A Framework for Evaluating and Improving Skills and Knowledge of Children up to 6 Years of Age

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***Abstract*—This paper outlines the effects of educational and casual software applications on young children, and defines a framework for monitoring, assessing, and improving their knowledge and skills. It shows how the use of such applications improves children skills in the main learning domains and increases their familiarity with the world. After analyzing specific abilities developed by different categories of computer programs for kids, the authors present an architecture framework for evaluating personal progress and suggesting custom steps for further improvements.**

Keywords—e-Learning for kids, learning domains, educational platforms for children

I. Introduction

The use of computer technologies has become an integral part of our everyday lives. Similar to adults, children are using mobile devices more and more frequently. For that reason, there are more than a hundred thousand applications for kids available on the market. Most of them are educational, which makes it possible for children to acquire new knowledge and skills in a unique, creative and fun manner. There are also casual non-educational applications, built for entertaining purposes that do not stimulate any personal development. Continuous use of such programs can cause several problems with the development of kids, like deferring progress and leaving gaps in key knowledge areas and skills.

Educational software applications for children solve many challenges encountered in kids' everyday life, learning and development, and helps them gain new experience. Approaching a specific problem requires a specific set of skills, and that is why young children need the opportunities to obtain them. Computer programs for learning provide the ability for acquiring specialized knowledge of a subject through a configurable environment.

By using software for the education and development of children up to the age of six, we can control the pace at which they learn and practice. We can also make sure that learners are using as many senses as possible for perceiving the given information. The flexibility of computer-based tools allows switching between learning and practice mode seamlessly, making exercises more acceptable. Introducing high technologies in an early age would develop interest, positive attitude and awareness to them. Learning about the alphabet, numbers, colors, forms, rhythms, inference and crafting will build children's social skills and strengthen their self-esteem. It is widely adopted that kids with greater confidence will be more helpful, responsible, successful and eager to face and solve problems.

II. Benefits of Educational Software for Kids

There is a large variety of mobile applications targeted for children up to the age of six and most of them are designed for learning purposes, like teaching skills such as spelling, math and various social skills. To be classified as an educational application, a tool should meet the following requirements:

- The software must provide the appropriate content through the right graphical user interface, suitable for the specific age group of the users.
- The content should aim to encourage the expansion of children's knowledge, theoretical, social and emotional skills, as well as their psychomotor development.
- The application should engage its users with activities aiming to stimulate their progress.

Recent research in the area [1] concludes that educational mobile applications for children up to six years old help them acquire key new knowledge and skills by teaching them to think, live, work and succeed in the real world. These essential talents and abilities taught to the kids include, but are not limited to:

- *Thinking and reasoning* - logic, strategy, problem solving, critical and analytical thinking.
- *Creativity* - developing new solutions, creations and innovations.
- *Independence* - self-sustainability, motivation for personal growth and self-learning.
- *Emotional development* - self-consciousness, stability and empathy.
- *Communication* - using multiple forms of expression.
- *Collaboration* - team work, taking into account others' points of views and cooperation.

- *Responsibility and ethics* - honesty, respect, tolerance and learning from own actions.
- *Technical skills* - successful usage and application of information technologies.
- *Health* - fine motoric, physical and mental health.

III. Review of Different Categories of Educational Software for Children

Educational software for children can be divided into several types of categories - by age, by learning domain, by genre and by subject. The various classification schemes and a description of each category beneath them is presented next.

A. Categorization by Age

Children at different ages have diverse abilities, skills and necessities. That is the reason why the applications they use have different functionalities and complexity. Below we describe the requirements and recommended features of each individual age from two to six years.

Kids at the age of two experience drastic increases of their dexterity and understanding of the surrounding environment, which instigates their interest towards the mobile devices and technologies. They can often manage to drag parts of a puzzle to the correct place and thus solve it. The most appropriate applications for that group are those that prompt them to develop children's' fine motoric, as well as their creativity, language, communication, and even their social and emotional skills.

For three-year-old kids the shared games are becoming easier, as they are starting to cooperate and their level of understanding and ability to keep a set of rules increases. Children at that age can retain their concentration for a longer time and have better motor skills. They love to take part in role plays, singing and dancing. Educational software for that audience should encourage learning new letters and numbers, improve creativity, inspire the imagination and introduce human sciences like exploring parts of the human body.

With four-year-olds we see that the time they keep their attention on something is drastically increased. They can take part in games requiring memory, where the duration and complexity of the tasks can be gradually increased. Children at this age need to develop their social skills like communication, sharing and exchanging experience with others. Applications for that group should develop social and cognitive abilities, memory, as well as increase the language and mathematical literacy.

Kids at the age of five are in the preschool phase, which experience the need to blend in and be useful to their environment. Applicable tools for that age should support the study of phonetics, mathematics, crafting, as well as develop imagination.

Six year old children are aware of the rules, like to follow them, but also break them. They start creating circles of friends, which develops their participation and identity. The applications for this age group should urge studying - grammar and mathematical skills, and even include larger scope of material like history and geography.

B. Categorization by Learning Domain

Most educational software applications for kids contain multiple levels of various difficulty and requiring different skills. Rules for advancing to another level and the changes in learning materials, goals and outcome can be modeled after the Taxonomy of Bloom [2] - a set of hierarchical models used to classify educational learning objectives into levels of complexity and specificity. The taxonomy lists the learning objectives in three different learning domains - cognitive, affective and psychomotor, and the hierarchy implies that each level requires the knowledge and use of a skill from previous levels. Because of that, the complexity of each level of learning objectives increases with each level.

The *Cognitive* learning domain has been used the most to structure learning objectives, activities and assessments traditional education. It is broken down into six levels of objectives, listed below:

- *Remembering* the learning material. This objective involves activities like repeating, memorizing, remembering and recreating facts about the presented content.
- *Comprehending* - the ability to understand the facts by defining, interpreting and identifying facts and main ideas.
- *Applying* the learned material - involves demonstrating, exercising and using the learned material to solve problems.
- *Analyzing* - breaking down the material in composite parts to better understand it, see how those parts relate to each other and making inferences.
- *Synthesizing* is the ability to formulate new facts, statements and relations from elements of the material.
- *Evaluating* - making judgements about information in the material by presenting and defending opinions.

The *Affective* learning domain deals with how people feel towards other living things and what emotions they express. Just as in the Cognitive domain, learning objectives here are separated hierarchically and each task should be clearly defined. There are five levels of skills in this domain: *Receiving* (remembering and recognizing), *Responding* (reacting), *Valuing* (associating a value to certain knowledge), *Organizing* (learned material), and *Characterizing* (building abstract knowledge).

The *Psychomotor* learning domain is directly related to physical functions, reflex reactions and interpretive movements, used to manipulate a physical tool or perform a physical task. Originally Bloom and his group did not create any skills for this domain, but scientists proposed several hierarchies later [3]. Learning objectives defined for this domain include the following ones focused on building the behavior and/or skill of the learner: *Perception* (use sensors to guide motor activity), *Set* (readiness for a particular action or

experience), *Guided Response* (first steps in developing a complex skill), *Mechanism* (learning response is habitual), and *Complex Overt Response* (efficiently perform a complex motor act).

C. Categorization by Genre

The mentioned software applications can be divided into groups of related games that exhibit similar and unique set of gameplay characteristics. The list of games in a specific genre do not need to provide similar content, but rather common challenges and goals. Learning applications for children can fall under the following genres: *Instructive* (containing questions that test knowledge and skills in certain areas), *Manipulative* (learning through experimenting and manipulating pre built objects), *Puzzles* (electronic versions of traditional puzzle games), *Role Games* (guide the players through a set of practical social activities), *Simulation* (virtual simulations of given environments), and *Casual* (entertainment only games with little or no educational content).

D. Categorization by Subject

Categorization by subject separates applications in groups of closely-related interests and specific fields of study. Those categories include both academic subjects and extracurricular activities. The most general subjects for that age group are: *Reading and Writing* (learning a new language), *Mathematics* (arithmetic operations), *Sciences* (physics, astronomy, geography, biology, etc), *Social* (improving emotional understanding and other personal skills), *Arts* (visual arts, music, theater, movies) and *Hobbies* (developing personal interest).

IV. Analyzing Children's Development

The development of a child includes the sequence of physical, language, intellectual and emotional changes, taking place from its birth to early maturity. During that time, kids are progressing based on their parent's gene and the events in the prenatal period, as well as their surrounding environment and way of life. In addition to the natural stimuli, that progress can be actively accelerated and controlled through either established practices, or use of software applications for education and development of children up to six years old.

Children development includes all of the skills used by a child in real life, such as knowledge, social interaction and emotional control, language and speech, motor skills and sensory awareness. Many people think that everyone is progressing with the same speed, but this is far from the truth, which makes monitoring children's development very important. By checking certain stages of the age of a child, we can guarantee that it is going on the right track. If certain requirements for its age are not met, we can investigate further and look for any deviations from the normal path. The slightest deviation can be an indicator for a possible future diagnosis.

Issues with children development can be caused by genetics, prenatal circumstances, a current diagnosis or medical factors, and lack of opportunities or exposure to stimuli. A specialized evaluation can bring greater clarity about the development and degree of care of a child, as well as help formulate a problem and plans for solving the challenges. When resolving such problems, it is very important to act fast and with confidence, in order to reduce the differences in a child's and its peers' abilities, the trust and disappointment that the parents can face.

V. An Evaluation and Improvement Framework

To evaluate children's skills and abilities, identify knowledge gaps and propose steps for improvement, we designed a framework for monitoring and analyzing the level of individual and groups of children. It provides the ability to keep track of one's skill levels by manually adding a score for each record, as well as accept automated insertions by third party applications like games, educational software, kindergarten management systems, and medical software. The functionality is accessed by a platform, intended for parents, teaching and medical personnel, which can be used for tracing single child's development and weak points, or the performance of a whole group of children in a specific facility.

For tracking a child's individual skills, we chose an evaluation system where each skills is marked as either of the three states:

- *Able* - used when the ability is fully managed and can be by the child.
- *In progress* - indicates that the child is currently in the process of learning acquiring this skill.
- *Not able* - the child has not mastered the ability and is not currently learning it. If such a grade has been placed, it should be analyzed and acted upon.

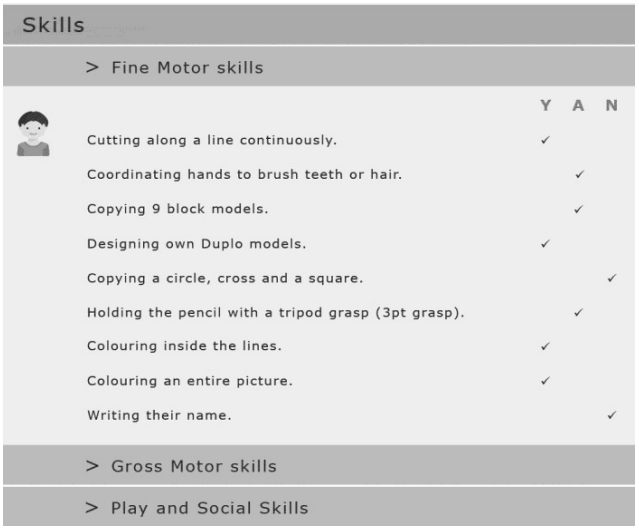

Fig. 1. Skill evaluation view screen

A sample screen for a personal skill report is shown in Fig. 1 above. The system displays a child's skills in groups, each one having the associated grade. The different skills monitored for each child are divided in several categories:

- *Fine Motor* - finger and hand abilities that rely on the individual's physical abilities. Examples: using of scissors (3-4 years), letter writing (4-5 years)
- *Gross Motor* - involve movement of the whole body. Examples: climbing stairs (3 years), jump on a rope (6 years).
- *Phonological* - the knowledge of sounds made by letters and how they are combined into words. Examples: producing rhymes (3-4 years), identify last sound of a word (5-6 years).
- *Play and Social* - participation in social activities associated with pleasure and enjoyment. Examples: role playing (2-3 years), changes the rules of the game (4-5 years).
- *Self-care and Organization* - performing and planning daily life activities. Examples: puts own socks and shows (2-3 years), makes friendships (4-5 years).
- *Sensory Processing* - registering and responding to sensory input. Examples: draws circles and squares (2-3 years), counts to twenty (5-6 years).
- *Stages of Language* - comprehension and usage of language through speech. Examples: sentences with a few words (3-4 years), follows the conversation (5-6 years).
- *Written Communication* - includes handwriting, typing, spelling and grammar. Examples: simulates reading while others are (2-3 years), word spelling (5-6 years).

The main purpose of the platform is monitoring the children's development via their skills' progress, and if needed, propose steps for improvement. The individual action plan suggested by the system may include traditional practices, as well as controlled usage of specific educational software. For example, a 4-year old kid that cannot write its name, is offered to receive help from the teacher in the regular kindergarten exercises, and also practice a mobile game for learning the alphabet, for a given amount of time. Such action plan can be viewed and managed by the platform administrators and users (parents, teachers and doctors), allowing it to be shared with others, searched for, and compared with other applicable schedules.

The three main types of users in the system are shown in the use case diagram, shown in Fig. 2 below. The *Administrator* role grants exclusive permissions for managing all parts of the platform – from each individual's profile to API management. Users with role *Teacher* have access to children profiles within a certain group, and the ability to generate reports with those profiles' data. *Parents* are limited to accessing only their children's profiles.

The definition of skill types and categories is organized in a taxonomy, stored as an ontology, inspired by previous work of the authors [4]. Such an ontological structure allows flexible definition of relationships between them, and easy derivation of sequences, combinations and substitutions of activities required to acquire them. The presented system will expose programming interfaces for full management of the users, skills, progress and recommendations to external systems. They will allow a young child's scores to be filled remotely by educational facilities like kindergartens, as well as by mobile software they use. By providing those core functionalities, the platform will give the opportunity to other developers and facilities to build extended solutions for their own scenarios, on top of it.

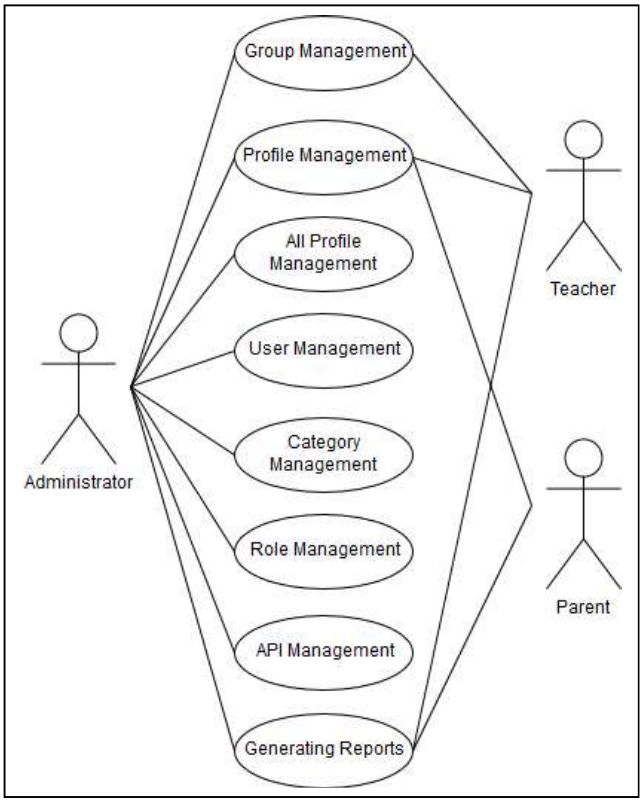

Fig. 2. Use case diagram of the system

VI. Conclusion

In this paper we described how educational software is used by children up to six years old and how different categories of such programs affect specific skills and overall progress of an individual. We also pointed out that any problems with a child's development can have serious consequences, and that brings the need for a reliable framework for monitoring and evaluating that process. Last, we introduced a platform for supporting the core requirements for tracking, evaluating and suggesting improvements for different skills and activities required for each state of the development of young children.

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