreters.

We believe that ESL learning games on cellphones can potentially address the above challenges, especially when the cellphone is the fastest growing technology platform in the developing world that is reaching even the poor population. We believe that learners can improve their ESL skills by using mobile devices in out-of-school settings, at places and times that are more convenient than school hours. We also believe game-like design can improve enjoyment

of the learning experience and foster spontaneous adoption. The use of videogames for education in developing regions is not far-fetched. At least two non-government organizations, Pratham and the Azim Premji Foundation, have used computer games in their initiatives for children in the urban slums and rural areas of India respectively. Most important, a large-scale evaluation by Pratham[1] showed significant gains on mathematics test scores from playing computer games that target math learning [4]. It is plausible that similar learning outcomes can be replicated using mobile games that target ESL. We also believe many of our lessons will transfer to other languages.

A longstanding issue is the tension between learning and fun, and the challenge that designers face in balancing both of these (often conflicting) concerns when designing e-learning games. From our experience, designing such games that target low-income learners in the developing world is considerably more challenging due to their lower levels of familiarity with technology and videogames. The American psychologist Jerome Bruner proposes the notion of the format [7], which is the structure of an activity that is familiar to the learner. Of particular importance is the security provided by the familiarity of the format that facilitates the acquisition of new knowledge and language.

In this paper, we present the receptive-practice-activation format which constitutes the conceptual model behind our game designs. We then report on how this format could be refined so as to balance the learning and motivational needs of our target learners, based on our experiences in the field with three games that have collectively undergone nine rounds of iterations.

2. BACKGROUND

At the time of writing, we had concluded five field studies since 2004 [13]-[16] with children from the urban slums and rural areas of India, and were beginning the 11th week of our sixth field study with the same demographics. The first three studies were exploratory in nature and were intended to help us learn first-hand about the everyday learning contexts of our target learners as part of a broader needs assessment. Our small-scale experiments with various ideas for technology-assisted learning during these studies eventually led us to formulate the idea of mobile learning for ESL on cellphones. In the two follow-on studies, we investigated the feasibility of using mobile games to provide an engaging learning experience.

Each of the first five studies lasted two weeks, while the sixth was substantially longer. Our goal in the latter was to perform frequent iterative prototyping in the field while immersed in the local culture. Our fieldwork was assisted by bilingual interpreters. Local researchers also participated in later studies to lend a deeper understanding of the local cultural context to the team.

We will not revisit previous published results in this paper unless it is necessary to provide the necessary background information. Instead, we begin, by presenting in the following subsection, the design for a parrot game that is new and which we deployed in the fourth field study. We will then describe, in the next section and after, how this design underwent one iteration during the fifth study and informed our designs for two subsequent ESL learning games, namely, Frogger and Floored, which we field-tested during the sixth field study.

2.1 Parrot Game (First Iteration)

The "catch the parrot" game aims to help learners improve their understanding of letter-sound correspondences, i.e. relate letters with their sounds. Since our target users could be first-time users of cellphones, we designed this game around a conceptual model that we reused when designing all future games, so that having a conceptual model that is common to all our games is expected to promote the learnability of their user-interfaces. In this model, an e-learning game comprises several receptive-activation cycles, in which the same items such as letters, vocabulary words, etc. are introduced to the learner repeatedly in graduated time intervals across multiple cycles, as informed by the research literature [18][24] on how long-term memory retention works. More specifically, every cycle comprises:

- a receptive phase, which aims to develop competence in one aspect of ESL (e.g. alphabet, sight vocabulary, etc.), followed by
- an activation phase, which tests the player on some or all of the items "taught" in the preceding receptive phase. However, the player will be tested on the items in a sequence that differs from the sequence in which they were presented.

To avoid overwhelming the player with too much new material at any time, our model was designed around several *short* receptive-activation cycles. In this way, the player is presented with a small amount of material. She is then tested on it before she receives feedback on her answers. Only then is a new cycle started to cover more material – both new *and* repeated, i.e. from previous cycles – until she obtains correct responses on the entire syllabus.

Figure 1. The receptive phase (left) and activation phase (right) in the initial parrot game. The learner was being taught "A" among other letters in the receptive phase and was tested on the letter "E" in the activation phase shown.

In the specific case of the parrot game, it attempts to teach three letters in any receptive-activation cycle, such that each receptive phase focuses on three selected letters. The parrot game combines visuals with sound: when teaching a letter, it shows the symbol for the letter within the speech bubble of the human sprite (Figure 1), even as the human moves from one parrot to the next, such that every parrot repeats the targeted letter aloud as soon as the human has moved beside it. The parrot game is finished with the current letter once the human has moved off the screen, and the remaining letters are covered until the game has completed all

[1] A longitudinal randomized experiment over more than two years with over 10,000 urban slums students.

three letters for the current cycle. The player then transitions to the activation phase, where she is tested on the same three letters.

In the corresponding activation phase (Figure 1), for the letter that the player is currently tested on, the game shows its symbol in the speech bubble of the human sprite. Unlike the receptive phase, however, every parrot corresponds to a different letter, and only one parrot stands for the letter that the player is being tested on. The player can move the human sprite from one parrot to another, such that the parrot that is currently beside the human says aloud the letter that it represents. The player is required to choose the parrot that correctly corresponds to the letter that she is tested on.

The use of multiple receptive-activation cycles in our conceptual model was informed by our review of slightly over 35 commercial language learning packages. The reader can refer to [15] for more details. For the audience of this paper, however, the issue that is much more pertinent is: to what extent is the receptive-activation "format" that we have gleaned from many bestselling commercial software applications for First World markets applicable to low-income learners in underdeveloped regions? What adaptations are required for this format to be more relevant for the latter users? To address these questions, we turn to our experiences in the field.

2.2 Experience with Initial Parrot Game

The parrot game was first evaluated during the fourth field study in August 2006 with kindergarten and 1st-grade girls living in the urban slums in India. This study took place in an afternoon school that was founded and directed by a non-government organization (NGO) partner. This program targets girls from the neighboring slums who would otherwise not have an opportunity to receive an education. Classes are free-of-charge and last 3½ hours every afternoon, since students have household duties in the mornings. Students are recruited when parents hear about the program from word-of-mouth or when teachers make home visits to convince parents about the value of formal schooling for their daughters.

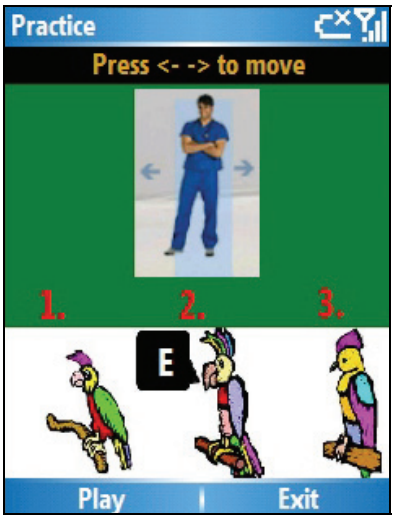

Figure 2. The practice phase in the redesigned parrot game. The human was next to the parrot that was echoing the /ɛ/ phoneme (pronounced as "air") for the "E" grapheme.

The parrot game was one of the three games that we had designed to teach the English alphabet, and we deployed these three games with 14 kindergarten and 1st-grade students [15]. In general, the parrot game and subsequent games that we described in this paper were introduced in the following way: at the start of a session, we briefed all the learners on the learning goals for that day. We next divided the learners into smaller groups of about 7-8 and showed them how to play the game that we had scheduled for the session. This demonstration lasted 10 minutes, after which a cellphone was handed to each child to play the given game.

We did not observe any major usability problems. But we needed to remove the time limit for the "easy" level of difficulty since our users were using cellphones for their first time and required more time to select their answers. We also believe that our users found the games engaging, since they appeared to be so engrossed that they did not pay attention to our videotaping them. There was also indirect evidence that users were learning the alphabet. They did not know every letter prior to gameplay, but most of them finished all three games within three days, and it required a knowledge of the entire alphabet to complete the games.

In contrast, our experience in piloting the parrot game with a rural population would turn out to be significantly more challenging, as we will next report.

3. PARROT GAME (REDESIGN)

The parrot game was next deployed in the fifth study in January 2007 with 24 1st- and 2nd-grade children at a village school in Southern India. Like students from the urban slums in the August 2006 study, none of the participants in the January study reported having any experience with videogames or cellphones, but they understood what cellphones were. Although the fifth study lasted two weeks, the parrot game was deployed for only two days since it was tangential to our primary research agenda for January [16], which was to investigate how mobile games could be designed so as to be engaging and culturally relevant for rural children.

More specifically, the parrot game was introduced in January as a "side project" at the request of the Mysooru Literacy Trust, which was the NGO who had "adopted" this school.[2] The MLT believed that our study participants, who were beginning to learn English, should learn phonetics as part of their early literacy curriculum so that they are equipped to decode (i.e. read aloud by sounding out) words phonetically. We had not designed this game originally to teach phonics, but the MLT had seen it in our earlier presentation and advised how it could be changed to cover phonemes (i.e. the basic units of sound) and their respective graphemes (i.e. symbols for individual or clusters of letters). Moreover, the MLT provided a syllabus of the grapheme-phoneme pairs that we should cover. Finally, the MLT recommended that the parrots in the activation phase be visually distinct from one another (Figure 2). This change was meant to avoid creating potential confusion since each parrot represents and says a different phoneme.

3.1 Experience with Second Iteration

We piloted the parrot game as soon as we have iterated on it based on the above feedback from our NGO partner. In contrast to our relatively smooth experience with urban slums children in August 2006, guiding rural children of a similar age bracket to

[2] To avoid confusion, the NGOs that facilitated our fieldwork in August 2006 and January 2007 are two different organizations.

play and learn with it proved to be a more formidable challenge. While the former could use the parrot game on their own to learn how to pronounce the letters in the English alphabet, the latter required our interpreters to sit beside them to coach and provide feedback on the pronunciations of the various phonemes. We do not think that the reason stemmed from usability or learnability issues. This was because we had been familiarizing rural children with mobile games and cellphones for more than a week, as part of the primary research agenda. In other words, the village children were coping reasonably with the cellphone games in the January 2007 study by the time we introduced the parrot game.

Instead, we believe that the rural learners needed adult facilitators to assist them in learning with the games because the former had a lower English baseline compared to their slums counterparts, who had enough exposure to the sound system of the English language to benefit from the instruction provided by the parrot game. Some background information is necessary here: while slums students in the afternoon school receive English lessons in kindergarten and more advanced classes and are also exposed to the use of English by urban dwellers, the rural school introduces English only in the 5th grade and hardly any villager speaks English. As such, the parrot game appeared to build on the knowledge of the English phonemes that urban slums children had, by reinforcing their understanding and retention as they repeated aloud after the game.

In contrast, rural learners appeared to lack this background. They depended on their facilitators to repeat the phonemes aloud from the game and to distinguish between close-sounding phonemes. They also articulated the phonemes less frequently and with more mispronunciations than slums learners. In fact, it seemed that they realized their errors only when facilitators corrected them. It came as no surprise that the current design for the receptive phase was inadequate for preparing the rural learners to be tested during the subsequent activation phase, when we observed that most of them were usually not able to select the correct parrot.

3.2 Third Iteration

The above observations that we made on the first day prompted us to make two major modifications in the next iteration, which came in time for further trials on the second day. First, we introduced a "practice phase" (Figure 2) after every receptive phase and before its respective activation phase, in order to give the learner plenty of exposure to and practice with items in the syllabus for as long as she wants. Unlike the receptive phase, in which syllabus items are introduced to her at a pre-programmed pace, in the practice phase, she has the freedom to switch freely between the items for the current cycle by moving the human sprite to any of the parrots to listen to its corresponding phoneme. In this way, she gains the flexibility to focus in a self-paced manner on those items that she is weaker on, so that she could more effectively prepare herself for the activation phase. In the particular case of the parrot game, this flexibility also meant that she could repeatedly listen to more than one parrot until she could tell their phonemes apart.

Second, we introduced user-interface controls for the facilitator in the receptive, practice and activation phases in the form of left and right soft keys on the cellphone keypad (Figures 2 and 3). These soft keys are labeled "Exit," "Start" and "Play" and provide the facilitator with more control over the flow of the parrot game. For instance, the Exit functionality was added to make it easier for the facilitator to quit and restart the game should she learn that the learner lacks the prerequisite knowledge for the current phase and needs to return to an earlier phase to relearn the basics. Similarly, the Start button was added to the receptive phase at the request of the facilitators to enable them to start this phase explicitly. They commented that students were not always ready to concentrate on the pre-programmed instructional sequence in the receptive phase and were often caught off-guard when a receptive phase began, possibly because rural learners lacked familiarity with interactive software to realize that the end of an activation phase is always associated with (and followed by) the start of the receptive phase for a new receptive-practice-activation cycle.

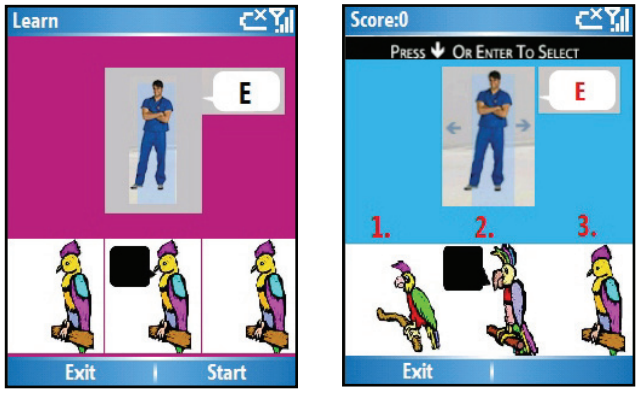

Figure 3. The user-interface controls for the adult facilitator in the receptive phase (left) and activation phase (right) of the redesigned parrot game.

We also made other modifications in response to feedback from the facilitators. For example, since learners repeated the phonemes aloud after the game, we slowed down the audio playback of the phonemes in the receptive phase by increasing the pause intervals between phonemes. The additional delay gave learners, especially those who were less confident or prepared, more time to struggle with the grapheme-phoneme associations and the pronunciations. It also enabled facilitators to provide more thorough explanations, corrections and feedback. Likewise, because the cellphones were held nearer to the child users than their facilitators in many cases, we increased the font sizes to enhance visibility for the latter.

After the parrot game was deployed on the second day with the above revisions, the facilitators told us that the changes made it easier for them to guide the rural children in learning phonetics. The facilitators also reported that the children were learning what they covered. However, based on the results of a recall test that we conducted immediately after the deployment, we found that 13 of the 25 students who had played the game did not remember any of the 7 phonemes that were covered. Two more students did not feel confident enough to respond to the test questions. Among the 10 remaining students, the average number of phonemes that each of them recalled correctly was 1.5 out of 7. It was plausible that learners needed more than a day to develop a stronger grasp of the material before learning effects would show up on formal tests. The more likely reason for the poor test performance, according to the facilitators, however, was that the learners had perceived the parrot game as an application to be played for pleasure, versus learning. They drew this conclusion from

observations of how the children were focused on having an enjoyable time with the game without putting in the time and effort to remember the material.

The refined conceptual model that revolved around the receptive-practice-activation cycle was not without its own drawbacks. The most significant problem was that the game with three phases was comparable to an application that has three different modes, and modes have been widely acknowledged as a common cause of usability problems. Worse, because we wanted to situate all three phases in the "catching the parrot" setting, we were constrained to maintain as much of the same "look and feel" for all three phases. As a result, the rural learners found it difficult to see which phase they were in, possibly due to their limited computing experience. We tried to address this issue by having three distinct background colors for every phase, and with affordances such as arrow signs for the human sprite in phases where the user is allowed to move it, but it remained difficult for the learners to associate the current screen with the phase that they are in. It would take one more field study to find a satisfactory solution to the above problems.

4. FROGGER AND FLOORED

Our next field study took place throughout eight weeks in South India, at the same rural government school as January 2007. We designed and implemented a broader range of applications so that we could target a more comprehensive curriculum beyond the alphabet and phonetics targeted in the parrot game. After which, we iterated on the game prototypes based on our experiences with them in the field. Among those applications that we tested in this period, we focus on Floored and Frogger in this paper since their designs build on the above lessons most. Our experiences with both games are expected to yield additional insights for designing e-learning games with lower-income learners in India that balance entertainment with education.

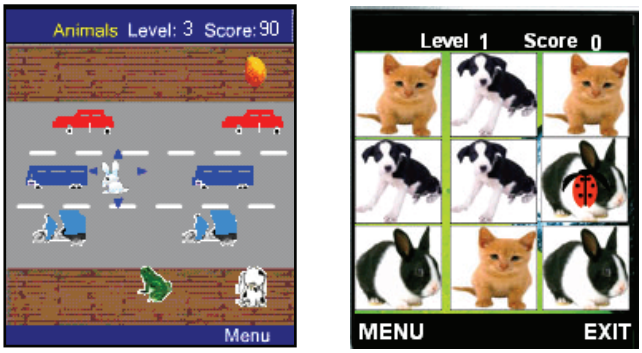

Figure 4. The activation phase in the initial iteration of the adapted Frogger (left) and Floored (right). The player was helping the selected animal (i.e. the rabbit) to cross the road in Frogger, and flipping tiles to show the cat in Floored.

Whereas the parrot game targeted letter-sound correspondences, Frogger and Floored aimed to develop the learner's vocabulary in spoken English. Their syllabi were adapted from the government's recommended syllabus. This time, we came with more cellphones than in January so that we could include all the students from the school in our research study. The larger sample size enabled us to avoid evaluating subsequent iterations of the games with the same students all the time, i.e. learning effects. In all, 47 students from grades 2 to 5 took part in the study, while 1st grade students had to be excluded since they were undergoing registration for school.

4.1 Game Designs (First Iteration)

The original Frogger and Floored games were not designed with ESL learning in mind. We decided to adapt on their designs and incorporate ESL learning material into them after we learned from January 2007 that both of them were the two most popular games among the eight games that we tested with the same children [16]. Our adaptations revolved around the receptive-practice-activation cycle that had evolved from the above field trials with the parrot game. With this cycle, the advantage is that we can introduce new words to learners and give them more exposure to the same words *at their own pace*, before testing their newly-acquired knowledge by having them apply it to accomplish goals in a game setting. In contrast, educational software that target markets in the developed world do not usually include features resembling the receptive and practice phases, which is not a grave omission for middle-income learners who typically have well-educated parents and teachers.

For clarity of exposition, we will describe the activation phase for both games (Figure 4) before their preceding phases (Figure 5). In the original Frogger game, the goal was to help a group of animals cross the road one at a time without getting run over by a vehicle. We adapted Frogger to target the English vocabulary for everyday animals, such that when an activation phase begins, the game says the word for one of those animals at the bottom of the screen. The player needs to select and help the correct animal cross the road.

In the original Floored, the goal was to flip the floor tiles until all the tiles are facing up with the same side showing. There are two or more states associated with each tile, such that when the player moves the ladybird sprite to a new tile, the destination tile flips to display its next state. We adapted Floored such that whenever an activation phase begins, the game plays a word aloud. The player has to flip the tiles such that all of them show the picture for that word. In doing so, we adapted Floored for vocabulary building, especially for nouns and verbs that could be conveyed pictorially. For the study described in this paper, we reused the same content from Frogger in Floored to develop vocabulary related to animals.

In Frogger, during any receptive phase, the spoken English words for three animals are taught. These animals are first shown on the bottom lane on the screen, and each animal crosses the road as the game says the word corresponding to it. The audio playback takes place twice – once at the normal pace and again at a slower pace to help the learner follow its pronunciation more accurately. As we have discovered in January 2007, pronunciation is particularly difficult for our target (rural) learners and we expected the slower audio replay to benefit them. In addition, to make it more intuitive to the player that the audio playback refers to the animal that is currently being taught, a caricature of the player's school-teacher is shown in the top left-hand corner. It enlarges and then reverts to its normal size whenever a word is played back, so as to create the impression that the teacher character is teaching the spoken word for the animal. We will touch more on the caricature below.

Once all three animals have crossed the road, the receptive phase transitions to the practice phase, where a bicycle moves onto the

screen. The bicycle acts as a "pointer" which the player can move to the left or right such that it is always next to one of the three animals who are now on the top-most lane on the screen. Each time the bicycle moves beside an animal, the game shows a larger image for that animal and plays the audio for its word. In this way, the player gets as much exposure to the spoken English words for the animals that she needs. Unlike the activation phase, however, there is no vehicle traffic in the receptive and practice phases to avoid distracting her from vocabulary learning.

On the whole, our adaptation of Floored differed from Frogger in three significant ways. Firstly, whereas Frogger's receptive phase was situated in the "road crossing" game setting, in the hope that immersing vocabulary learning within a game setting would make the learning experience more pleasurable, we situated Floored's receptive phase in the classroom setting, such that the caricature of the teacher at the bottom left-hand corner of the screen would say the spoken English word for the picture in her speech bubble. We were not satisfied with this design at that time, but could not ideate a less mundane receptive phase that continued to leverage Floored's game setting. The differences in the receptive phases in both games turned out to have important consequences, as we will discuss shortly.

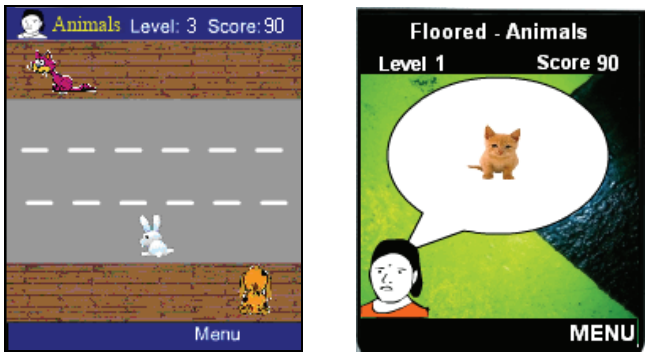

Figure 5. The receptive phase in the initial iteration of the adapted Frogger (left) and Floored (right). In Frogger, the player had been taught "cat"and was being taught "rabbit." In Floored, she was being taught "cat."

To add, coming back to the caricature of the teacher, the English words in Frogger and Floored were recorded using the voice of the teacher in the caricature. This was because our participants in the January 2007 study did not always heed the audio prompts in another application.[3] These prompts were recorded in the voice of a team member whom the children did not view to be an authority figure, and they would tease, bully and even pinch her. Hence, we wanted to investigate if the voice recordings of a more confident stranger, or that of an authority figure (e.g. the children's teacher) accompanied by her caricature, could better engage the children's attention. This idea came from our NGO partner, who believed that participants would take the audio recordings more seriously if they recognized the recordings to be in their teacher's voice.

Secondly, mindful of the above difficulties that players in January had with distinguishing between the three phases in the receptive-practice-activation cycle, we integrated the practice phase with the activation phase, i.e. we did not design a separate practice phase. Instead, in the activation phase, each movement of the ladybird is accompanied by the audio playback of the word that corresponds to the new picture displayed on the destination tile. The player therefore receives additional exposure to the words corresponding to the tiles as she moves the ladybird around the board. The audio playback in the activation (and practice) phase took place at the normal pace while playback in the receptive phase took place at a slower pace. We would have liked to cut down on the number of separate phases in Frogger, but we needed to work within the constraints of the game rules (since we wanted to build on a game that has been shown to appeal to our target users) and could not think of how the settings for any two phases could be integrated naturally.

Thirdly, we needed to make the transition from an activation to a receptive phase more evident so that learners would not be caught unprepared when an activation phase was over and they needed to focus again on the instructional sequence in the ensuing receptive phase. Our solution in Floored was a simple "You Win!" splash screen that required the user to hit a button to continue to the receptive phase. It was informed by the January study, when users showed off the level completion screens in their mobile games to adults like us, as a means of gaining our approval and recognition for their gameplay achievement [16]. We implemented this feature for the summer to investigate if the same behavior would repeat in an e-learning game. In contrast, for our adaptation of Frogger, we wanted to experiment with a fancier transition and had the animal walk off the screen after it reached the destination lane.

Even though the above contrasts between the adapted Frogger and Floored were sometimes unintentional and arose from serendipity, they appeared to have profound impacts on how players interacted differently with both games. Their differences – and similarities – constituted the basis for some interesting design lessons.

4.2 Key Questions

The parrot game and the ensuing analysis above had raised some questions: Can rural children tell the three phases in the receptive-practice-activation cycle apart? Were the first two phases effective in equipping users with the knowledge to succeed in the activation phase? Were the caricature and voice of the teacher sufficiently "authoritative" in drawing learner attention to the material taught? Were games designed based on this three-phase model engaging and interesting to play? Were players learning through the games? Although we had some preliminary results with the parrot game, we sought to address these issues more conclusively by evaluating Frogger and Floored in the field. Most important, we argue that the observations that repeat across more than one prototype hold the most generalizable lessons for designers in this field.

4.3 Lessons From First Iteration

We evaluated Frogger and Floored with 29 students on 3 days and 16 students on 3 days respectively. A session for any child lasted an hour on average and took place under naturalistic conditions at the rural school. On average, a player took about 15 minutes to familiarize herself with a game, and the process usually involved playing its activation phase more than three times. The rest of her session was spent on gaining more practice with the game, and

[3] This application was not described in this paper due to the lack of further relevance.

players began to win the game after they were first introduced to it for 30 minutes. For the players who completed all the levels in the game before their sessions ended, we asked that they replay the entire game so that they could potentially become more familiar with the targeted English material.

We were naïve in thinking that situating the receptive and practice phases for Frogger within its "road crossing" setting would help to make the learning experience more pleasurable. Players seemed to grow bored with the receptive and practice phases after playing these phases more than thrice, and were eager to skip ahead to the activation phase to play the game proper. In other words, although we had not expected formal schooling to be necessarily interesting to many rural children, situating our learning episodes within a game setting did not help to make the ESL material or the learning experience any more appealing.

Worse, by situating the receptive and practice phases in the "road crossing" setting, we made the learning goals behind both phases less obvious to rural children, who – as we believed – associated education more closely with a school setting as opposed to a game setting. In particular, during the practice phase, players focused on moving the bicycle "pointer" in the leftward direction, more so than paying attention to the audio playback of the English words or the enlarged image of the animal referred to by the pointer. We offer two plausible reasons. First, players found it more intuitive to move the pointer to the left, versus right, because the bicycle in the icon was facing left, and back-pedaling in the real world was likely inconceivable to them. However, it strained our imagination to devise a pointer interaction technique that was both a good fit with this setting as well as afforded (i.e. provided cues for) the left and right movement actions. Second, the game setting together with the opportunity to ride a bicycle in this fantasy world was a possible distraction to learning.

More troubling, in the receptive phase, players did not appear to understand that the animations of the animals crossing the road were meant to teach them vocabulary, and that they should paying attention to the audio recordings. Alternatively, the learners might have known about the vocabulary building objective but chose to focus their attention on watching the animated creatures crossing the road instead of listening to the audio playback.

There were also navigational difficulties with the three phases in Frogger. For instance, we observed that players did not always know that they had to move the bicycle "pointer" off the screen in the practice phase to proceed to the activation phase. Similarly, learners were sometimes confused between the words tested in the activation phase, and would clearly benefit from back-tracking to the practice phase for additional instruction. Having consistent user-interface controls that provide the user more control over her transition between phases is thus expected to enhance learnability of the user-interface, usability during gameplay and ESL learning. We decided to implement such controls in the next iteration.

In comparison to Frogger, rural children appeared to understand the receptive and activation phases, as well as their distinction, in the Floored game significantly better. Even though it was possible that the users made sense of the two phases in Floored due to the game having fewer phases (than Frogger), we argue that it were the dramatically different settings – beyond cosmetic differences in background colors or variations on the same fantasy theme – which helped to accentuate the sharp distinctions that existed between phases. Most importantly, it was intuitive to players that they needed to pay attention to the voice recordings and visuals in Floored's receptive phase because it was situated in the classroom setting, which players instinctively associated with learning and schoolwork. In fact, we observed that learners paid more attention to the receptive phase in Floored than the same phase in Frogger. For example, in Floored, learners said aloud the words for the animals as soon as their pictures appeared in the speech bubble, ahead of the audio playback, even though we found that the same learners did not know any of these words during their pre-test.

On a related note, for both Frogger and Floored, players did not recognize that the voice for the audio recordings belonged to their teacher, when we asked whose voice the recordings were from. In fact, none of them recognized that the caricature was that of their teacher either.

Figure 6. Rural children displaying their "You Win!" screens. Success in the English language learning games, and mastery of the technology, was a considerable incentive and source of pride for these children. These kinds of displays were repeated over and over.

Next, when the "You Win" splash screen appeared in Floored, players were visibly excited and would clamor to show their cellphone screens to us and their peers (Figure 6). On the other hand, the animal walking off the screen in Frogger appeared to be less intuitive in communicating to the players that they had won, since they would look perplexed when the game transitioned to the receptive phase. Most importantly, it was precisely the design of the "You Win!" screen, which required the player to press a button to continue to the next phase, that made it possible for the children to bring their cellphones around the classroom to show off their exploits. While we had observed similar behavior in a few children in January 2007 with games that focused entirely on entertainment [16], the fact that this behavior repeated in summer 2007 with e-learning games played by a larger sample of children showed that this simple splash screen design could potentially leverage social relations as a powerful motivator of learning.

5. FROGGER AND FLOORED REDESIGN

We set out to redesign Frogger and Floored based on the above lessons. For Frogger, we changed its receptive phase by situating it within the classroom setting, such that the new receptive phase resembled the receptive phase in Floored (Figure 5) with a teacher supplying the English word for the image in her speech bubble.

Similarly, we modified the practice phase for Frogger by situating it in the classroom setting as well. However, to keep the practice phase distinguishable from the receptive phase, we designed the practice phase to have a significantly different background (Figure 7). Specifically, the practice phase contained a blackboard which displayed the pictures for the three vocabulary words belonging to the given receptive-practice-activation cycle. There was an icon of the participants' teacher pointing to one of the three pictures with a stick, such that the user could move this icon

to the left and right to point to a different picture by pressing the left and right arrow buttons. Whenever the player moves the teacher to point at a new picture, the game would say its corresponding English word. With the exception of the picture which is currently selected, the other two pictures would be dimmed out.

Since our participants could not recognize their teacher from her caricature, we replaced her caricature in the receptive phases of the Frogger and Floored games with her photograph. For a similar reason, we made use of her photograph for the above pointer icon in Frogger's practice phase, versus taking her caricature. Lastly, we modified the activation phases in both Frogger and Floored, such that when the game said the word that the player was tested on, the teacher's photograph would appear at the same moment to create the impression that she was quizzing the player.

Figure 7. The practice phase in the second iteration of Frogger.

Like the third iteration of the parrot game, we implemented user-interface controls in Frogger and Floored for flow control via the left and right soft keys. Among the navigational shortcuts that we could think of, we expected that players will appreciate having the freedom to transition to the next phase most. Hence, we made this shortcut highly accessible by associating it with the left soft key. Conversely, shortcuts such as exiting the game or reverting to the previous phase would frustrate the player if she were to press their buttons by mistake and had to repeat the game. As such, we made them less accessible, via a menu associated with the right soft key.

5.1 Experience with Second Iteration

We evaluated the second iteration of Frogger and Floored with the same 47 students between grades 2 and 5. With the new receptive and practice phases that were situated in a classroom setting, it seemed that our players understood that they were supposed to learn the words covered in these phases. Once the phases became intuitive, players figured out for themselves what they needed to do in both phases to learn the material. In comparison, when participants were interacting with the previous iteration of the receptive and practice phases, it did not seem to occur to them that the game was attempting to convey the English words of the animals on the screen through the audio playback.

More important, our concerns that participants may not be able to tell the phases apart once there were three phases turned out to be unfounded. While we had previously believed that incorporating three phases in Frogger would not confuse the users if the phases were distinctively different, the above observations supported this earlier design decision to retain three separate phases in Frogger. Unlike Frogger, it was much easier for us to think of a design for Floored where the practice and activation phases were combined seamlessly. The design implication is that when it is not that easy to come up with a fantasy setting that naturally integrates any two consecutive phases, keeping the overall design simple by having the receptive-practice-activation cycle span three entirely separate phases is not such a bad idea, despite the lack of creativity.

On a related note, participants told us that they were now able to recognize their teacher in the receptive and practice phases from her photograph. Since the teacher is arguably the main source of formal knowledge and instruction in this cultural context, where school is usually "teacher-centered" as opposed to centered on the learner's needs and prior knowledge, we argue that her photo went hand in hand with the background images in both phases to reinforce the classroom atmosphere that we wanted to establish in the gaming experience. Similarly, her photo may have helped to establish expectations on the part of participants that the teacher character was there in the game to teach them. Users appeared to pay the same amount of attention to the audio playback before and after the caricature was replaced with the photo. However, they were visibly excited to see their teacher's face in the game. Some of them even showed us the cellphones and pointed out their teacher's photo to us.

On the flip side, many users mispronounced the audio recordings when they repeated aloud after the teacher's voice. For example, learners would pronounce "rabbit," "dog" and "frog" as "dabbit," "odd" and "frock" respectively. The most likely reason was that the teacher at the rural school could barely speak to us in English and that she was could not pronounce some English words well.

There were various design options that we could take. But more importantly, the interrelated issues of authority and the language model surfaced in our design considerations. We have associated the teacher with both the receptive and practice phases so as to lend a stronger air of authority to the designs for both phases and to encourage players to focus on the ESL material more seriously. However, since rural participants had very little access to ESL resources outside school, it was imperative that our games act as a good model of the English language for learners to learn from. We could train the above teacher in her pronunciation, but it would be some time before we could obtain high-quality audio recordings. In our view, a more feasible approach would be to use the voice of a more qualified English speaker, while retaining the photo of the teacher at the rural school. This option would work if users could not identify that the voice in the audio recordings no longer matched that of the teacher in the photo. We needed to conduct more fieldwork to investigate the feasibility of this idea.

Moreover, the facilitator controls were used to adapt both games to the English baseline of each player. In particular, the left soft key for skipping to the next phase was used increasingly as the learners became more familiar with the targeted vocabulary words through repeated gameplay, and simply wanted to advance to the activation phases to test their vocabulary knowledge. In contrast, the shortcut for moving back to the previous phase was seldom

used, unless the facilitator or player advanced to the next phase by mistake. On the whole, the facilitators did not comment on these controls, which implied that these controls met their navigational shortcut needs and that they were not cumbersome to use.

Quantitatively, the 47 learners scored an average of 1.96 out of 5 on the pre-test and 3.85 out of 5 on the post-test. The effect size was 1.33 and post-test gains were significant (p-value < 0.001, std. dev = 1.42) on a one-tailed t-test.

6. FINAL DESIGNS

We decided to apply the above lessons and ideas to Frogger and Floored, but with a new syllabus for each game, to investigate the extent to which we could replicate the above results.

In the third iteration of Frogger, we modified the activation phase in order to target vocabulary for everyday vehicles. Specifically, instead of helping the correct animal cross the road, the goal was to help the animal get onto the vehicle that was designated by the teacher character in the game. Two other major changes that we made was to implement the same facilitator user-interface controls and the "You Win!" splash screen that were found in Floored.

For Floored, we changed its content so as to shift the learning focus from developing a vocabulary of everyday animals to lexical verbs such as climb, jump and run. To improve the quality of the pronunciations for the verbs, we did the audio recordings using the voice of a team member who spoke excellent English with an Indian accent. We did not make other substantial modifications to either Frogger and Floored since we did not observe any further outstanding design problems to be addressed.

6.1 Experience with Third Iteration

Since there were no more students at the rural school who had not yet played the earlier two iterations of Frogger, we tested the third iteration with all 47 students between grades 2 to 5. Similarly, we evaluated the latest iteration of the Floored game with 16 students from grade 3.

We learned during the pre-test for Frogger that participants could name the English words for the vehicles in their everyday lives. We did not anticipate this when we designed the third iteration of Frogger, but on further reflection and hindsight, we did not find it surprising that these English words had been adopted into their native language as loan words. In terms of design implications, we noticed that children made use of the facilitator controls to skip directly to the activation phase. In fact, they used these controls in this iteration of Frogger more frequently than in earlier versions of Frogger or Floored. This observation was highly consistent with the earlier observation that players skipped to the next phase more often as they become more familiar with the targeted vocabulary words through continued play, thus suggesting a strong positive correlation between familiarity with the targeted ESL material and frequency of use of the navigational shortcuts.

In earlier iterations of the Floored game, we observed that learners mispronounced many of the vocabulary words for animals. In fact, at least two of them were not able to follow the audio playback at all. In comparison, learners were able to repeat words aloud with a more accurate pronunciation after we switched from the teacher's voice to the voice of the above team member for voice recordings. We learned from the pre-test that the students did not know many of the verbs covered in Floored. Yet, we observed that learners had difficulty pronouncing only one verb ("cook"), and that was presumably because they had confused this word with a similar word ("cock") from the previous day's English learning activity. This result supported our design assumption that audio recordings taken from a more qualified English speaker would make it easier for rural learners to acquire the spoken English words targeted in the game.

In quantitative terms, the 16 learners from class 3 who played Floored scored an average of 3.50 out of 8 on the pre-test and 7.06 out of 8 on the post-test. The effect size was 2.73 and post-test gains were statistically significant (p-value < 0.001, std. dev = 1.30) on a one-tailed t-test. More importantly, none of the users noted that the voice recordings in the latest iteration of Floored did not belong to their teacher. It seemed that they did not realize that the voice in the recordings no longer matched that of their teacher's.

Finally, children reacted enthusiastically to the "You Win!" splash screen in Frogger as they did when playing Floored.

7. RELATED WORK

The first work to argue that games can be used for education was the classic [1]. Its content is dated as of today, and in any case, it does not offer practical advice for designers. There is more recent work in the emerging "serious games for education" literature like [5], [18] which provides a high-level survey of the field and is not directly related to design. Other work is either anecdotal [26] or examines the field from the perspectives of non-designers (such as epistemology [27] and the socio-historical analysis of literacy development [12]) or is specific to a particular game genre such as simulations [2].

In our opinion, the most relevant recent work is [10], which offers a set of learning science principles that could be applied to game design. The limitation, however, is that it does not connect these principles with the potential for videogames to motivate the learner. And in any case, none of the above focuses specifically on designing e-learning games which target low-income users in the developing world.

Previous work in the HCI community that target underdeveloped regions fall under the domains of domestic labor [18], crop price finding [25] and micro-credit [22]. To our knowledge, [23] is the only work on e-learning games, but it targets a shared computer platform with multiple mice for input and not the cellphone.

8. CONCLUSION

In this design case study, we described the receptive-activation format from a review of successful commercial language learning products in developed country markets, and how we applied this format to the design of a parrot game for urban slums students to learn the English alphabet. Through subsequent iterations on this game and two additional games that were informed by our field experiences with rural learners, we discussed how this format had to be expanded to include a practice phase and facilitator controls to cope with the lower educational baseline of rural children. We also drew other lessons that touched on issues related to authority, an accurate language model and the social aspects of motivation.

In particular, we learned that the learning goals in our e-learning games were more obvious to rural learners when we maintained a distinction between pleasure and education in game designs, such that the learning phases were situated within a classroom setting. Our observation was especially notable since the fantasy setting is commonly applied as a heuristic to enhance the enjoyment value of games [18], and we demonstrated that we were able to achieve a good balance between pleasure and learning with the expanded format, to the extent that learners exhibited post-test gains. Even though we have presented our key findings in the context of a research project on language acquisition, we believe our lessons will apply to other educational domains in the developing world.

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