On Evaluating SkillVille: An Educational Mobile Game on Visual Perception Skills

Maricia Polene A. Balayan, Vanessa Viel B. Conoza, Jasmine Mae M. Tolentino,
Rowena C. Solamo, and Rommel P. Feria
Web Science Group, Department of Computer Science, College of Engineering,
University of the Philippines Diliman
$mariciabalayan \| vanessavielbconoza \| jasmtolentino@gmail.com, rcsolamo \| rpferia@dcs.upd.edu.ph$

***Abstract*—As technological advancement and innovation continually rise globally, the applications of such progress is evident in many fields, most especially in education. Knowing that education is essential to foster holistic growth especially in children, the researchers aim to maximize the potential of technology as a way to facilitate learning in a child's growing years.**

From books to educational applications and games, various educational mobile tools for children have now been developed. However, most of these applications lack significant features for learning, such as an assessment of one's performance, as well as the involvement of the teachers and parents of the users. SkillVille aims to propose solutions to these problems.

SkillVille is an educational mobile game developed using Corona SDK and published in Android platform. This paper discusses SkillVille as an aid for learning focused on three (3) basic and most common visual perception skills namely language and spelling, searching and sorting, and memory skills. Learning analytics is used for monitoring performance and possible improvement of users per game played. This also includes discussion about evaluation of the application by school teachers and user experience testing by children of ages 4-7. Test results show SkillVille's high potential as a learning tool for children.

I. Introduction

SkillVille is a mobile game which aims to promote learning of basic **visual perception skills**, which is the identification, organization, and interpretation of sensory data received by the individual through the eye. It plays a significant role in learning, and is a prerequisite for reading, spelling, solving mathematics, integrating visual information to the other senses, and basically putting meaning to the things that people see. In particular, visual sequential memory, visual memory, and visual form constancy are some of the subcategories of visual perceptual processing that are integrated into the game. [1] In the process of developing the application, educational technological approaches such as game-based mobile learning and learning analytics had to be researched and utilized. **Mobile Learning** has been setting the trend in improving education with the use of emerging technologies of our generation. Having that mobility factor and continuous advancement in today's hand-held gadgets, mobile learning paves way for the improvement of learning experiences throughout the years. It raises the bar a step higher as it gives additional motivation and engagement especially to young children. [3] **Analytics**, on the other hand, is related to recording and tracking significant information for the purpose of further analysis of this data to be used, usually, for the improvement of the system. **Learning Analytics**, therefore, combines data analysis with student interaction in educational tools, to create a more integrated and customized learning experience. It uses intelligent data, student performance and analysis models to find out how students learn and improve on their experience. [2] With the goal of utilizing existing methodologies and innovations in technology while maximizing the potential of a mobile game for its intended purpose, the developers incorporate simple learning analytics into the mobile game.

With the emergence of mobile learning, various educational mobile applications for children have already been developed. However, these applications have different learning goals and features, and only a few come with performance assessment. Some existing applications similar with SkillVille in terms of its goals and features include **Pitch Paradise: A Mobile Game as an Educational Tool for Music** [4], an Android mobile game aiming to teach children the basic concepts of music, **Fit Brains: Sparky's Adventures** [5], an iOS brain training application for kids aged 2 to 8, and **K12 Choc-It-Up** [6], an Android and iOS application that focuses on visual recognition. Performance assessment is one of the key features in learning, as it allows performance tracking of the users. Pitch Paradise

generates a basic performance assessment that flashes on the screen at the end of every game. SkillVille implements a more accessible and in-depth assessment by saving all previous performance indicators of the children for each mini-game. On the other hand, Fit Brains: Sparky's Adventures has a feature called "Parent's Corner", which shows a detailed and visual report on the child's progress. Similar to this feature, SkillVille also intends to involve the parents and teachers of the children, by making the assessment files of all games available for email. The generated assessments in SkillVille are intended for parents and teachers, as such information may overwhelm and not bear much meaning to the children. The only disadvantage of Fit Brains: Sparky's Adventure is that it is only free for a limited time, which compromises its accessibility to all possible users. K12 Choc-It-Up has no assessment feature, but like SkillVille, it targets visual recognition. K12 Choc-It-Up is composed of mini-games focused on color, shape, number, and letter recognition. However, it only applies basic searching skills, while SkillVille practices visual memory, searching and sorting, and spelling skills of the children. These reviews contribute to the factors considered in the implementation of SkillVille, whose effectivity will be determined by how teachers and parents of young children perceive it through an evaluative and user experience testing.

II. SkillVille

SkillVille focuses on three (3) basic and most common visual perception skills namely language and spelling, searching and sorting, and memory skills. The game has a community-like setting where each house caters to a specific skill with different levels.

A. Game Architecture

SkillVille's game architecture follows MVC architecture consisting of the Model, View and Controller modules. The View module handles the game rendering. This is the module where the user interaction takes place. It is in charge of the interface and display. Basically, this module can also be referred to as the application layer which is the one visible to the users. Meanwhile, the Model module contains the game functionalities, state data of game objects and entities and the game rules. The view module communicates with the model module to determine what to display. Finally, the Controller module handles the user input and manipulates the model. This module usually contains the action listeners.

1) Features: Just like the usual mobile applications designed for touch screen devices such as smartphones and tablets, basic drag-and-drop actions, taps and touches are the basic inputs for the games. Native action listeners keep track of these interactions. The game includes a scoreboard where the top score and the three most recent scores will be shown for each game and for every level. At the end of each game, the total score will be shown to the user and the name and age will be asked. A simple performance assessment is generated by the end of each game and is stored in the documents resource directory of the application in a form of a text file. This is the learning analytics aspect of the game where it includes a record of the number of correct and incorrect answers, the elapsed time for specific interactions and more. This may be viewed when the user chooses to be send results via email.

B. Game Flow

Upon starting the game, the user is directed to the main menu. In this menu, the player will have the option to view game instructions, view the scoreboard, or choose from the three (3) different mini-games. In all three games, the user is given the option to choose the difficulty level of the game–either easy, medium or hard. Each difficulty level has a corresponding time limit. The goal of each game is to score as many correct answers as possible. When the time expires, a Profile dialog box prompts the user to input his name and age. Analytics for the previous game will then be generated and made available for sending to the parent or teacherof the child. An option for sending a consolidated report of any of the mini-games is also available in the scoreboard module.

C. Game Design

The concepts for all three mini games were designed in collaboration with the College of Education, University of the Philippines Diliman.

Memory Game. The first mini-game, in a form of a pattern memory game, aims to practice the visual sequential memory skills of the children. Given a set of objects, these objects follow a sequence of blinks and sounds. The goal of the user is to correctly identify the sequence of blinks and sounds after the occurrence. As the game progresses, the length of the sequence increases.

Searching and Sorting Game. The second mini-game addresses this ability in a form of a searching and sorting game. The goal is to search through the given set of objects and find which ones will fit the given categories, i.e. shape, color, animal, body part, living or nonliving thing. The user must drag the object into the correct basket. Some images do not belong to any category, which requires children to really be keen in searching. The number of images increase, as well as the number of objects needed to be correctly categorized, depending on the difficulty of the game.

Language and Spelling Game. The third mini-game tests the spelling and language skills of the children. An image will be shown and the user must identify the name of the object. The incomplete spelling of the object is given and the user must fill in the blanks by dragging the correct letters from a given set. The player may tap the hint button, which then plays a voice that reads the word. This hint feature uses Google's text-to-speech functionality.

The words used in both the Searching and Sorting game, and Language and Spelling game came from the *Dolch Word List*. It is a list of frequently used words compiled by Edward William Dolch, PhD, a major proponent of the "whole-word" method of beginning reading instruction. It includes the most common 220 words and 95 nouns encountered in children's books, The list was prepared in 1936, and was originally published in his book *Problems in Reading* in 1948. [9] The researchers also added a few words in the game, similar to the ones in the Dolch Word List.

D. Analytics

Each game takes into account its own set of significant variables necessary to provide analytics for a child's performance. These significant variables will be based on the learning mechanics of each game. The analytics is parsed and saved into text files that will be available for emailing to the parents and teachers.

TABLE I: Significant Variables

	Per Game	Per Round / Per Item
Game 1: Memory	- total score - number of rounds	- round time - round score
Game 2: Searching and Sorting	- total score - number of pauses	- round time - round categories - correct and incorrect words per category
Game 3: Language and Spelling	- total score - number of pauses	- speed per item - number of mistakes - number of hints used

At the end of each game, two (2) text files are created. One is the assessment file particularly for the most recent game, and the other one is the general assessment file which includes all assessments for each mini-game since the application was installed. Apart from the significant variables being indicated in the assessment files, each game assessment entry also indicates the player's name and age, and the timestamp of when the game was played.

E. Users

Research from several disciplines confirms what early childhood educators have long observed—that the early years of life are crucial for establishing a lifelong foundation for learning. It has been studied that during the first 6 years of children's lives, they learn at a rapid pace (Lerner and Egan, 2003). Furthermore, early intervention also helps detect learning disabilities as early as possible. [1]

Even though the design of the application is in accordance to consultations made with the SPED Department, SkillVille is developed to be used by children aged 4-7 years old who may or may not have any learning disability. The child playing must already be an emergent, basal reader, and must have naming and phonetic skills.

III. Discussion

A. Testing

To evaluate SkillVille, two testing phases have been conducted. The first phase was intended for children, while the second phase was for teachers and parents.

First Phase: Children

1) Tester Profiling: A total of thirty (30) children participated in the testing of the mobile game. Twenty seven (27) of the kids were students from Mayfield Montessori Academy, while three (3) were from Healing] Smarty's Play Place. The schools were recommended by the SPED Department of the College of Education, University of the Philippines, Diliman, as these schools have both SPED and non-SPED students.

The children belong to different age groups. One (1) was aged 4, thirteen (13) were aged 5, seven (7) were aged 6, and nine (9) were aged 7 years old. All children were currently preschool to grade 1 students, and are emergent readers.

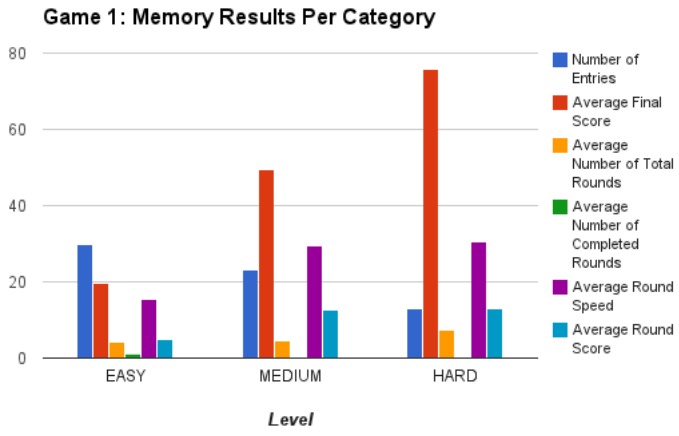
2) Methodology: Since the children are within the target users of the application, this phase was conducted through a hands-on experience of the application. They were asked to play all mini-games on 7-inch Android tablets. Children aged 4-6 years old were asked to play the easy and medium levels of each mini-game, while children aged 7 years old were asked to play the medium and hard levels. After playing all games and levels assigned for their age, the children were allowed to play any game and level of their choice. All children played the game with the researchers' supervision.

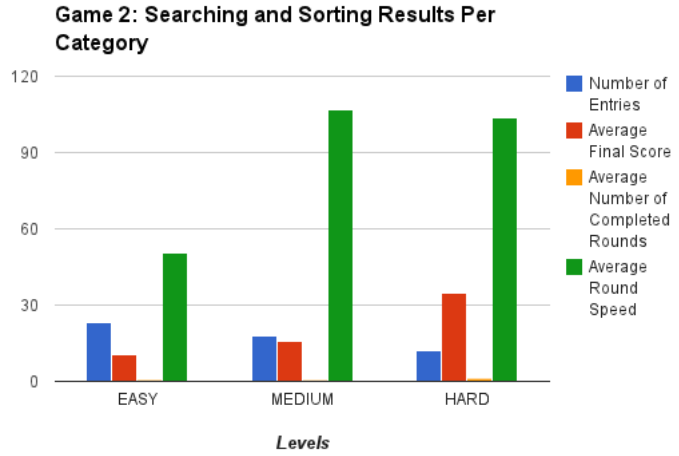
The following steps were followed for the first testing phase:

(a) A brief introduction of SkillVille
(b) An explanation of the instructions, and

demonstration per mini-game
(c) Actual playing of each mini-game

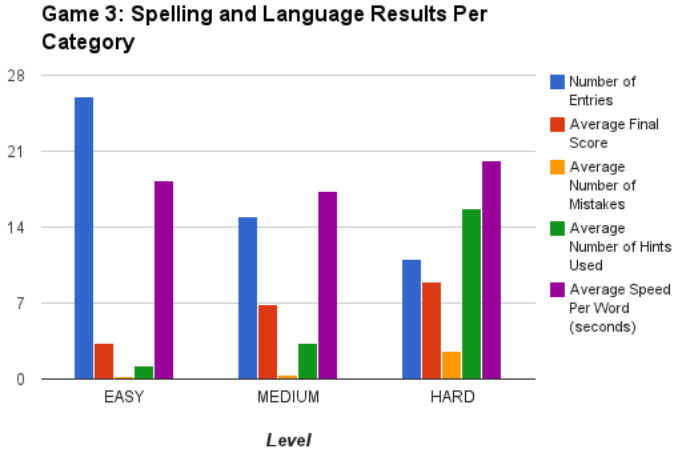
3) Results: The results were reflected on the generated performance assessments per mini-game. The following graphs show the average performance results of the children for each mini-game across all levels. These are based on the significant variables as discussed in Section III-D of this paper.





For all three games, results show that the highest number of plays are for the easy level. This is basically because there are more testers from the younger age range than the higher 7 year olds. In terms of average scores, the children's score generally increased as the levels increased. Furthermore, for all games, there were no obvious trends for the age and score relationship. Meaning, an older age does not ensure a higher score. This shows that we need not limit the game levels to any specific age.

The first and second mini-games are divided into rounds. For both games, the average number of completed rounds



resulted low. This could mean that the time given is too short, or that the goal for each round are difficult for the children. For the second game, it was observed that some images were confusing for the children, which made them hard to categorize. For the third game, results show that the number of mistakes and use of hints increased as the level increased. This could mean that the increase in difficulty for each level is evident for this game. The pause count, which is a significant variable for games 2 and 3, was not plotted in the graphs because the results were 0. No child used the pause buttons even if they knew that they could use them.

While the analytics for all games are all performance-based, they are not meant to diagnose nor detect disabilities of children. Only standardized diagnostic tools are credited for doing such work. SkillVille's analytics feature merely aims to save and present the progress of children as they play. The learning analytics generated were then sent to the respective teachers of the students.

Second Phase: Teachers and Parents

1) Tester Profiling: A total of nine (9) teachers and two (2) parents evaluated the application. Five (5) preschool and elementary teachers were from Mayfield Montessori Academy. The other four (4) were therapists from Healing Touch & Smarty's Play Place. The parents who evaluated had children enrolled in Healing Touch & Smarty's Play Place.

The teachers from Mayfield Montessori Academy had students within the age range of 4-7 years old. The therapists from Healing Touch & Smarty's Play Place were more focused on children with special needs. The parents had children aged 4-7 years old who also took part in the first phase of the testing.

Both schools handle students with or without learning disabilities. Mayfield Montessori Academy has a few special children integrated in regular classes, while Healing Touch & Smarty's Play Place specializes in attending to children with special needs. Therefore, the evaluation from their teachers can count as evaluation of the application for both children with and without learning disabilities.

2) Methodology: The following steps were followed for the second testing phase:

(a) A brief introduction of SkillVille
(b) An explanation of the instructions, and demonstration per mini-game
(c) Evaluation of the application based on Hurd and Jennings' suggested criteria for educational games [12]

For the last step of the testing phase, the parents and teachers were given evaluation sheets with the following criteria:

1) Overall Value: The overall value is depicted based on the educational content of the game. This includes subjects covered, academic significance of the game and the average session time for each level or game.

2) Usability: The usability criteria gauges the complexity of the game. This is based on how the game design is matched to the target audience. Usability also includes the user experience which can be described by some factors such as the ease of play and intuitiveness of the game.

3) Accuracy: This accuracy is based on the correctness of the educational content. For the game, this includes accuracy of the words and pictures used, accuracy of the categories and accuracy of the mechanics.

4) Appropriateness: In this criteria, the focus is on how well the game's content and design are adapted to the target users' needs. This includes the right fitting of the mechanics to the goals of the game, the game's presentation of mechanics and its menu structure and program flow. All of which mentioned in relation to the target audience.

5) Relevance: Relevance is about how meaningful and applicable the game's content is to the target audience again.The application must assist them in achieving their learning goals.

6) Objectives: Player's goals and the criteria that determine success or failure must be well defined.

7) Feedback: The feedback is about the responsiveness of the application with regards to the user's interaction. This includes the existence of sound effects for correct or wrong answers, scores indicating success or failure, performance analysis and the like.

8) Engagement: This engagement refers to how the game is enjoyable for the users that it engages the user to play more and be willing to progress through the game. This is a great predictor of how the game is an actual opportunity for learning.

9) Motivation: Motivation is quite relevant to engagement in a way that good motivation cultivates greater engagement for the users. A good motivation for an educational game includes setting goals, providing scores or feedback and issuing challenges and rewards.

On a scale of 1 to 5, 1 being the highest and 5 as the lowest, they evaluated the mobile game on each criteria. Comments and suggestions were also asked.

3) Results:

TABLE II: Evaluation Results (Average)

Criteria	Average Rating
Overall Value	1.91
Usability	1.82
Accuracy	2.55
Appropriateness	2.18
Relevance	1.73
Objectives	2.18
Feedback	2.27
Engagement	1.82
Motivation	1.82

Based on the results, *Overall Value* got a considerably high rating from the parents and teachers. Parents commented that they liked the concept of the game for their children. The teachers, on the other hand, said that the game is very promising and has high potential for its purpose as a learning tool. It was also said that the game is good to be applied in different activities for students. However, the teachers suggested to polish the content even more.

Usability, Engagement and Motivation received an average rating of 1.82. This implies that the game was averagely well received by the parents and teachers. A teacher commended the game for its motivating images and sounds. According to some teachers, the game is enticing enough to engage the children. They also found it easy to play. Moreover, they suggested to include more stimulative pictures to further increase engagement especially for special children.

Among all criteria, *Accuracy* received the lowest average rating of 2.55. The comments were generally on the vagueness of some images that made them hard to figure out. Most suggested that the images can be more accurate by having more concrete representations especially for abstract words. Using standardized tools

as guide, and researching on effective user interfaces and graphics for kids could help improve the accuracy. However, it was also pointed out that the answers to games were generally accurate.

Appropriateness and Objectives received an average rating of 2.18. Some teachers commented to improve on the instructions to further stress out the goals for each game. Some also pointed out to review some images or words that might not be appropriate for the target age group. This can be tied up to the issue on accuracy as well.

Relevance had the highest average rating of 1.73. The evaluators found the game relevant to the children. They pointed out that visual perception is a good skill to target for the children. They also found the email function very relevant and useful for a home and teacher relationship.

Feedback got an average rating of 2.27. According to the teachers of special children, adding visual and auditory feedback would be very helpful especially for the age range of 4-7 years old. They need positive, verbal reinforcement for every item they answer. However, they found the email system as an effective form of feedback for the parents and teachers.

IV. Conclusion and Recommendations

Based on the comments and suggestions made by teachers and parents, SkillVille has a high potential as a learning tool for children. Having three mini games, each catering to different skills, makes it more value-adding to a child's learning experience. However, there are still further improvements that can be made to make the game better such as additional audio instructions and feedback, which are helpful especially for special children. Moreover, it would be a good feature to have an online portal for the analytics and performance assessment generated by the application.

Most existing educational games don't have performance based assessment and SkillVille was able to address that issue. But to further enhance the involvement of the parents and teachers, it would be great to have a way where they can upload words or pictures to be included in the games. A desktop application counterpart would also be a good suggestion for future work but that will not be under mobile learning. Development in other platforms such as iOS would also increase the target users of the application.

In addition, it is recommended to conduct further user experience testing for children with learning disabilities in order to acquire more information on its compatibility to the said users and to take note of the specific needs the application must have to be able to serve its purpose to the users effectively.

Overall, SkillVille is highly recommended for children as an enhancement tool for learning but not as a substitute. It is very useful in keeping track of a child's performance based on the games. In conclusion, SkillVille is positively received by children, teachers and parents as an educational mobile game.

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