

Evaluating Tangible User Interface-based Mobile-  
learning System For Young Children

BY

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# Abstract

“I never try to teach my students anything, I only try to create an environment in which they can learn.”

Albert Einstein

Recently, young children’s educational behavior has become a popular topic for researchers seeking to help develop their skills and abilities in a pleasurable manner. Lately, we have seen the emergence of several communicational units that include powerful and advanced technologies, such as mobile devices. In fact, according to a CISCO report, ‘in 2012 the numbers of mobile-connected devices in circulation are greater than the number of people on earth. By 2016 there will be 1.4 mobile devices per capita, and there will be over 10 billion mobile-connected devices, including (M2M) modules, exceeding the world's population at that time (7.3 billion)’ [1].

In this thesis, we introduce a mobile-based edutainment system called ‘Tap and Learn’ that targets young children and aim to assist them in developing their learning abilities and social communication skills. The Tap and Learn system allows children to learn about new objects and entities in their environments by simply tapping over them with a RFID-mounted smart phone which responds by producing a set of multimedia feedback that aims to foster their learning skills in an entertaining manner. The M-learning system does not require y special tools or environments to be operated and required minimal literacy levels. In addition,, the system enable the parents to participate in their children's learning by allowing them to personalize the learning material and the media content of the games so they suit their children's cognitive level and their learning wants.

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# List of Abbreviations

**AR** Augmented Reality

**CCI** Child-Computer Interaction

**CBL** Computer Based Learning

**CISCO** Computer Information System Company

**CSCW** Computer Supported Collaborated Work

**ELT** Experiential Learning Theory

**GUI** Graphical User Interface

**HMD** Head Mounted Display

**HCI** Human Computer Interaction

**HCI** Human Computer Interface

**ICT** Information and Communications Technology

**LAN** Local Area Network

**M2M** Machine-To-Machine Modules

**MXML** Minimal XML

**M-learning** Mobile Learning

**MoLeNet** Mobile Learning Network

**PDA**s Personal Digital Assistants

**RFID** Radio Frequency Identification

**SRL** Self-Regulation Learning

**TUI** Tangible User Interface

**3D** Three Dimensional

**2D** Two Dimensional

**USB** Universal Serial Bus

**VE**s Virtual Reality Environments

**XML** Extensible Markup Language

# CHAPTER 1

## 1.1 Introduction and Motivation

In recent years, educational technologies and computer programs have been developed in different ways, especially in regards to children's education. It is well known that childhood are the time for brain development and shaping during which humans can learn more quickly than at any other time in their life. Also, at this age they can learn a lot while playing. For example, in that age group, children learn social behaviors, logical thinking, skills, and emotional abilities. One of the main systems that can be used for children's education is the M-learning system, that is a combination of both E-learning and Mobile device computing [2], together with wireless and mobile phone networks, in order to develop, support, and provide rich teaching and learning environment (MoLeNet Project in UK) [3]. Moreover, the authors in [4] considered the M-learning system as a part of the flexible learning system, as shown in Figure 1.1, they described M-learning as an activity that gives users the ability to be more creative when interacting with their environment, or generating information through the use of a compact digital, moveable device that can be carried normally and fits in a purse or a pocket. Depending on the learner's requirements and available technologies, flexible learning methods evolve and the learner can work via her\his mobile devise, anywhere and anytime, in a more effortless and enjoyable

manner [5]. The combined usage of a multimodal edutainment system centered on a handheld device has the potential to deliver a rich experience for collaborative learning, with tasks not limited by physical location such as with the use of a traditional desktop personal computer [6]. Lately, a number of studies have focused on the term edutainment, which means combining both education and entertainment to provide young children with a learning environment that is more attractive, joyful and of greater assistance to them [7] and [8].

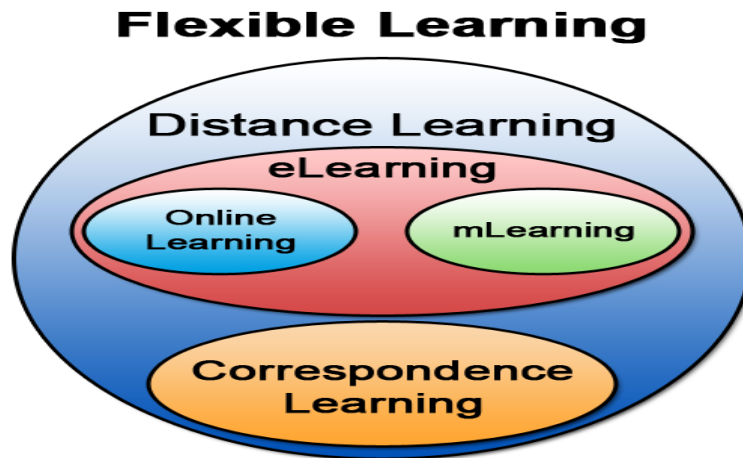


Figure 1.1: The Subsets of Flexible Learning. Adapted from Brown, T.H,(2003). [4]

Edutainment and technotainment theories have been completely transforming the correlation between playing and learning. Since the early 1990s, interest has risen in developing edutainment systems for children. More specifically, applications that possess the attractiveness of electronic games while helping the child attain certain educational objectives [9]. Researchers in [10], [11] stated that adding some multimedia technologies to the learning area can clearly make it more pleasurable, successful and beneficial. In addition, Edutainment is an involving

alternative to traditional education method, according to [12], [13] and [14] it can be divided into the four following categories:

- 1) Edutainment by purpose and content
- 2) Location-based Edutainment
- 3) Edutainment by target group (i.e. age group)
- 4) Edutainment by type of media (i.e. includes edutainment on TV, smartphone, computer, Internet and web-based educational systems).

Most of the edutainment works can be divided into the above mentioned categories. A group of researchers designed learning tools and systems to maintain the interactive storytelling [15] [16]. Other works supported learning skills such as painting by developing computer applications that offer a way for children to share their ideas and thoughts [17] and [18]. Additional works supported M-learning which can help develop several basic skills such as reading and writing, in a simple, attractive, and joyful manner, since they do not require special skills to use. They can also be applied inside and outside the home, and at any time. There are many benefits to be gained from mobile learning through collaborative, and constructivist learning environments [19].

The commercial market does have a lot of educational toys and games that target young children, however, these toys provide minimal educational benefit for children's learning due to their limited educational materials and the difficulty of physical movements. Furthermore, in the last few decades, some projects developed by researchers in the field of E-learning contained fascinating, enlightening and pleasurable programs and systems for children's education. Unfortunately, most of them required too much interaction, which is not suitable for young

children who are at a very early stage of learning [20]. Most of them also did not support physical movement, an important aspect of children's learning [21]. Some works such as in [22], [23], and [24] did support the M-learning systems that have an educational component for young children, giving them the chance to learn and have fun anywhere, and at any time, with the use of a mobile device that is attractive and lightweight, and provides several physical actions and an Internet connection. However, the majority of M-learning systems require parental control and assistance while their children use the different software on the mobile phone. Plus, those systems support more the entertainment field than the educational field. Most of the works that have been published in the domain of edutainment and M-learning do have shortcomings, as will be discussed later.

After studying existing systems for the education and entertainment of young children, in both the market and the literature, we have developed an M-learning edutainment system that can fit the needs of both toddlers and young children, and that can be used for various stages of learning and at different levels of abilities. The aim of this thesis is to evaluate the M-learning edutainment system for very young children, to analyze whether it fit and support their learning experience, technical skills and behaviors, while they are having fun. This thesis also aims to learn from existing educational games, both E-learning and M-learning methods and edutainment systems.

## 1.2 Existing Problems

In the domain of young children's edutainment, there are many problems that researchers tried to solve and implement. In this section we grouped the essential problems according to the

system's characteristics or the achievement goals of those studies. These problems are summarized as follows:

- Some existing systems required specific places or large physical areas such as laboratories or cave technology as in [25] which is unsuitable to deploy in schools or at homes. As a result users prefer to use those systems for experimental reasons.
- Most of the systems could create some health, physical or intellectual problems such as vision problems since users might sit in front of a computer for many hours. Also, there is a lack of interactivity among users who utilize them, and between the systems and the users themselves such as in [26] .
- Several existing systems like [15] have focused on the entertainment aspect and almost neglected the learning objective.
- A number of existing systems are expensive and therefore unaffordable for many because they include high quality modules and functionalities, as well costly input tools such as HMD in [27] and [28], while other systems need particular peripherals that are sold individually.
- Some existing systems limited the user's play space due to the numerous cables they required for operation. These systems therefore create an uncomfortable environment for users such as in [29].
- Several existing systems were not suitable for children's abilities and required high technical skills such in [16], while other systems did not enable parents or teachers to customize the learning contents to meet their children's needs.

### 1.3 Objective and Contribution

This thesis contains two parts. The first part of our work is a theoretical overview on the improvement of the educational and entertainment fields, and an illustration of mobile learning technologies, as well as a background on why we are using the M-learning edutainment concept. In addition, we discuss why the M-learning edutainment concept is an important factor in young children's learning environment. The second part of this thesis discusses the process of both the pre-evaluation and the post-evaluation of the system also includes some implementation details. In our M-learning edutainment system, young children are able to obtain additional information about topics they learned about through the utilization of visual and audio presentations such as, image, text, and audio. In essence, the contributions of this thesis could be stated as follow:

1. Conducting a preliminary study with young children's parents that aim to help us determine the parent's level of acceptance of mobile-based technology and the features that could potentially lead to a better learning and playing experience.
2. The design and implementation of a mobile-based edutainment system that incorporates RFID technology. The system aims to promote learning through play by allowing children to increase their knowledge about new entities by simply tapping over these objects.
3. The quantitative and qualitative evaluation of the edutainment system with fifteen children. The quantitative assessment was based on a number of educational and behavioral parameters adopted from the self-regulated theory model.

## 1.4 Questions

This thesis deals with specific issues concerning the development of an M-learning edutainment system for young children. We are trying to identify the best ideas from various existing systems for our target area and integrate them to our system. Our Tap and Learn system's software will be installed in a mobile platform that will be explained in upcoming chapters, along with its advantages and disadvantages. We will also evaluate the Tap and Learn system to see how its results cover young children's learning requirements and interests. The following major questions will be considered and will work as a guide when studying related research in the following chapter:

- What types of educational systems are currently available?
- What educational methods and ideas are used to develop children's learning skills and enrich their experience?
- What are the limitations and advantages to children from the use of those systems?
- How do users interrelate through the system?
- What can be learned from these experiences for upcoming work?

## 1.5 Publications

1- Rajwa Alharthi, Rania Albalawi, Mahmud Abdo, Abdulmotaleb El Saddik, "A context-aware e-health framework for students with moderate intellectual and learning disabilities" in Proceedings of the 2011 IEEE International Conference on Multimedia and Expo (ICME), July 2011, Barcelona, Spain.

## 1.6 Thesis organization

**In Chapter 2** We introduce our Tap and Learn system, followed by overviews of related or similar concepts. We will then compare the related works to one another and to our system, based on certain defined learning criteria.

**Chapter 3** Is about the pre-evaluation of the Tap and Learn system and includes an online questionnaire that parents answered.

**Chapter 4** Presents the proposed Tap and Learn system, with details about the design phase including the RFID based TUI method. We will also discuss the overall system architecture and provide an explanation of both hardware and software modules.

**Chapter 5** Presents the Tap and Learn system's evaluation of performance, usability, and learning experience for young children, obtained through numerous test cases and qualitative and quantitative evaluations. This chapter contains more details about different game scenarios that are involved in our M-learning edutainment system.

**Chapter 6** Presents the conclusion of the evaluation of our Tap and Learn system and indicates our vision of future work.

# CHAPTER 2

## Literature review

### 2.1 Background

During the last few years there has been great demand for the design of edutainment tools that can provide children with means of being entertained and educated, simultaneously. Actually, computers, tablets, mobile phones and other efficient technologies target young children's educational attitude and are trying to encourage healthy behaviors. Researchers have done many studies resulting in the development of diverse edutainment systems, varying from specifically entertaining softwares to educational games. These studies and methods incorporated attractive multimedia tools such as 2D and 3D virtual world animation, personal digital assistants PDAs, web cameras, video projectors, multi-touch screens, tablets, drawing tools, digital compass, mobile-phones, and others, providing the best learning environment for young children in effortless, high quality and comfortable ways. Moreover, each of these preceding works has its own concept, learning and interaction style. Learning styles are the way that information is most easily absorbed, developed, and applied by an individual. They are usually divided into three different methods of learning. Auditory learning includes listening and speaking as major ways

of learning, visual learning includes seeing and reading as the main ways of learning, and finally tactile learning includes several actions or physical activities [30]. The majority of the proposed works that have been done, however, require a minimal level of motor and computer skills, as there are many interactions that are not suitable for young children who are limited in their writing, reading and speaking abilities. This fact has made it very hard for young children to benefit from these tools since they don't have the abilities to deal with such systems. Some of the proposed works have been done using mobile-phone so that it can easily fit into the users' lifestyles as an entertainment and educational tool, but few of them paid much attention to young children or dealt with them as a central user. The following section is a literature review about the different methods that researches have used in the field of edutainment for young children. It also includes several aspects and learning criteria that we developed in our edutainment M-learning system.

## 2.2 Computer Software Method

There are several computer software that have made an impact on children's learning and have therefore modified their behavior. In fact, almost in every household or school we find laptops and/or desktops containing different useful and functional software for children's edutainment, aimed at enhancing children's communicational and educational abilities. For example, FaTe2 is an edutainment system that targets children between the ages of 8 and 11, and gives them the opportunity to explore, play, communicate and build their own stories in a collaborative environment [17]. Nowadays, children are using computers from an extremely early age but they still face difficulties when they are dealing with both hardware and software, since it often isn't appropriate for kids, particularly of younger ages [31], [21] and [32]. Also,

computers are not flexible and are not made to be used in an outdoor environment, so it is hard for children to move or to do several physical activities while using one.

### 2.2.1 KidPad

[33] Presents a collaborative storytelling tool called KidPad, which improves children's story related skills such as typing and drawing. KidPad targets elementary school children (6-11 years old) and allows collaboration among participants by accepting inputs from more than one mouse at a time. Consequently, every child in a group can paint, zoom or pan simultaneously, using their own mouse and as a result see their actions, as well as the actions of the other children, on the screen. KidPad has many local tools that act as a cursor, and each one of them represents a specific mode, as shown in Figure 2.1. Every tool symbolizes a specific communication mode. For instance, a red drawing crayon is able to draw in red at its existing. By using KidPad, children can develop their mental ability by sharing their ideas and stories, represented by their shared drawings. The tool lacks a vocabulary mechanism though, which would be a good feature to help children develop their linguistic skills.

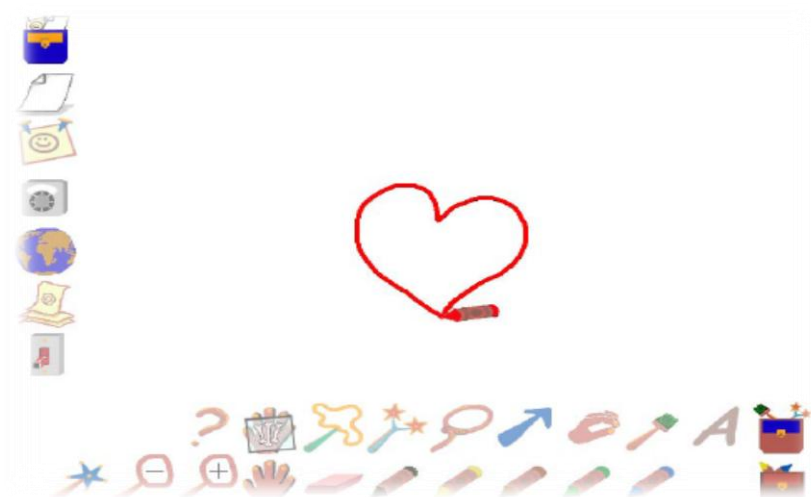


Figure 2.1: KidPad with all local tools.

### **2.2.2 Hopscotch**

[8] Presented an interactive game for young children called Hopscotch. The game uses a computer music technique and is considered an edutainment tool since it has a physically interactive component. Hopscotch includes the sounds of various animals and cartoon characters to progressively make children observe the world of digits, music, and sound. Children can also create many music elements involving pitch, rhythm, timbre, etc, to make the polyphonic effect while other participants contribute to the game. Hopscotch offers a joyful and physical environment for children to play, with the help of interactive computer music, but it is simply good intentions. The music alone cannot work to increase children's learning and mental abilities. Figure 2.2 shows a child playing the Hopscotch musical game.



Figure 2.2: Hopscotch Music Game Played.

### **2.2.3 DEGS**

[34] Presented the DEGS system, an experimental development of a competitive digital educational game for young children (5-6 years old). The game uses a multi-touch screen and

includes several learning objectives such as verbal-linguistic. The four goals of DEGS are game context, education, game role, and interaction control, and each one has a specific target. For example, the game context is from the TV, books and the adult world, while the interaction control is to choose a set of actions children assume will meet the challenges. Also, DEGS contains the following four game samples: Words Master for Verbal-linguistic Intelligence, Who's faster for Logical-Mathematical Intelligence, Sound Detective for Musical Intelligence and Patch Socks for Visual-spatial Intelligence. DEGS is considered a competitive game because the screen is divided into two parts (left and right), one for each user. However, young children should not play by using DEGS for a long period of time, since looking at a computer screen for too long might damage young children's physical development, for example their eyes. Figure 2.3 shows some young children while they consult and play in turn in the DEGS learning system.



Figure 2.3: Children playing by using DEGS educational system.

#### **2.2.4 Tikatik**

In [35] researchers created a web2.0 service called Tikatik. It was designed to assist kindergarten students (4-5 years old), in a digital storytelling creation by using a book-like format which is

used to examine the effect of the digital medium ICTs in it. The Tikatik system uses fairy tales to encourage children to complete memory exercises, to expand their thinking, to increase their imagination, etc., to help improve the critical and creative thinking of the students. The Tikatik system aims to enhance kindergarten student's motivation toward learning, as well as their imagination, creativity and expression. It is easy to use since Kindergartens are able to demonstrate their story instead of writing it. It helps them easily demonstrate their story since it has an uncomplicated method of acquiring, from the Internet, images that add importance to their story. Figure 2.4 shows the Tikatik system's interface and includes text and image multimedia outputs as well as several input features such as the writing techniques section containing ribbons, plain paper, erasers, colored pencils, etc.

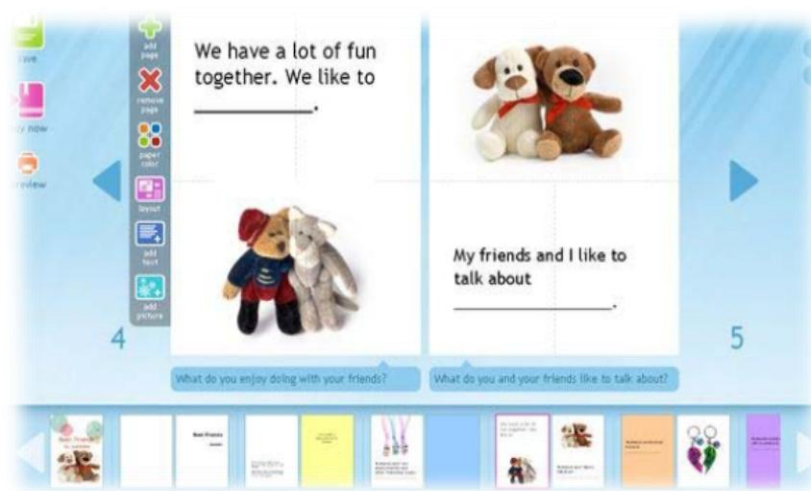


Figure 2.4: The Tikatik service User Interface.

## 2.3 Virtual Reality Environments Method (VEs)

Another approach used for children's edutainment is the virtual reality environment that is considered a multisensory interactive computer-based environment. It offers the opportunity for the user to become a dynamic participant in a virtually actual world [36]. VEs are considered a safe environment and include realistic 3D scenarios that reflect daily communication scenarios with this technology, learners are capable of making the transfer from the “learning by doing” to the “doing is learning” procedure [37]. VEs have great educational potential since it permits access to the inaccessible or the unrealizable, by supplying multiple and alternative presentations [38]. There have been two VEs methods that researchers followed for edutainment: the immersive learning environment, and the augmented reality environment, depending on whether users are completely or incompletely immersed in the environment. Unfortunately, a virtual environment cannot be built anywhere because it is very expensive and requires particular tools.

### 2.3.1 NICE

Researchers in NICE [25], [39] designed an immersive participatory learning environment for young children (6-10 years old) that relies on the automatic virtual environment called CAVE, and contains a multi-user, room-sized VR system. Children are able to interact in the CAVE through a simple device with a joystick and three buttons called the wand. They have to wear special glasses to interrelate and see both the physical and virtual world. In the NICE learning environment, children's major activity is to collaboratively create, cultivate, and tend a healthy virtual garden. The system also provides the children with the opportunity to create their own stories and share them with other children in the same virtual space. In addition, children in

NICE can learn together in both the same physical location as a group, or from remote locations. Through the NICE system, children can cooperate with VEs objects in their virtual environment, to gain knowledge of ecology and social communication, which will help enrich their life experiences. However, such a system needs special requirements to function, for instance a special laboratory, which makes it very expensive and difficult to create in a school or home setting.

### **2.3.2 Augmented authoring application**

[40] Implemented an augmented authoring application that contained a sensitive video annotation method to generate multimedia contents and information about real physical objects, through 3D augmented visualization schemes. By using normal hand gestures, users in this edutainment system are able to interact with the physical objects within their learning environment, in a pleasurable manner. For example, if users place their hand over a physical object, some related information about it will come into view on the screen or be projected on the wall. They can also interact with the system using their voice and can see themselves in the view as shown in Figure 2.5. Users can easily continue learning about several physical objects that interest them, with timely feedback and haptic features to assist them in developing their abilities. There is a limitation to this system though, since no more than two users can interact and collaborate with it at the same time. Also, the varying distance between both users and the camera will increase the processing time of the system.



Figure 2.5: User while interacting with the real physical objects.

### 2.3.3 Tangible Cubes

[28] Investigated an AR game called "Tangible Cubes" which consists of an interface used to teach children (7-12 years old) about endangered animals in a simple and enjoyable way. In the cube faces, children can find images as well as explanatory videos that describe the endangered animals and their physical characteristics, as well as the types of food they eat, their habitat, and an explanation of the cause of extinction of those animals. Figure 2.6 shows a boy trying the Tangible Cube interface, which is similar to Magic Story Cube [27]. In addition, Tangible Cubes has three cubes that include symbols or letters to show images, videos and information that are related to the endangered animals on the screen. However, Tangible Cube only supports 2D, and children using this game can therefore not see the animals from different points of view as if it was developed in 3D.



Figure 2.6: Shows a boy trying the tangible cube interface.

### **2.3.4 Digestive and circulatory AR systems**

Researchers in [21], created AR system for children (10-11 years old) as an emerging technology, educationally interesting as it can help increase student motivation and supports the teaching procedures in educational contexts. This system targets elementary school students in order to explain the digestive and circulatory systems in an easy and attractive way. It includes three learning applications that include a major menu with many buttons on both the right and the left side of the screen: the digestive system without animation (to show digestive organ in details), the digestive system with animations (to add functionality to the digestive organ), and finally the circulatory system (to show circulatory organ in details). Figure 2.7 shows the major menu and the AR marker used as a mouse. It also shows a child while he is discovering the heart section, and includes correlated textual information. In this work researchers developed a software library called HUMANAR [41] to support the improvement of Reapplications. Furthermore, the AR system has many sensory modalities for sight, hearing and touch, which make students more involved in the educational process. However, during the experimental

phase, researchers found that students preferred to use the regular mouse because the AR marker was difficult for them to use.



Figure 2.7: The major menu and AR marker used as a mouse also e.g. of heart section.

## 2.4 Tangible User Interface (TUI)

Recently, researchers discovered the usefulness of TUIs, defined as “devices that give physical form to digital information, employing physical artefacts as representations and controls of the computational data [42]. TUI is much easier and more interesting than other interfaces for HCI [43]. It has many competent features, one of which is the fact that it encourages collaboration between learners in the same environment, since it maintained the Computer Supported Collaborated Work CSCW. TUIs for young children have massive benefits since they can interrelate with the digital information by physical methods, and the edutainment environment is easier for them. However, TUI usually makes the learning process for children

more about pleasure than learning, which can definitely affect their progress and might make them inattentive.

### **2.4.1 I/O Brush**

Researchers in [18] designed a visual art tool called I/O Brush, which targets young children (4 years and up) and gives them the opportunity to explore materials and objects around them, helping them develop various skills and behaviours. I/O Brush is a drawing tool that allows children to choose objects from their environment and use that colour in order to paint their personal drawings. I/O Brush has two components: the regular brush and the drawing canvas. The brush has many embedded elements such as optical fibers, a CCD video camera, lights, and touch sensors, as shown in Figure 2.8-A. When it is swept over an object, the brush can extract the object's colour, movement and texture. Later, the child can use the brush to draw his own painting, on the canvas, with the colours that the brush extracted. I/O Brush is considered an interesting tool for children to play with and to use to explore objects around them, as shown in Figure 2.8-B. However, it tends to be more of an entertainment tool rather than an edutainment one, since the learning boundaries are limited to colours.

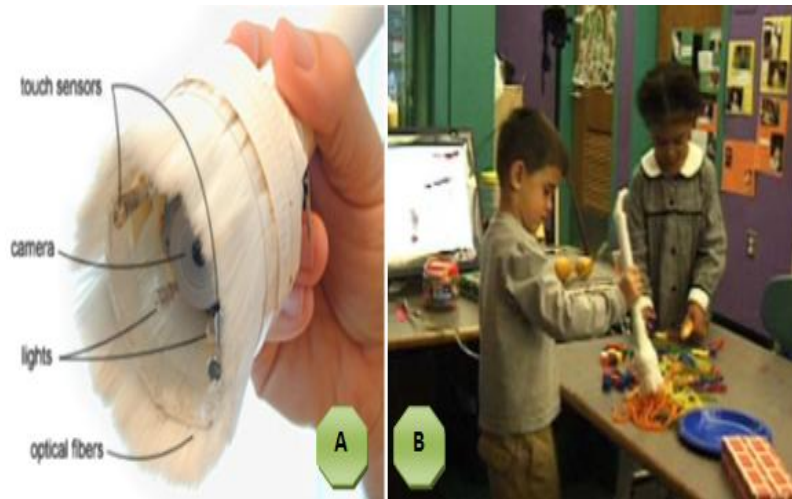


Figure 2.8: A-The I/O Brush tips, B- children while exploring materials by using I/O brush.

### 2.4.2 TOK

[44] Presented a tangible platform for storytelling called TOK, which assists preschoolers (5 years old) in improving their skills and self-regulated learning, by creating their own stories. These stories include rational relationships between diver's characters as well as objects. TOK includes a set of pictures and a platform which consists of a two page book. The left page of the book consists of 15 rectangular marks where children can place their picture cards, while the right side consists of a Portuguese version of the classmate PC. Figure 2.9 shows the TOK tangible interface. The picture cards in TOK represent just one element, and are divided into three basic views: places, locations, and objects. Also, the pictures are shown as an animation once they are placed on the left page, and each one has audio related its drawing. Children do not have to use all of the 15 cards when they build their own stories. Instead, they can modify their stories by adding or removing cards, or changing their position, in order to begin a new story. In addition, whenever a child places a new picture card on the left page of the book, they can hear corresponding sounds that they have created with their own voice. TOK can be used as an

inexpensive edutainment interface for storytelling in the classroom, and allows for the development of children's skills, either individually or with other children.



Figure 2.9: The TOK tangible interface platform.

### 2.4.3 Magic Stick

Researchers on [7] designed a Magic Stick tool which is considered as an edutainment tool for young children to help them learn and understand the name of different objects in their environment. Magic Sticks use an RFID reader to tag different objects, and when children tip on it the system shows the object's name, as well as several pictures, in order to offer better understanding and help with memory. In Magic Stick, parents and teachers have the ability to determine the qualities and names of suitable images to appear on the screen. They can also add or remove images from the database and web service interface. This system includes different elements such as an RFID reader, a Bluetooth chip, and a software application on the computer. For instance, when a child is reading a book he has the ability to use Magic Stick to touch a word or a picture, for example a bear the system will respond by saying "I am a bear", and showing additional bear pictures. Figure 2.10 shows a child using Magic Stick in the experiment. Children

can use this system individually or with a partner, and at home or at school, since it is not expensive and is easy to us.



Figure 2.10: A child using the Magic Stick edutainment tool.

#### **2.4.4 Reactoon**

[45] Presented a storytelling tool called Reactoon, in a tangible environment for children (5-9 years old). It is an authoring tool used to build 2D animations from a tabletop, with a tangible user interface and a multi-touch screen, so users do not need to read or write while using this application. The Reactoon system has its own communication protocol called Table-Top Tangible User Interfaces TUIO [20]. It is developed for a tangible interface tablet, to characterize the properties of control objects (fiducially markers) and finger gestures on the tabletop surface. For example, a user can delete a character by making a small dragging movement on the selected character to be deleted. Reactoon has been specifically developed to help meet the requirements and expectations of children in the creation of their personal stories. The main focus of this system is the animation production which created from a natural interface that can utilize the tools quick and instinctive achievements. Figure 2.11 shows users creating an animation. By

using this system in children's classroom, teachers can offer an interesting environment, stimulating children's learning because of their interest in these resources. Users also have the ability to watch other stories that were created and build their own new stories, including interesting characters and positions, based on previously formed ones.



Figure 2.11: The Reactoon System while users creating an animation.

## 2.5 Commercial Edutainment Products

Browsing the commercial market, we found numerous toys and games targeting young children (birth-10 years old). Indeed, educational tools have made rapid progress in the commercial market and offer an ideal environment for children to enhance their learning abilities and behaviours. Nowadays, those tools can be found in every child's home, with different goals, prices and purposes. They target different age ranges, according to the features they provide for children, and assist in increasing children's motivation and ability to focus. The tools may even enhance their cognitive skills such as problem solving, organization, and critical thinking.

Unfortunately, most of the commercial games are similar to the TUI since they support the entertainment aspect more than the educational one. As a result, users tend to lose their focus on the learning contents. It is also easy for children to get bored from their game, especially if it does not have different kinds of games adapted to various skills and abilities. However, the opposite might also happen, as they might become addicted if they spend too much time playing, which can cause several health and social issues. Even though these commercial children tools and games incorporate various educational capabilities, they still limit the benefits from learning because of their stationary nature.

### **2.5.1 LeapSter2**

Researchers in [46] designed an edutainment system called LeapSter2 from LeapFrog. Through diverse games, LeapSter2 supports children's reading skills such as learning the right words and vowels, as well teaching them fundamental math operations and different object's shapes. Moreover, by using LeapSter2, children can upload their drawings and share them with peers through an online creativity studio. This can be done via a USB connecting LeapSter2 to the computer. Parents can also see their children's paintings and activities by accessing the online LeapFrog education path. They can therefore recognize their children's habits, abilities, and progress, and can help their children improve their skills and behaviors in their real environment.

### **2.5.2 VTech Baby's Learning Laptop**

In [47], researchers designed a laptop toy called VTech Baby's Learning Laptop, that targets very young children (6 months and up) who tend to imitate their parent's actions. Baby's

Learning Laptop easily catches the attention of young children with its colourful design and the flashing lights produced when pressing certain buttons. In addition, Baby's Learning Laptop works under three different modes. In the first mode, children can learn the names of different shapes that this toy incorporates as buttons. For example, if a child presses a button that has a horn's picture, they will hear the word "horn", while lights flash on the laptop screen. The second mode gives a description of the objects drawn on the screen. Once the child presses a button, only one light of that particular drawing flashes, with a small sentence concerning that object. The third mode is meant to give children pleasure by playing a set of pre-saved songs, music, and sounds, once a button is pressed. The Baby's Learning Laptop is actually a very nice and entertaining toy for very young children. However, it would be much more beneficial, in our opinion, if visual representations were shown, since it would greatly influence not only the interaction of the children with the toy, but also the learning experience. It is also worth mentioning that such toys would suits the needs of pre-school children and kindergarteners.

### **2.5.3 Family Story Play**

In [48], researchers presented an entertainment system called Family Story Play which supports young children's (2-3 years old) communication skills with dialogic reading activities. In Story Play, children can interact with long-distance family, who can teach them how to develop their literacy by using a reading book over video chat. Figure 2.12 shows a child using the Family Story Play. There are several aspects to the system: a tangible book reader which has removable book pages, a camera, a microphone, video conferencing technology, and numerous book readers that are linked together via a wireless internet connection. The main functions on the Story Play interface is a character called Elmo (the Sesame Street Muppet Elmo), who works as a guide for young children, and assists them while they are using the system and having fun with it. This

system can improve children's social skills, dialogic reading methods, and their engagement in long-distance communication. However, children still need their parents to help them employ this system properly.



Figure 2.12: A 2 year girl interacts with her relative.

## 2.6 Mobile Learning Method

In recent times, mobile learning as a combination of both mobile computing and E-learning [2], has developed and presented new opportunities and technologies to the field of children's learning. These can be used at various times and locations [49], [50]. Different studies prove that the use of M-learning for children can improve several of their basic skills such as reading and writing, and can be accomplished in a pleasant manner. Children have the ability to participate in M-learning activities individually or in a group. For example, in [51] focused on mobile devices to encourage lifelong learning. E-learning with mobile functions is progressing with the advance in wireless equipment that is also facilitating the rise of M-learning. For instance, users can

access M-learning lectures in both indoor and outdoor environments [52]. Mobile learning helps children participate in learning activities in several ways, all the while discovering various physical environments such as parks, woodlands, their home or a lab [53].

### **2.6.1 Strega Comanda Colore**

In [22], researchers created an M-learning application for smartphones that mimics an outdoor Italian game for children named Strega Comanda Colore (Colour Commanding Witch). In the English culture it is called “Simon Says”, but with the aim of finding colours everywhere, with good visual effects. This kind of game is considered a collaborative entertainment game because it allows children to play with it by themselves or with others. For example, in the individual mode, the system itself is considered a server (witch) who can select a colour at random and ask the child to catch a picture of an entity that has the selected colour. The child must accomplish this task before the time runs out. The difficulty level and amount of time can be modified by the user. In the multiplayer mode, possible through the use of Wi-Fi or Bluetooth, one of them can play the witch who selects the colour, and the other must find it. This game is considered an interesting activity as well as a learning platform for normal and mentally deficient children, and can even be used as a rehabilitation tool for children with mental disorders. The down side though is that this application can only recognize a definite number of colours (purple, red, blue, cyan, orange, yellow, green) and that children cannot play this game using simply a regular desktop PC.

### **2.6.2 Gymkhanas**

[54] Presented an M-learning game called Gymkhanas that consists of different challenges to be met, these challenges are a type of learning activity and applicants can develop skills while having fun. Gymkhana contains both physical and intellectual activities, but does not require high technical knowledge or special skills because of its simple web interface. Its limitations are that players cannot move or be notified about the next challenge until they have solved the current one, so it is extremely intensive. Also, there is no help for groups if they have a problem during the challenge or if they get lost. Since Gymkhanas can be installed in the android smartphones, applicants can employ the GPS in order to track their current position. The three main challenges as part of the Gymkhanas game is Textual challenges, Photographic challenges, and augmented reality challenges. For instance, the Geopositioning button in Photographic asks you to go to a specific position to take a picture, and gives you the location and Google map directions for it. Figure 2.13 shows a screenshot of a photographic challenge before and after the player has selected a picture to be sent as a response.



Figure 2.13: A screenshot of a photographic challenge before and after the user has selected a picture to be sent as response.

### 2.6.3 KCEC

[55] Presented an English learning system called the KNU Children English Class E-learning (KCEC). This system uses both a smartphone and a web application to educate children while they stay at home. The KCEC system has three fundamental learning contents based on new core framework: word dictation, multiple-choice, and arrange the word, with diverse courses and different difficulty levels. Through the course administration page in the KCEC system, the manager has the ability to modify, create, and delete any content. During the implementation of this system, researchers solved several technical problems and presented faster loading times per page, and created an easier user interface for children to use, as shown in Figure 2.14. The KCEC system helps children study faster and more easily, and the use of a smartphone makes the learning more interesting for them. However, it is difficult for very young children to use such a system since it supports the learning aspect more than the entertainment one.



Figure 2.14: A snapshot from the system in both web and smartphone applications.

### 2.6.4 uLearn

In [24], researchers developed an M-learning application called uLearn, for children (8-9 years old), that supports independent learning by using smartphone technology and GPRS data network. By using a smartphone camera, children can access a large repository of multimedia that assists them in gathering information about different animals in their surrounded environment. These could be small mammals, insects, fish or birds. With their own smartphone, each child is able to take a picture of the visual codes that are attached to a target object, or close to it, after which they can download information related to that object such as animal images, noises the various animals make, and other detailed information about the animal they were observing. The child can also ask questions such as “what is that?” in order to receive various multimedia contents related to their current positional context. Despite the short tutorial session provided during the evaluation of this system, however, children found it difficult to take an image and capture a visual code.

### **2.6.5 ALC**

[56] Presented an M-learning system called Augmented Learning Content (ALC) for children (8-13 years old), to help them identify real images rapidly and accurately, on-line or off-line, by using mobile devices without space limitation. ALC proposes a blended learning approach, combining off-line content with several multimedia tools on the mobile, and by using the existing method and a high-resolution camera to identify the off-line contents. ALC contains an English dictionary for children, and has three types of educational multimedia content: English spelling, an audio stream and a video stream. These are used to examine children’s different basic skills such as listening, writing, and reading, and to determine the efficiency of such a system in their learning. The ALC system improves children’s skills in a simple and attractive manner. For example, by using their own camera device, children can take images from several

pages of an English book, and then ALC transfers each image to the database. The system then accesses the stored on-line contents that match the captured image, and displays the information for the child using multimedia, as shown in Figure 2.15. The ALC system has two main problems which are its sensitivity to the light and its surrounding environment, and also the fact that it is not easy to use ALC in real-time because of the low computational resources of a smartphone.

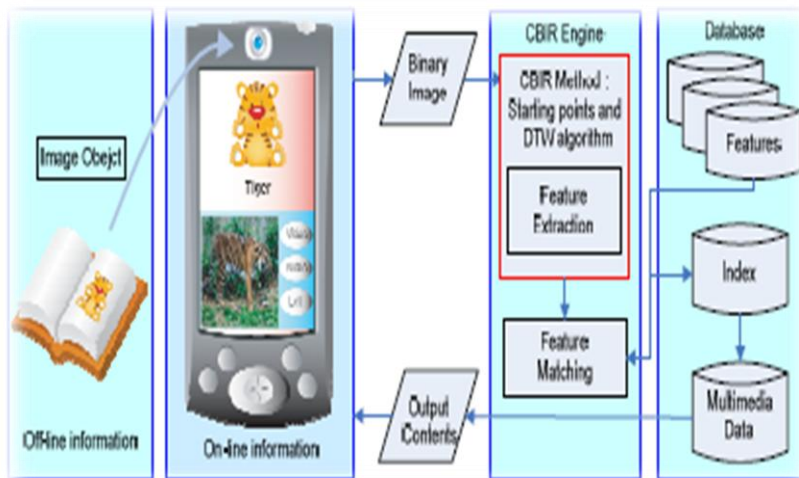


Figure 2.15: ALC system overview.

## 2.6.6 Excursion-game

[57] Presented an M-learning system called excursion-game that targets middle school students to assist them in obtaining historical awareness while playing and having fun. The Excursion-game system aims to enhance the student's experience of historical locations at a minimum cost and with simple architecture. It includes the Game Application which runs on any smartphone, and the Master Application that exists in the game's master notebook, compatible with Bluetooth or a memory card reader. Researchers in the Excursion-game system aimed to assess student's experience while playing the game with, and without, technological support. The evaluation of

this learning system contained diverse stakeholders including students and teachers, expert's historians. It also recognizes student's engagement in the game and their skills improvement by giving them a simple multiple choice test on the day after the visit, or asking them to write an essay in school. For example, Excursion-game is good for students since it makes them feel various emotions, stimulating their imagination and curiosity, and keeping them focused on the learning experience, with less interruption. Figure 2.16 shows a snapshot of the Excursion-game system while children play with it.



Figure 2.16: The 3D reconstruction of the Trajan Way visualized on the phone (left) and the existing remains (right).

## 2.7 Summary and Comparison

This section provides a summary based on the above review of existing literatures. The different aspects that we summarized are:

- a- **Age range:** The user’s age range that contributed in every system’s evaluation, or the ages mentioned in the author’s work description.
- b- **Physical movement:** The body movements necessary to communicate with each system.
- c- **Suitability for in/out environment utilization:** If the user requires a static or dynamic position, or if a specific location and space is necessary to utilize each system.
- d- **Output Multimedia:** different outputs that come into view after the user interacts with each system.
- e- **Customization:** whether or not the system’s contents can be modified by parents, guardians or users themselves, in order to achieve their needs and requirements.

Table 2.1 presents a summary of above related work in term of a, b, c, d, and e points.

Related Works	Age Range	Physical Movement	Mobility	Multimedia	Customization
KidPad	6-11 years old.	No	No	Graphics, Text.	Yes
Hopscotch	Young children.	Yes	No	Audio, Music.	No
DEGS	5-6 years old.	Yes	No	Text, Audio, Image.	No

<b>Excursion- game</b>	Middle school students.	Yes	Yes	Text, 3D reconstruction s of the identified place.	No
<b>KCEC</b>	Young children.	Yes	Yes	Text, Image.	Yes
<b>NICE</b>	6-10 years old.	Yes	No	Audio, 3D, Animation.	Yes
<b>Tikatik</b>	4-5 years old.	No	No	Text, Image, Audio, Music.	Yes
<b>ALC</b>	8-13 years old.	No	Yes	Audio, video, image, text.	No
<b>Family Story Play</b>	2-3 years old.	No	No	Video chat, Audio, Text.	Yes
<b>Augmented authoring system</b>	N/A	No	No	Video, speaker, falcon haptic device.	N/A
<b>Reactoon</b>	5-9 years old.	No	No	Animation, Sound,	Yes

				Images.	
<b>TOK</b>	5 years old.	No	Yes	2D Animation, Sound, Video.	Yes
<b>Circulatory AR system</b>	10-11 years old.	Yes	No	Text, Animation.	No
<b>I/O Brush</b>	4 years old and up	No	No	Images.	No
<b>Gymkhanas</b>	N/A	Yes	Yes	Text, Image, location (Google map), textual- AR	No
<b>Tangible Cubes</b>	7-12 years old.	No	No	2D Image, Video, Text.	Yes
<b>Magic Stick</b>	1-4 years old.	Yes	No	Audio, Animation, Image, Text.	Yes
<b>LeapFrog2</b>	Young children.	No	Yes	Image, Video game, Audio.	Yes

<b>Baby's Learning Laptop</b>	6 months And up.	No	Yes	Audio.	No
<b>Strega Comanda Colore</b>	N/A	Yes	Yes	Images.	No
<b>uLearn</b>	9 years old.	Yes	Yes	Text, Audio, Video, Animation and Images.	No
<b>Tap and Learn System</b>	2 and up years old.	Yes	Yes	Text, Image, Audio, Vibration.	Yes

As can be observed from the comparison tables above, most of existing systems do not support characterises that found in this Chapter. Hence, Tap and Learn edutainment system support most of those characterises and we will evaluate it within our evaluation procedure.

# CHAPTER 3

## **Pre-Evaluation of M- Learning System**

### 3.1 M-learning survey for young children

In the last few decades, the M-learning field has brought us immense progress and great changes. These have proven to be effective and successful in many different contexts and with various target groups, in all sectors of education. Without a doubt, these changes left incredible traces in our society and changed children's play approaches, making them more interesting and able to attract children's attention in simple and rapid ways. Even for children, mobile devices can be considered as a tool for thinking and not just for playing. For instance, when children record everything they do while playing by using a smartphone, they can change their behaviours and actions for the better. Also, by generating extended learning communities that connect both real and virtual worlds through mobile, children can gain the chance to deal with protected real life situations, effortlessly giving them a worthy experience and helping them develop skills as well as supporting their lifetime of learning.

[58] Pointed that a good percentage of learners revealed enhancements in their reading and mathematics abilities after they were using mobile devices for learning. Similarly, it helped them build their self-esteem and confidence. [59] Offered a multimedia M-learning application that combined the advantages of several multimedia types such as text, images, and audio, which efficiently captured learners' attention in a quick, attractive and useful way. [60] Offered a mobile learning study where learners were able to gather data via video clips and pictures. The results of this study showed that learners were task-focused and that the mobile phone motivated them to reach for better results. At the beginning, the [51] research described the concept of M-learning by intensely interrelated it to the device. On the other hand, [61] and [62] defined that M-learning should concentration on the mobility of the learners, as in the following: "Any sort of learning that happens when the learner is not at a fixed, predetermined location, or learning that happens when the learner takes advantage of learning opportunities offered by mobile technologies".

Mobile devices are considered advantageous for gaming because of the opportunities provided for community and collaboration as they support learning situations where users can work together to reach certain learning objectives, based on their group's performance . Moreover, [63] presented the technological criteria of children, such as having control, social experiences and expressive tools. Technology should mostly support their curiosity as well as their like of repetition and control in their environment [64]. M-learning offers better flexibility for learners to engage with course materials, activities, and instructors, anywhere and anytime. However, few of the existing researches explored the use of smartphones as game controllers. Only recently has M-learning become narrower and more focused on the idea of smartphones or the new tablet devices such as the iPad. Taking this narrower opinion in our consideration allows

us to concentrate on what we can offer learners in a just-in-time type of experience, in order to supplement their developments [65].

Due to the above, this chapter gives immense details about the questionnaire survey we did at the beginning of the design process of our edutainment M-learning system. The survey's goal was to help us determine the type of evaluation methods and feedback that we should use to address our needs, as well as the qualities, processes, and materials that we are going to include in our edutainment system to meet our objectives and reach success. Additionally, we used the results to outline the information, the skills, and the tools that we will need to develop our system. Our fundamental reason for using M-learning in our study is its popularity among young learners. Furthermore, it has many improving features every year, for example, the self-directed learning feature that assists users to learn at anytime and anywhere they prefer, in a simple and joyful manner.

The title of our on-line questionnaire was "Mobile learning for young children" that distributed randomly through some social media websites like Facebook. It targeted parents who have young children, in order to capture their opinions about the different features of the M-learning application, and to obtain information about the different learners, based on specific information and requirements that we are included in our edutainment system. The child's age and gender, the educational objectives, the needs, the setting (formal or informal), the child's ability to use a smartphone, for what reason they use it, the kinds of media they find interesting, the input/output interaction style, and other points that we will discuss in greater detail later in this chapter. In addition, fifty parents with young children participated in our on-line survey, over the course of three weeks. In the following section, we will give an extensive analysis of the parents' responses.

The questionnaire contained sixteen questions about young children and M-learning. We asked parents their child’s age and gender, but did not take those characteristics into consideration when studying variations in young children’s competence insights and valuing of social and emotional needs, educational skills, physical abilities, activities and even confidence. Table 3.1 shows charts of age and gender of the young children that participated in our survey. We should mention that most of them are familiar with smartphones and use them on a daily basis. The results are the following: 54% of young children were male and 46% were female; 49% were between 2 and 4 years old, 35% between 5 and 7 years old and 16% above 7 years old.

Male	Female	Age Range		
		2-4	5-7	Above 7
54%	46%	49%	35%	16%

Table 3.1: Young children’s age and gender.

Approximately 95% of young children were already using smartphones, as we mentioned before, for several reasons. Young children find that smartphones are the most interesting objects and they like to play games on them, they like to learn via smartphones, since it is simple and pleasant for them (especially for children of very young ages), and they also like listening to music and sometimes watching cartoons. Parents agree that the idea of tapping over different objects and entities to learn about them is pleasurable and interesting for young children. They can employ it anytime and anywhere, without too much effort or too many requirements, and

they can learn and have fun in the same time. Figure 3.1 shows general skills that children can develop with the use of a smartphone in their learning, from parent's point of view. Reading skills 72.9%, spelling skills 68.8%, intellectual skills 60.4%, and finally writing skills with 52.1%. Moreover, we agree that parent's involvement in their children's learning activities is a key factor since they can encourage them in their learning and help develop positive social and emotional skills. However, we believe that a high quality M-learning system should not require too much parental assistance, especially if it's not targeting children with special needs such as autistic children. We do consider that the parent's involvement in the learning content is important, but in limited situations. The results of our questionnaire show that 49% of parent's agree that an M-learning system that does not require their assistance is more capable of enhancing children skills and abilities, while 51% disagree.

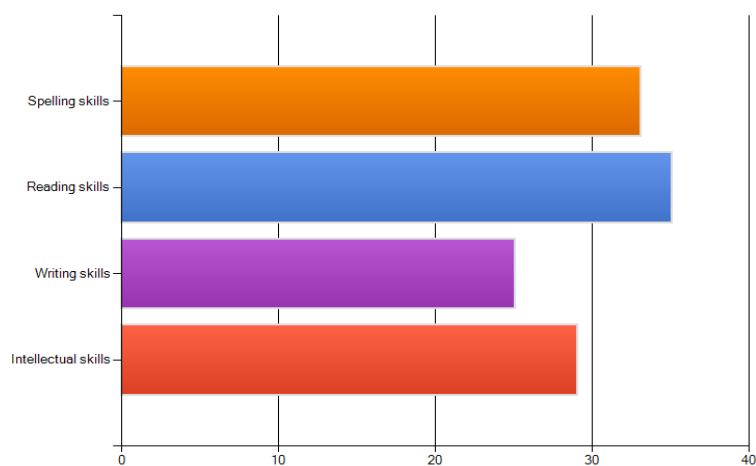


Figure 3.1: Chart of general children learning skills that are develop via M-learning.

Multimedia outputs are considered central in educational systems and technologies that target young children. Actuality, the more media types the system has, the more efficiently and quickly feedback occurs. In our survey we asked parents about different visual and audio media that

children might prefer, and they were in agreement that a learning system that provides several kinds of media such as audio, image and text, will be more efficient.

Parents concur that media that has both visual and audio characteristics can capture young children's attention for more time than other media kinds. Video has the highest percentage, as shown in Figure 3.2, with 87.5%. It is then image with 82.5%, followed by animation with 77.5%. After that, other media sorts such as text, speech, etc. have comparable percentages. All of the parents that participated in our survey agreed that children who deal with a touch-screen interface while using a smartphone liked it and found it easy and pleasant to use. Furthermore, since children are dealing with smartphones in their daily life, they might encounter media that is not suitable for them, and/or that their parent prefers them not to see. As a result, 98% of parents agreed on the importance of having control over the media that is going to be presented to their children while they are using a smartphone. It makes them feel comfortable about their children's learning.

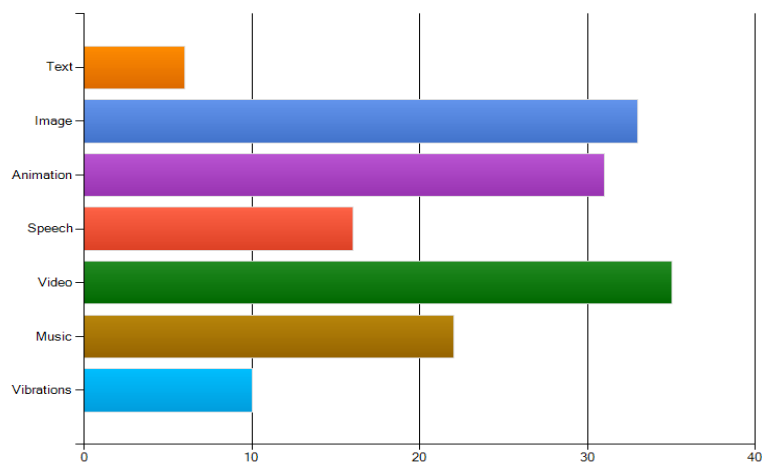


Figure 3.2: Percentage of several media kinds that children utilize it in their life.

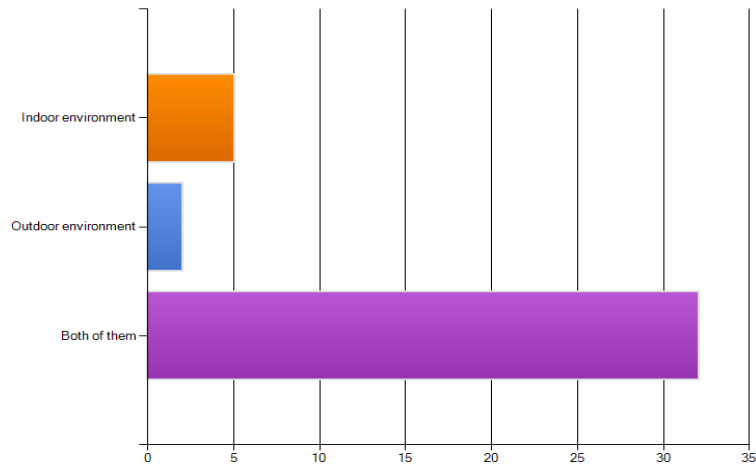


Figure 3.3: Parents selected both indoor/outdoor environments as the preferred learning environment.

In addition, there are currently many educational and entertaining systems targeting young children. Some of those systems can be used in an indoor environment like a school or home, while others can be used in outdoor environments like museums and gardens. However, a smartphone M-learning system that children can use both indoor and outdoor is essential for 82.1% of parents, as expressed in Figure 3.3. Also, more than 71% of parents' opinion supported the idea of offering physical movements such as walking in children's edutainment system, as shown in Figure 3.4.

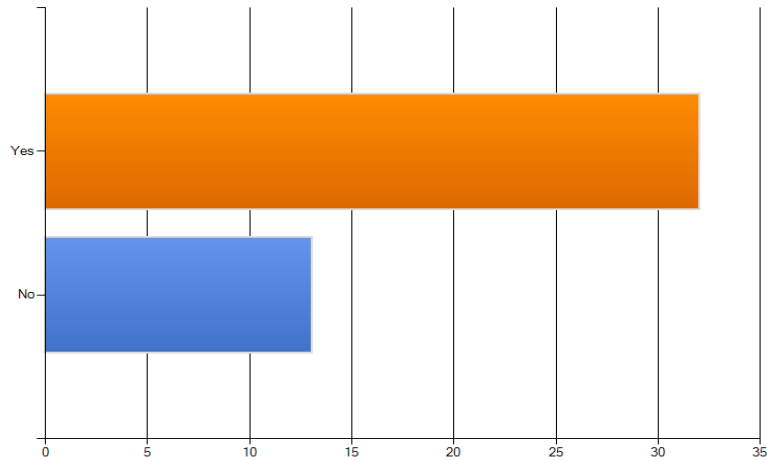


Figure 3.4: Parents preferred edutainment M-learning systems that support physical movements.

Most children are learning systems that have purely educational objectives don't match children's interests. On the other hand, systems that have entirely amusing objectives might catch their attention and be fun, but they are in fact a waste of time since they have no educational value and do not motivate them to learn. In this survey, 92.7% supported the idea that offering both educational and entertaining aspects in children's M-learning system is essential to develop their skills and allow them to have fun at the same time. Furthermore, children's learning systems that are interesting, motivating, and attention-grabbing can provide good social interaction between children and their parents, teachers and collaborating children. Actually, 88% of parents were in agreement with this point of view and how the social and emotional communication is advantageous, encourages children's learning and promotes self-confidence. Another point that we found interesting was the repetition method that assists children in memorizing the materials their parents want them to know. Parents who participated

in our questionnaire agreed with its importance at 93.5%, clearly showing that it is a feature that we should include in our edutainment M-learning system.

Our edutainment M-learning system should provide several features that are important for young children. We asked parents about general characteristics that make smartphones a good and effective environment for children, and in fact all the mobile characters we included were selected, with different priorities, as shown in Figure 3.5. In summary, the importance of these qualities are as follows: 87.2% for helping children develop their skills such as writing, 79.5% for attractive style, 69.2% for a clear and simple interface for children, the same percentage, 69.2%, for including and supporting several difficulty levels, 56.4% for providing effortless and attractive conceptions, 53.8% for the interactive method, and finally, 41% went to the system cost, as it would excellent if it were inexpensive for all consumers.

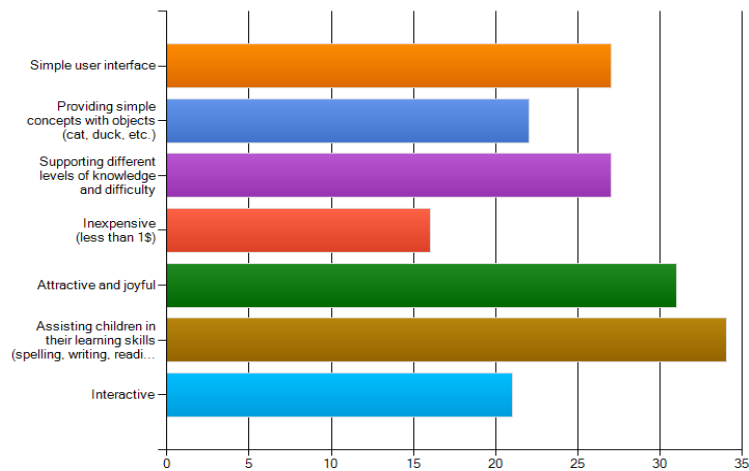


Figure 3.5: Educational features that important from parent's opinion in M-learning system.

## 3.2 Summary

To conclude this chapter, we include the on-line questionnaire survey that we administered in order to obtain a complete and comprehensible account of what we should include in our edutainment M-learning system. We will develop this system for young children, to provide them with an effortless, attractive and enjoyable approach to learning that they can use anywhere and anytime they like. Indeed, we are going to use M-learning in our thesis since we received respectable and efficient feedback about it from our questionnaire. We will also use M-learning because it has different multimedia capabilities, high-quality features, and can be a great influence in the domain of children's learning and entertaining.

# CHAPTER 4

## Tap and Learn Approach

This chapter discusses the overall system's architectural design as well as its requirements. We also give details of the hardware components and the software modules. In Section 4.1 we stated some studies in children's edutainment through the use of M-learning. Section 4.2, we draw the system requirements that are aimed at efficiently meeting children's educational and entertainment needs. Section 4.3 presents the system overview; Section 4.4 includes the overall system architecture and discusses its numerous modules. Section 4.5 discusses the implementation consisted of both software and hardware components. Section 4.6 presents the three game scenarios included in our edutainment system. Finally, Section 4.7 provides a summary of what this chapter includes.

### 4.1 Background

In recent times, numerous studies in the field of education have been conducted to generate effective and better learning methods [66]. Some of those studies have targeted the value of

gaming in children's learning environments, as well as the idea of combining the gaming and educational activities that children like to use them while they are learning [67]. Nowadays, games played using smart phones are becoming very popular among children. They love to play with them anywhere and anytime. Even children with special needs can take advantage of these games while undergoing rehabilitation [68]. These smart phone games deliver the opportunity to interrelate with learning material in different ways, while exploring a physical environment both outdoors (e.g. archaeological parks) and indoors (e.g. school, home) [53]. The use of games in education is greatly supported by the increased possession of mobile devices, wireless handheld devices, namely cell phones because of their comparatively low-price, flexibility, and mobility. In addition, a benefit of using mobile devices for gaming is the chance they provide for collaboration and community. They also support learning environments where learners can work in collaboration to achieve learning goals, based on their group's performance. They were also found to foster positive interdependence among learners, which translates into positive interpersonal relations and attitudes [69].

## 4.2 Requirements of the Proposed Tap and Learn System

We outline our proposed M-learning edutainment system requirements according to the problems that we discussed in chapter 1, and the requirements we defined in the related work surveyed in Chapter 2.

### **4.2.1 Learning through physical interaction:**

Learning through physical interaction means that the system should offer learning by enabling children to interact with real objects pertained to their learning. The experiential learning theory (ELT) suggests that children would get a stronger impression of different objects and entities if they had the ability to touch them and operate them. For example, learning by doing, with enough practice for the users to be comfortable, is considered a strategy that has many positive effects for users and allows them to gain knowledge [70],[71], [72], [73], [74] and [75].

#### **4.2.2 Learning anywhere and anytime:**

Our system should possess the quality of being able to provide learning through playing whenever and wherever is needed. For instance, children should be able to use it at school, home, outdoors, or even when traveling by car or plane. Unlike computer-based games which can be played in specific locations, smart phones and tablets can greatly provide this capability since they are always carried by adults, which make it possible for children to use it whenever they are with their parents or teachers. Mobile phones and handheld computers provide us the opportunity to interact and gain access to much information such as learning materials, anywhere and anytime. Gaming devices such as [76], [77] are also considered common entertainment tools for children and can help them enhance their skills and behaviours in a simple and agreeable manner.

#### **4.2.3 Multimedia Feedback:**

Sounds, verbal, and haptic feedback can greatly engage children in their playing and therefore can make their edutainment experience more fun and informative [78] [79] and [80]. Computer-based games always include different sorts of media feedback but they do not provide a haptic feedback because they are mostly played by a mouse which is limited in terms of its hardware

capabilities (i.e. a mouse does not have actuators). At a very early age, children do not have suitable technical skills to allow them to easily deal with numerous tools and technologies. They still have the desire to interact with people and play [81]. Also, it is not easy for young children to deal with certain input tools such as a mouse, a keyboard or other traditional tools, even though they are expected to be able to use them during the preschool years [82]. Smart phones and tablets already provide vibro-tactile feedback. Figure 4.1 shows children while playing with the Tap and Learn system. Therefore, the software edutainment game should be properly designed to provide the proper audio, text, and vibration feedback that keep the children engaged and excited about learning.



Figure 4.1: Young children while playing with Tap and Learn system.

#### **4.2.4 Guardian Customization:**

The system should involve the guardians (e.g. parents, teachers etc...) in the learning of the children by enabling them to customize the multimedia content of the games so that it is tailored to their cognitive abilities and age [83], [84],and [85]. Therefore, the system should possess a

mechanism that allows parents or teachers to easily modify the pictures, texts, and any other elements that help them to achieve the appropriate learning goals.

### 4.3 System Overview

Our proposed system uses the smart phone as a tangible user interface (TUI) that can interact with the objects and entities that are present in the children's playing environment. With the use of the TUI, children are able to control the computing environment; they will not lose their focus easily, and can feel and own their environment. In fact, from an educational and a psychological point of view, tangible technologies are valuable for learning since they allow the physical actions that are important for children’s learning [86].

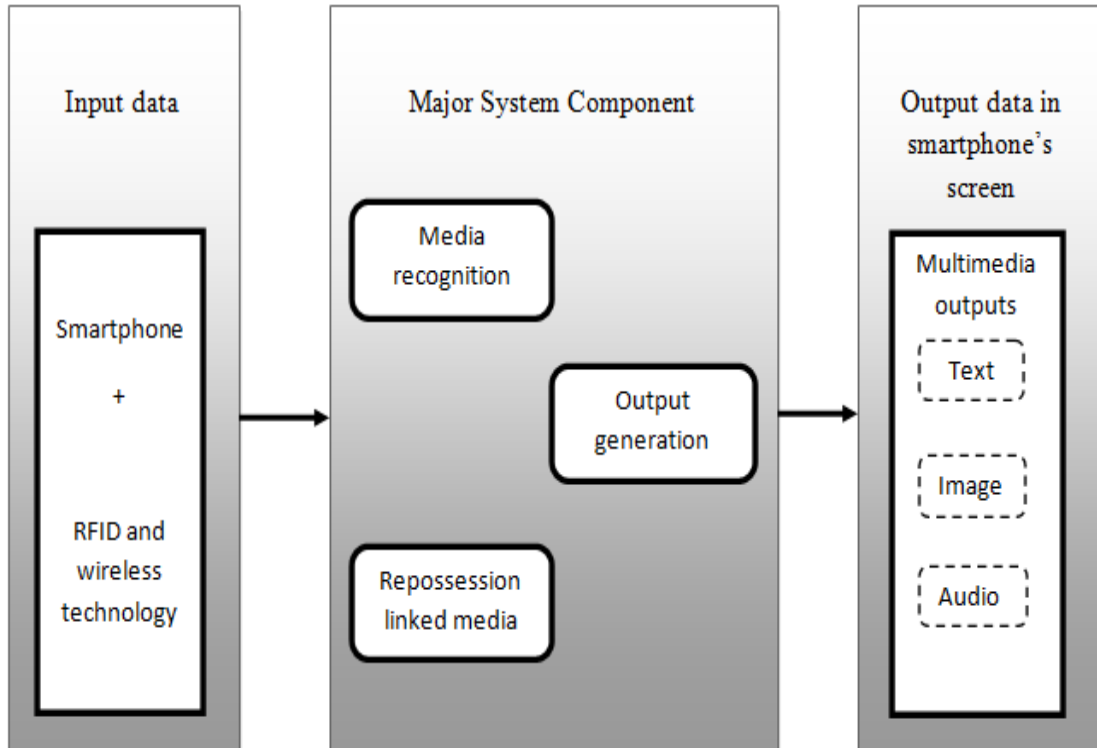


Figure 4.2: A high level block diagram of the proposed system.

Figure 4.2 presents a high level diagram of the proposed system. The fundamental idea of our M-learning edutainment system is that whenever a child touches an object or an entity in her/his surrounding environment, a set of a suitable media will be displayed on the smart phone's screen such as images, audio, and text, pertained to the object she/he has been touched. In order to empower the smart phone with object detection capabilities, we use the RFID technology that consists of an RFID reader that can detect special tags associated each with a unique identification (ID). The RFID detected information is transmitted to the phone's processor using Bluetooth technology. Consequently, guardians can attach RFID tags to objects of their choice and children can get information about these objects by simply tapping over them with the RFID-mounted smart phone's screen where the multimedia output is displayed.

The system incorporates a friendly Graphical User Interface (GUI) that enables the guardian to map the RFID tags with the media pertained to the object of their choice. For instance, if a mother would like to teach her child about a new animal, she can simply attach the RFID tag inside a toy of that animal, and map the name, picture, and text information to that tag through the GUI in an easy manner. To realize the functionality of the M-Learn system in education and entertainment, we have developed two simple software games, namely the "Alphabet" and the "Find a Match" games. The games offer children the chance to enhance their knowledge by either finding proper matches to entities or objects or by learning to write new letters and words. A more detailed description of the two games will be provided in Section 4.6.

## 4.4 Overall System Architecture

Figure 4.3 presents the high level overall system architecture. We describe the functionalities of each module in the subsequent subsections.

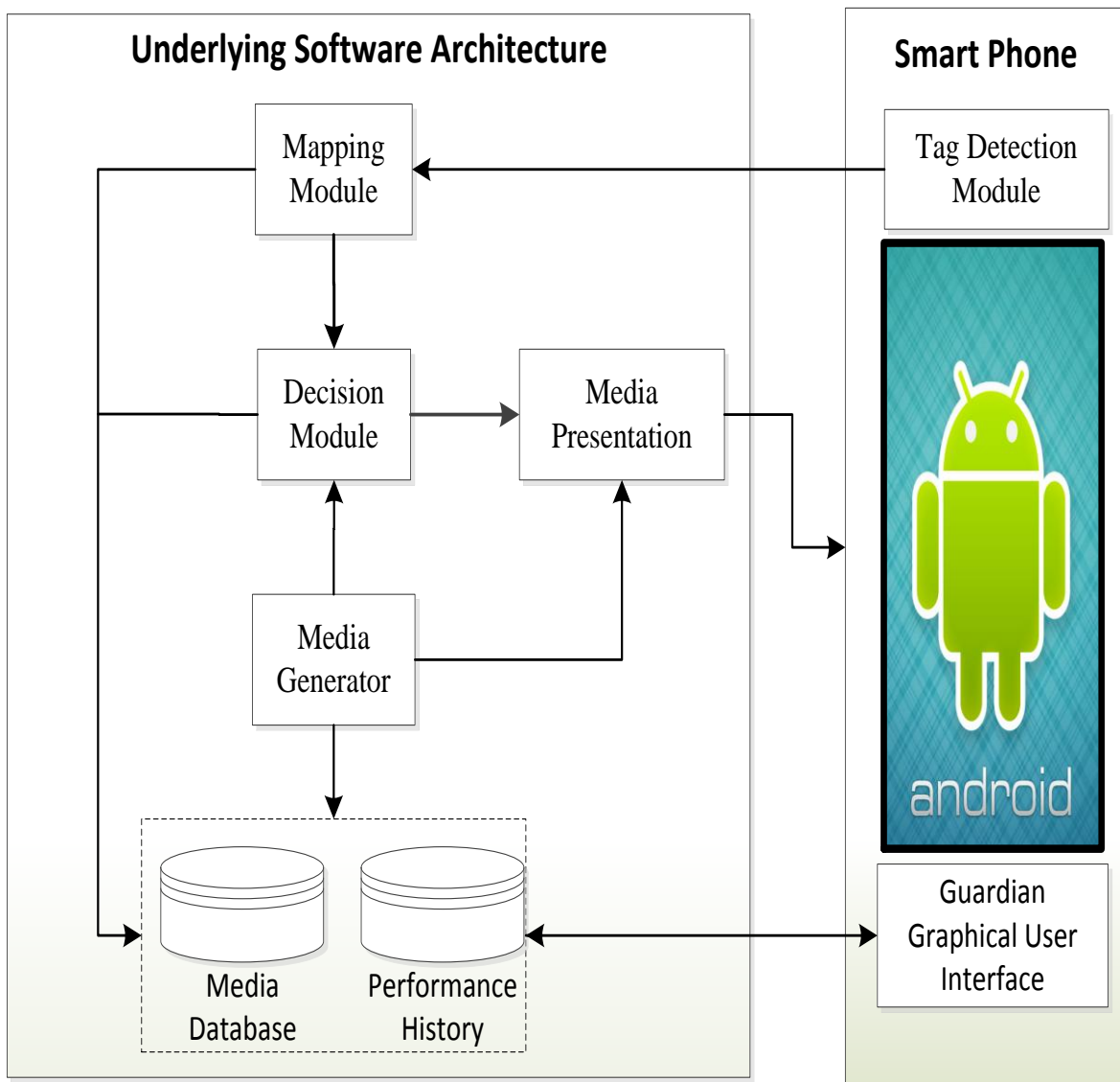


Figure 4.3: The overall system architecture.

### **4.4.1 Guardian Graphical User Interface**

This module is the guardian's door to the system since it gives them the chance to get involved in their children's learning and entertainment experience. This is done by allowing parents and/or teachers to customize the media content to be displayed to the child. It enables parents to accomplish the following:

1. Upload the desired media, such as pictures, texts, and sounds
2. Add/remove RFID tag identification numbers
3. Map the RFID tag IDs with the proper media that should be displayed upon tapping over each ID.
4. Enable and disable the vibro-tactile feedback if a certain task is successfully accomplished.
5. Check the performance history of the child which contains child's scores and statistics.

All the aforementioned features can be accomplished in an easy manner on the touch screen of the smart phone where simple instructions are displayed to guide the guardian during the customization process of the system.

### **4.4.2 Tag Detection Module**

The Tag Detection Module is the unit responsible for detecting the RFID tag identification of the tag being tapped. In other words, this module is the RFID reader mounted on the smart phone.

### **4.4.3 Mapping Module**

This module is responsible for providing the appropriate mappings between the RFID tags and

the different media such as the pictures, the audio and the texts that are saved in the media database. In other words, this unit is composed of a 4 column mapping table that enables the user to find the related custom matched Tag-Media information. Figure 4.4 shows the XML structure of the mapping table. The first column is reserved for the tag ID. The second, third, and fourth columns are reserved for the mapping between the tag ID and its associated picture location, audio location and textual description respectively.

```
<? xml version="1.0" ?>
<tags>
  <tagID>RTE T876ABC12 </tagID>
  <ImageLocation> C:\pictures\parrot.JPG </ImageLocation>
  <AudioLocation> C:\sound\squack.mp3 </AudioLocation>
  <Text> Parrot </Text>
</tags>
```

Figure 4.4: The XML structure of the mapping table.

#### 4.4.4 Media Generator

The Media Generator is responsible of extracting from the database the different types of media to be displayed to the player. The generation of media is done in an ordered manner based on the preferences of the guardians.

#### 4.4.5 Decision Module

This module constitutes the heart of the system. Its duties can be summarized by the

following:

a- Accepts media inputs from the Mapping Module and the Random Media Generator and performs the appropriate comparison to check whether or not the inputs match.

b- Checks the performance of the user and determines a suitable level of difficulty so that the system adapts to the mental and cognitive development needs of each user. A modified level of difficulty might consist of adding more challenging requirements to the game.

#### **4.4.6 Media Presentation Module**

This module is responsible for the display of the appropriate multimedia outputs that should appear on the smart phone's screen. The display of the media is based on the parent's preferences that they make through the Guardian GUI.

#### **4.4.7 Media Database and Performance Database**

The Media Database is the place where all the pictures, sounds, and texts are stored. On the other hand, the Performance Database stores the games scores that can be accessed later on by the parents to check the progress of their children over the time.

### **4.5 Implementation**

The implementation consisted of both software and hardware components. Below we give brief details about the implementation of each of those components.

#### **4.5.1 Software Implementation**

The software implementation consisted of the development of the 2 Android-based software games, the "Find a Match" and the "Alphabet". We have used the Android SDK [87] which includes a mobile device emulator that runs on the computer and which enables the development and the testing of Android applications without using a physical device. We used the Eclipse environment to run the emulator and do all the coding and debugging processes.

### 4.5.2 Hardware Implementation

The hardware implementation consisted of the integration of the RFID core module with the Samsung smart phone. Due to the difficulty of directly connecting the RFID module to the internal microprocessor of the smart-phone, we have established an external connection. The connection consisted of interfacing the 12 core RFID reader to a Bluesmirf Gold Bluetooth device which is paired with the smart phone's Bluetooth Figure 4.5. Therefore, the RFID reader transmits the information to the Bluesmirf which in turns transmits it to the smart phone through Bluetooth wireless communication.

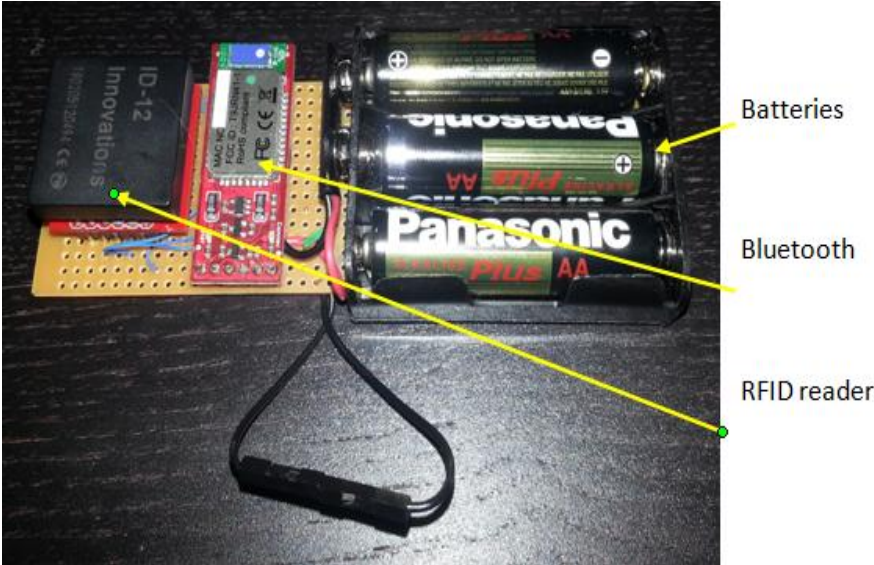


Figure 4.5: The external hardware that is mounted on the smart phone.

## 4.6 Tap and Learn System Game's Scenarios

The Tap and Learn M-system comprises two games, "Find a Match" and the "Alphabet", that aim to foster the cognitive skills of the users.

### 4.6.1. Find a Match Game Scenario

As can be deduced from the name, the "Find a Match" game requires the child to find an appropriate match for a certain word, object, etc. The game can be configured in two modes. The first mode is meant to enable interaction between the guardian/parent and the child. In this mode, the guardian predefines the correct answers of the questions he/she would be asking his/her child in an orderly manner as shown in Figure 4.6. Therefore, the guardian himself/herself asks the question to the child and the system knows the expected answer from the predefined question sequence.

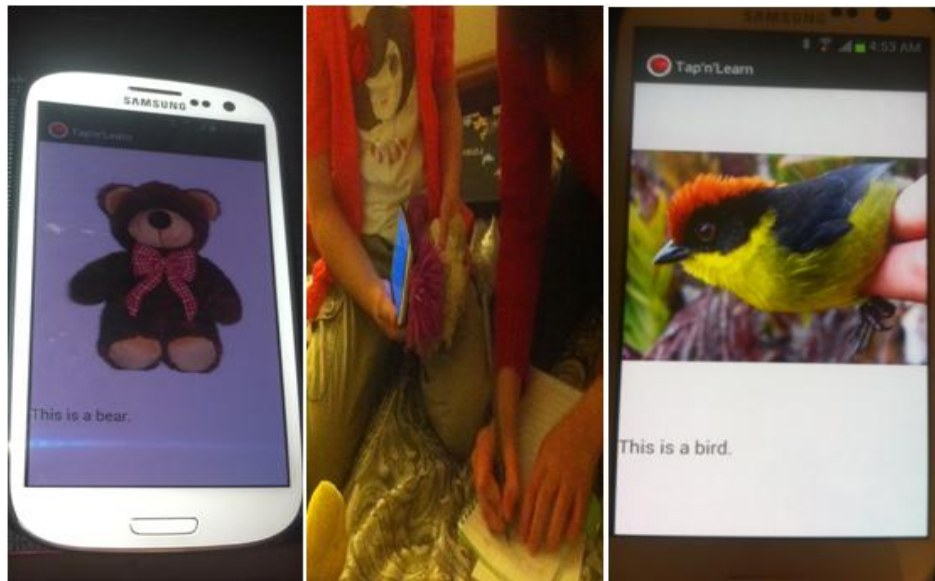


Figure 4.6: Children while playing with our edutainment system to match objects.

Now the second mode enables interaction between the child and the system itself as in figure 4.7. This is done by enabling the automatic media generation function which generates the questions to the child as set by the guardian.



Figure 4.7: Young children interact with each other via Tap and Learn system.

As in the first mode, the questions and the answers should be defined in advance, and the system asks the questions through the voice to speech feature. Figure 4.8 presents a flow diagram that clarifies the "Find a Match" game flow. As can be seen, the number of questions  $N$ , the game mode, and the number of allowed error has to be initialized first before the game starts.  $N$  is actually the number of questions that will be asked to the child while  $E$  is the number of times the child is allowed to wrongly answer before the system changes the question. If the guardian chooses Mode 1, then he/she has to ask the question to the child. On the contrary, Mode 2 would

activate the text-to-speech recognition engine that would enable the smart phone to read and utter the questions defined by the guardian. The rest of the flow diagram is self-explanatory.

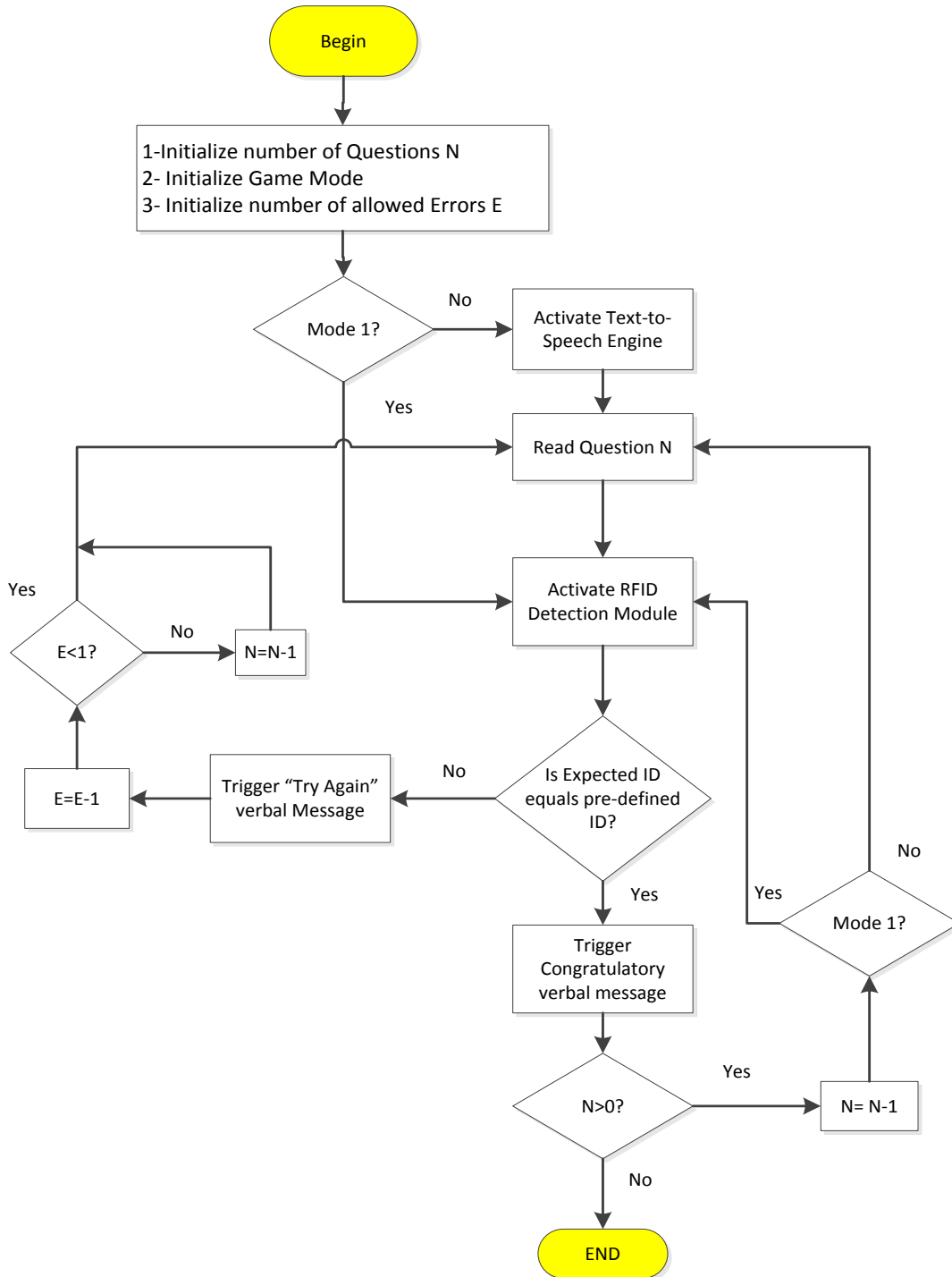


Figure 4.8: The "Find a Match" game flowchart.

#### 4.6.2. Alphabet Game Scenario

This game aims to teach young children the letters of the alphabet, since they are at the early stages of both writing and reading skills. As shown in Figure 4.9 we provide 26 RFID tags, one for each letter, so that by tapping on any letter, children can get multiple media outputs associated to it, to enhance their knowledge.



Figure 4.9: The alphabet tagged letters and numbers.

The game can also be configured to enable writing words that can be either asked by guardians or by the system itself in a similar manner to "Find a Match" game. As usual, no matter what the configuration is, the guardians should always predefine the letters and words information by order so that the system can properly function.

## 4.7 Summary

In this chapter, we have discussed the overall system architectural design, along with the functionalities of each of its components associated with it. We also presented some details about the software and hardware implementation. Finally, we elaborated on the game scenarios of the two games that are incorporated in the system and explained what the aims of each of the games.

# CHAPTER 5

## Tap and Learn System Evaluation

In this chapter, we will present the evaluation of our edutainment M-learning system. In particular, we will conduct both quantitative and qualitative evaluations that aim to test the system's potential impact on children's cognitive and social behaviour.

### 5.1 Quantitative Evaluation

The main goal of the quantitative evaluation is to examine statistically any potential cognitive (learning) benefits that could be acquired through the use of the Tap and Learn system. For this purpose, we adopt an approach that is based on the self-regulation learning model [123] that helps children be cognizant of their academic strength and weaknesses, and practice their learning. The self-regulation model distinguishes seven self-regulated strategies which can be described by the following:

- **Identification of the Objective (ID):** This strategy examines whether or not an individual can identify the objective of the task by checking his/her ability to begin the activity and listen or asks questions about the objective.
- **Planning or Exploration of the Means (EM):** EM scrutinizes the ability of an individual to plan and explore the means to reach the objective without being instructed by an adult.
- **Self-regulated Attention (SA):** This strategy examines the ability of an individual to stay focused on the task without losing his/her attention.
- **Self-regulated Request (SR):** The SR aims to test the capability of an individual to accomplish a task with minimal requests for help or explanation.
- **Self-Motivation (SM):** Self Motivation tests the ability of a person to express his/her pleasure and to stay motivated during the task.
- **Joint Attention (JA):** This strategy examines the ability of a person to initiate and respond regularly to joint attention without losing interest. Joint attention can be described as the shared focus of two individuals on an object.
- **Self-evaluation (SE):** It is the ability of the individual to identify his or her errors and to fix or correct them without the help of another individual.

For more details about the Self regulation model, please refer to [88] and [89].

### 5.1.1 Methods

We evaluated the Matching game within the M-learning system with fifteen young children from both genders (7 males, 8 females). Our target children ranged between 3 to 7 years old Table 5.1

and all of them were able to talk or say at least few words about the objects around them. Our experiments consisted of 10 sessions conducted over a five week period (2 days per week). Each session lasted approximately 35 minutes, at various times throughout the day (10am – 5pm). Consent forms were signed by the parents and every session was videotaped for further analysis.

<b>Participant ID</b>	<b>P1</b>	<b>P2</b>	<b>P3</b>	<b>P4</b>	<b>P5</b>	<b>P6</b>	<b>P7</b>	<b>P8</b>	<b>P9</b>	<b>P10</b>	<b>P11</b>	<b>P12</b>	<b>P13</b>	<b>P14</b>	<b>P15</b>
<b>Gender</b>	M	M	F	F	F	M	F	F	M	M	F	F	M	M	F
<b>Age</b>	3	6	4	4	4	6	4	3	6	5	6	5	7	4	7

Table 5.1: The age and gender of each of the participants.

We met the parents one week before the experiments and explained individually to each parent how the system works and what we expect from his/her child to achieve at the beginning and at the end of the sessions. We also asked each parent to provide us with a set of objects/things that they would like his/her to learn or gain more knowledge about so that we could prepare the game setting (e.g. tag appropriate toys objects).

Before starting the experimental session, we asked the parent to show his/her child how the game works by playing with the phone. Later on, we asked each child to play the Matching game which consisted of finding appropriate "matches" for the questions posed by the father or the mother to his/her child. Each session consisted of 15 tasks that require the child to find 15 proper matches for the name of objects or the information being told to him or her. The tagged

objects were comprised of toys of animals, birds, fish, environmental objects (such as trees, moon, sun), among others.

At the beginning of each game, the parent starts by telling his/her child some information about an entity which is related to an object among those provided to him/her and which he/she should find it. For instance, a mother might tell his/her child a short story about the sea and then asks him/her to find what among the objects is related to the sea. In this case, the child should tap on the fish in order to find the proper match.

### 5.1.2 Assessment Metrics

We observed the 7 self-regulation strategies to locate the positive and negative links between children's self-regulation strategies and their performance in the game tasks. A normalized score was calculated for each strategy. The score ranged between 1 and 3, 1-low scored, 2- moderate scored, and 3- high scored. (Please refer to Appendix B [90] for more details). The overall session performance  $P_s$  of each child was then computed by finding the mean value of all the 7 strategies, as shown in Equation 1.

$$P_s = \frac{ID + EM + SA + SR + SM + JA + SE}{7} \quad (1)$$

Where ID, EM, SA, SR, SM, JA, and SE are the abbreviations of the seven strategies explained at the beginning of Section 5.1, and S is the session number.

Besides the seven strategies, we measured the average Task Completion Time ( $\overline{TCT}$ ) per session in order to verify if there is any improvement in terms of the child's promptitude. Promptitude is the characteristic of being able to do something without delay and indicates how prompt or ready a child is. The completion time for each task was measured from the time the parent asked his/her child to accomplish a certain task until the time the task is successfully completed. Then the average  $\overline{TCT}$  was computed using Equation [2]:

$$\overline{TCT}_S = \frac{\sum^T TCT_T}{15} \quad (2)$$

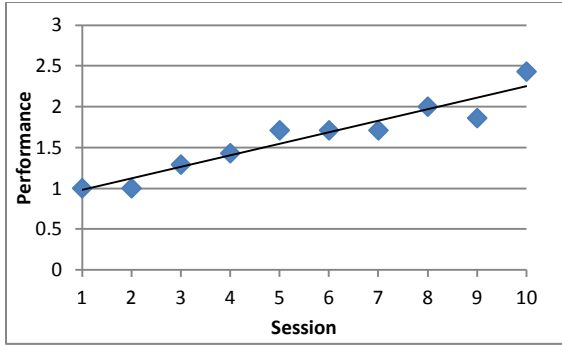
Here T is the task number within a particular session S.

### 5.1.3 Performance Results

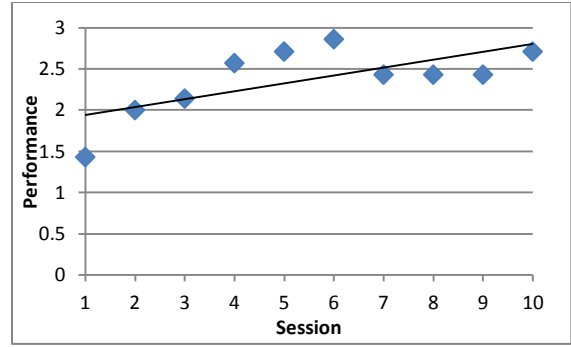
Figures 5.1 (a) through (o) presents the performance of each child over the 10 sessions after playing with the Find a Match game. The squares represent the performance value after each session. In order to properly visualize the progress of each child, we apply a regression analysis on each of the curves. This way, the calculation of improvements or decrements would be based on the regression curves fit to the data. Consequently, the higher the slope of the regression curve, the better the improvement.

It can be clearly seen that there was an improvement in the performance of most of the participants. However, for some of them the improvement was more significant than the others. For instance, participants P1, P3, P4, P5, P10, and P14 had the most significant improvement, while it was less significant for P2, P9, and P12, and very slight for P6, P7, P11, and P15. For

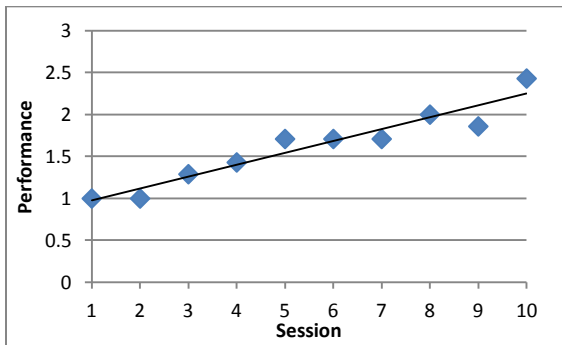
participants P8 and P13, we noticed that was almost no change in terms of their improvements. The reason why some participants improved more than the others might be due to their age. We have noticed that the younger the participant is, the higher the improvement was except in one child. This can be clearly realized in P1, P3, P4, P5, P10 and P14 whose ages ranged between 3 and 5 and who showed the highest improvement, except in the case of P8 (3 years old) who might not have grasped very well the theme of the game. On the other hand, P2, P9 were both 6 years and progressed less the younger children. The performance was also much slighter in the case of P6 and P11 who were both 6 years old. Now P13 was the oldest (7 years) and did not show any improvement at all since his/her performance was constantly good cognitive in all over the session.



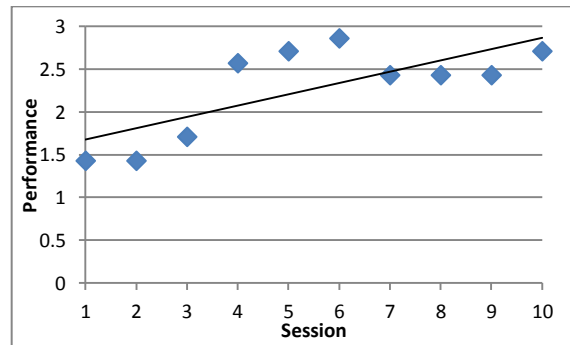
(a) Performance for P1



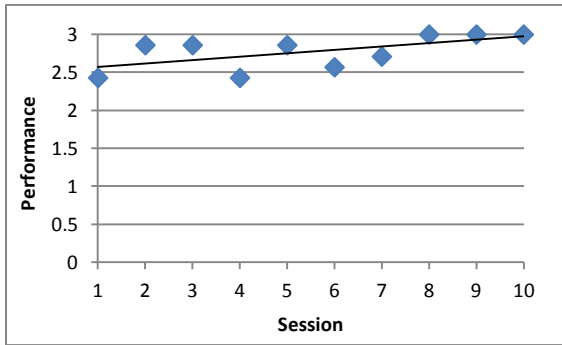
(b) Performance for P2



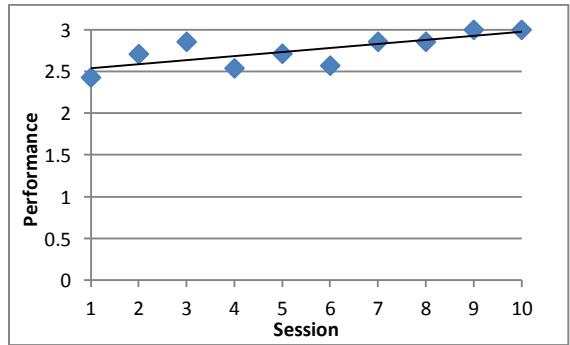
(c) Performance for P3



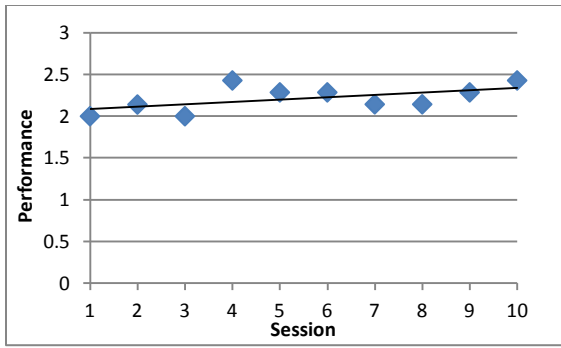
(d) Performance for P4



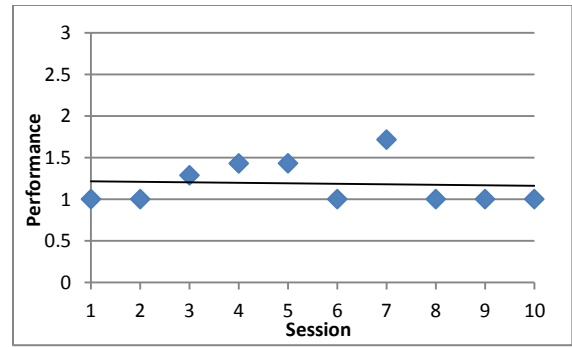
(e) Performance for P5



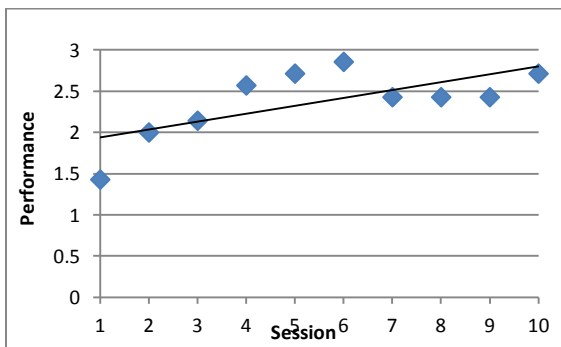
(f) Performance for P6



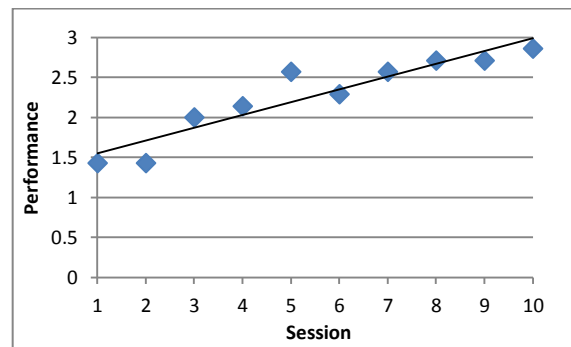
(g) Performance for P7



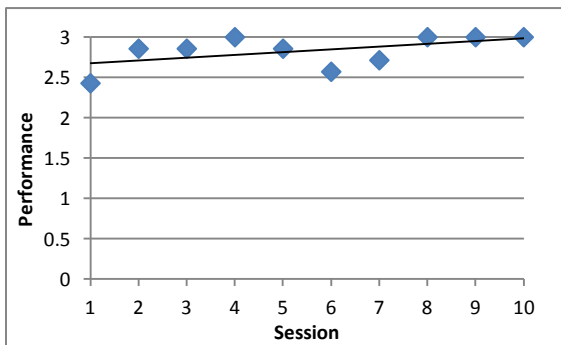
(h) Performance for P8



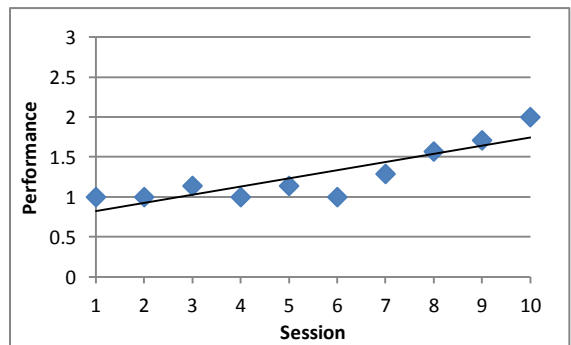
(i) Performance for P9



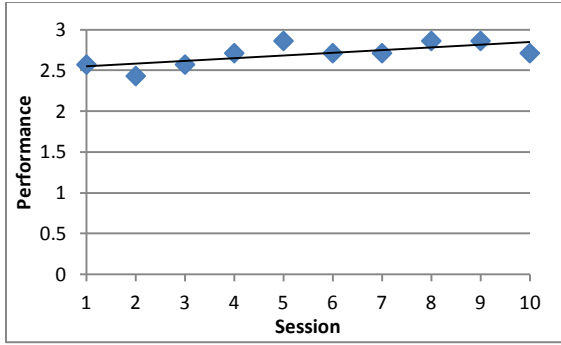
(j) Performance for P10



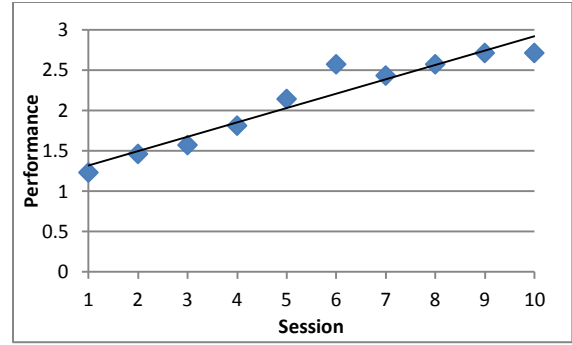
(k) Performance for P11



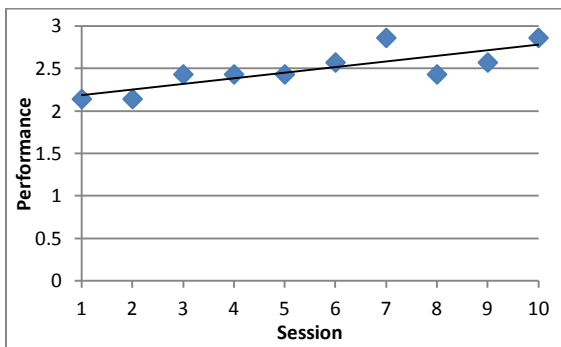
(l) Performance for P12



(m) Performance for P13



(n) Performance for P14



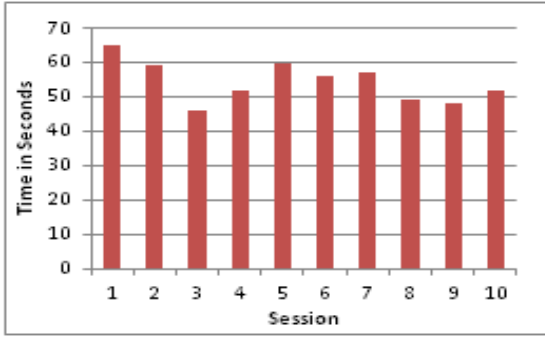
(o) Performance for P15

Figure 5.1: The performance of each subject ct over the 10 sessions.

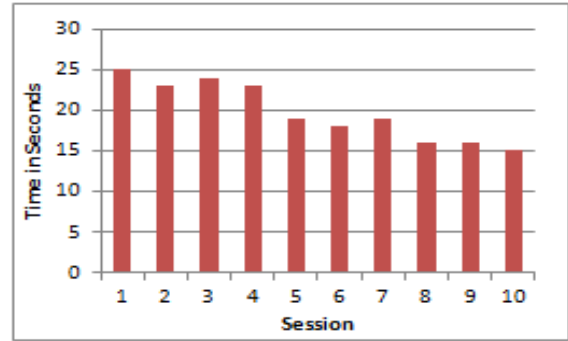
### 5.1.4 Task Completion Time Results

Figures 5.2 (a) through (o) illustrates the average task completion time within each session for each of the 15 participants. We realize from the data in the table that the average completion time decreased in different pace for all the children. The decrease in time might be for numerous reasons. The first reason that might come to mind is related to the familiarity of the children with the game. In other words, it is normal that a child takes more time to understand the theme of a game at the beginning while his time starts to decrease upon getting more familiar with the game.

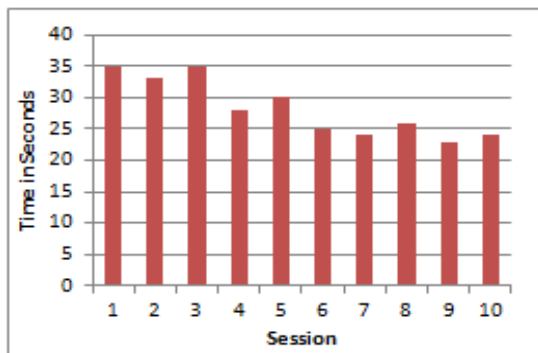
On the other hand, the improvement in time for most of the participants might be related to the fact that they have acquired knowledge about the objects from the information given by their parents every time they were playing the game which helped them solve more quickly the matching questions given to them. It can be clearly seen also, that in the case of P13 and P15 who are the oldest, their  $\overline{TCT}$  have not really improved since it was good from the first session. The most interesting improvement in  $\overline{TCT}$  is that of Participants P1 and P8 (3 years old) who seemed to be able to solve the tasks in a faster time than at the first sessions.



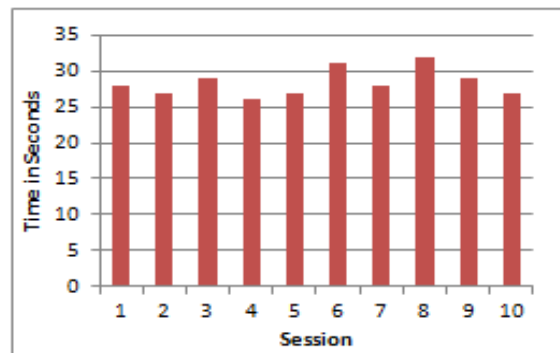
(a) Average TCT for P1



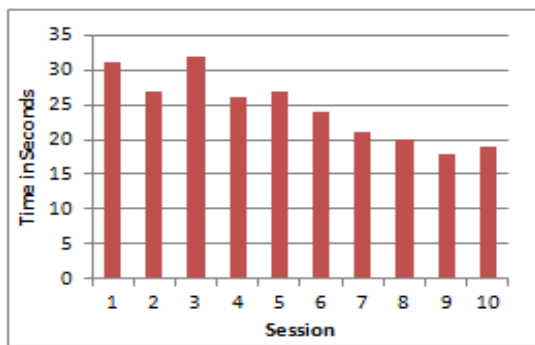
(b) Average TCT for P2



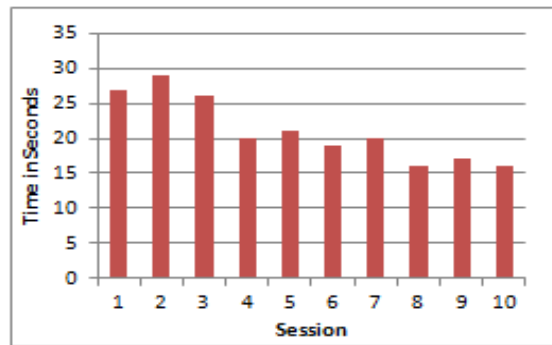
(c) Average TCT for P3



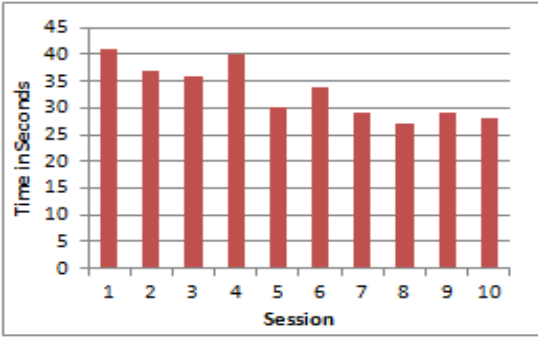
(d) Average TCT for P4



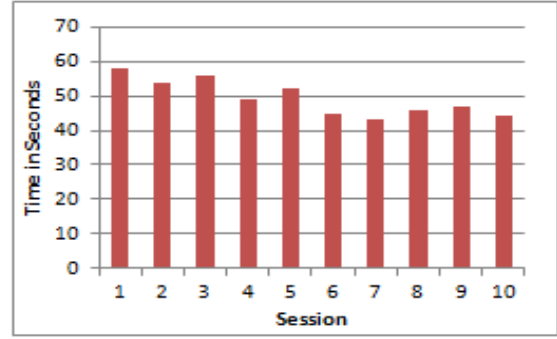
(e) Average TCT for P5



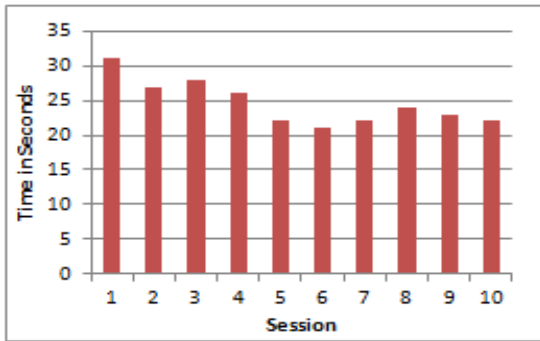
(f) Average TCT for P6



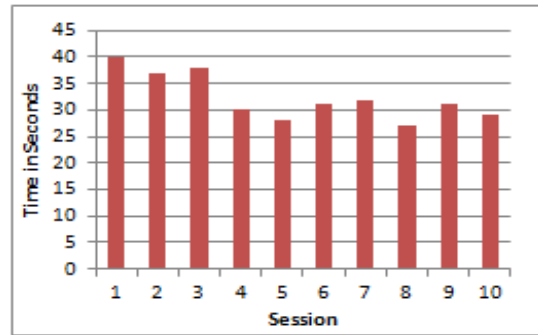
(g) Average TCT for P7



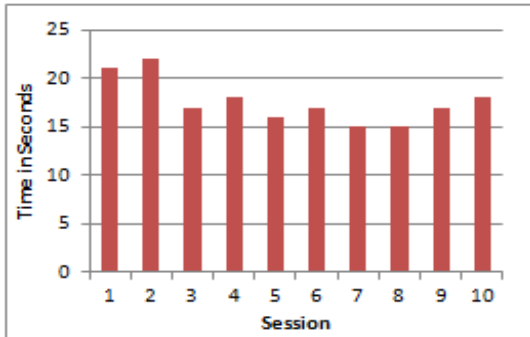
(h) Average TCT for P8



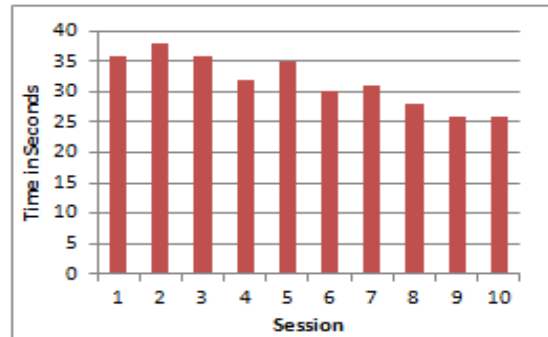
(i) Average TCT for P9



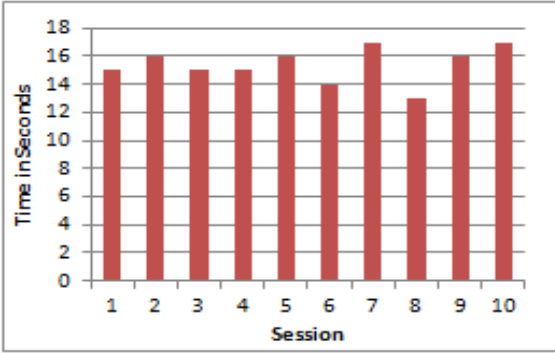
(j) Average TCT for P10



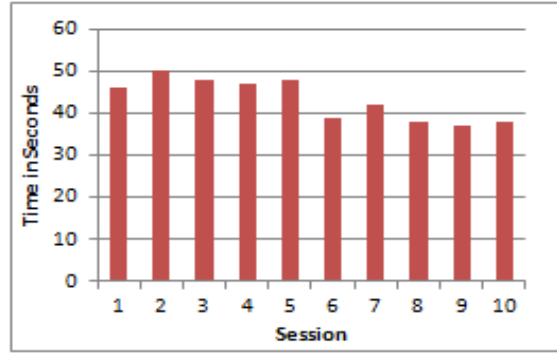
(k) Average TCT for P11



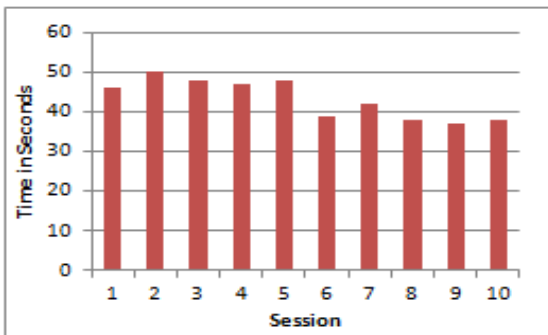
(l) Average TCT for P12



(m) Average TCT for P13



(n) Average TCT for P14



(o) Average TCT for P15

Figure 5.2: The average task completion time of the participants over the 10 sessions.

## 5.2 Qualitative Evaluation

The qualitative evaluation aims to examine the quality of experience of the children while playing with the Tap and Learn system. Unlike the first part of our experiments that evaluated each child individually, in this part we evaluate their quality of experience while interacting together in groups, as well as with their parents. This was done by carefully listening to the verbal conversations that occurred during the sessions. In addition, we pose several questions to the children at the end of each session that helps us understand the opinions of the children about the playing and learning environment.

### 5.2.1 Methods

The qualitative evaluations were conducted in 3 different sessions on the same days after the quantitative evaluations were performed. However, at this stage, we invited five children with their parents to participate together during each session. The children were asked to play the Alphabet game that requires them to write some words by tapping on the appropriate tagged characters. The words involved in the game were chosen by the parents prior to the evaluation sessions and defined inside the system accordingly. Each session lasted for approximately 30 minutes.

### 5.2.2 Various Transcripts of the Tap and Learn Evaluation

During our evaluation sessions, we noticed some motivating and exciting conversations happening between children themselves or with their parents. Actually, our edutainment system

created extremely valuable interactions within the group, encouraging young children in various ways. It helped increase their knowledge, confidence, satisfaction, collaboration, pleasure and communication. For example, during one of the Alphabet game session, we recorded a typical conversation between a P<sub>12</sub> and her mother, after the system asked her to write the word 'Star' as shown in Figure 5.3. The following is a transcript of their conversation:

P<sub>12</sub>: I know how to write Star.

Her mother: let me see then, what is the first letter.

P<sub>12</sub>: it's S

Mother: Okay where is S.

P<sub>12</sub>: It is there (then the child tapped on S)

Her mother: good Girl, now what is the next letter?

P<sub>12</sub>: It is a T

Her mother: Good, where is the T.

P<sub>12</sub>: the T like a turkey (children started laughing at this time)

Her mother: Yes, turkey starts with letter T.

.



Figure 5.3: A participated child while she was playing the Matching game.

Another transcript of a typical conversation occurred also between a group of children (P<sub>10</sub>, P<sub>5</sub>, P<sub>3</sub>) after P<sub>5</sub> was asked by the system to write the word orange.

P<sub>5</sub>: I know this one; it starts with an O (P<sub>5</sub> tapped correctly on the letter).

P<sub>10</sub>: It's an R now

P<sub>3</sub>: look, R is over there

P<sub>10</sub>: I learned how to write in school with Mrs Jelly

P<sub>5</sub>: Oh where is the G

P<sub>3</sub>: I think this is it (the child pointed at it with his finger)

P<sub>10</sub>: guys, no this is a J

P<sub>5</sub>: Opp, I think this is wrong, let me try what Jason (P<sub>10</sub>) said. Yes, this is correct

P<sub>10</sub>: it's my turn next

P<sub>3</sub>: the E is there.

### **5.2.3 Discussion**

From the previous two typical conversations, we can see that children were excited while they played with our edutainment system. They had the chance to socialize and discuss the questions together which really created a motivating atmosphere for them.

### **5.2.4 The Questionnaire**

In order to know the young children's opinions and to observe their level of satisfactions about our Tap and Learn system, we have asked them a number of simple questions at the end of the evaluation sessions. Here is a list of the simple questions posed to the children:

**Q1:** Did you like playing the game with the phone?

**Q2:** Did you learn new things from the games?

**Q3:** Was it fun to play the games?

**Q4:** Was it difficult to tap over the toys with the phone?

**Q5:** Would you like to have these games at home and at school?

In our questionnaire we used the Liker-type scale (summative scales) [91] that contains both yes and No statements. We sited them with scores between zero and one (Yes = 1, and No= 0) as expressed in Figure 5.4.

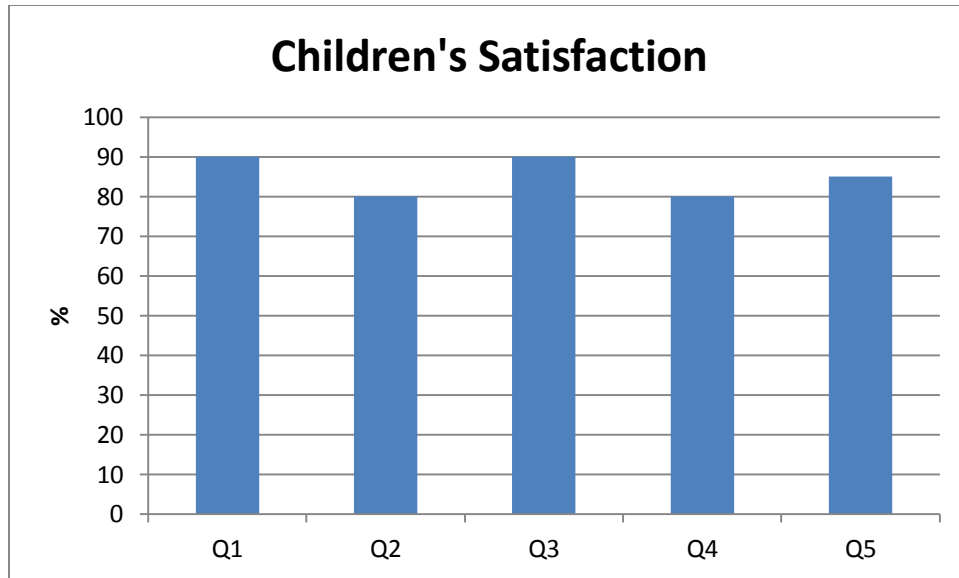


Figure 5.4: Tap and Learn satisfaction's results.

As can be seen from the chart, 90% of the children liked playing with the Tap and Learn system with the phone, 80% said they have learned new things, 90% said that it was fun to play the games, 80% had no problem to tap over the tags using the phone, and finally 85% answered that they would like to have such system at home or school.

## 5.3 Summary

In this chapter we presented the evaluation process of our proposed M-learning edutainment system. We have conducted both a qualitative and quantitative evaluations that aim to examine the impact of the system on the cognitive and social development of the children. At the end of the experimental sessions, children expressed their satisfaction with the system when asked about their playing and learning experience.

# CHAPTER 6

## Conclusion and Future Work

### 6.1 Conclusion

Recently, interest has risen for the development of edutainment systems for children, more specifically for applications that possess the temptation of electronic games while accomplishing educational objectives. Research is being carried out using tangible and physical interfaces for children's play and learning. Indeed, a lot of existing works in this area have focused on developing systems that either involve difficult interaction, or are not appropriate for young children who are at a very early stage of learning. Based on that, in this thesis we have presented an M-learning edutainment system that was developed to educate young children in an effortless, entertaining and engaging way. The children learn about different objects and entities around them without concern about the location's space or other limitations that might control children's physical movements. The ability to move is an important factor in children's educational and entertainment systems.

Young children can interact with our edutainment system through the use of a special user interface which we called Tap and Learn. It can easily be attached to a smartphone which would

serve as an attractive cover for children, and as an input for our system. Hence, our edutainment system can be attached to any smartphone, at home or outside, and does not necessitate any specific hardware. Additionally, it is a lightweight device that enables children to learn anytime and anywhere. Moreover, our M-learning edutainment system includes two different types of children's games, the Alphabet game and the Find a Match game which promote learning through playing in an entertaining manner. Children are able to tap on entities, numbers, and letters of the alphabet, and obtain in return a set of appropriate media like texts, images, audios and vibration feedback. The visual media is displayed on the smartphone's screen, which is considered as an input and an output apparatus. We have evaluated our system with 15 children in out\indoor environments like the home, and park, with children between the ages of 2 and 7 years old.

We did extensive research in order to determine the most important factors to incorporate into the Tap and Learn System to meet children's requirements and satisfy the parent's. We wanted a system that would be functional throughout the children's numerous stages of development and performance, which is challenging since we deal with children who are just learning how to talk, read and write. We also did an online survey that provided us with more information about children's needs. In addition, the two children's game scenarios included in the Tap and Learn system were evaluated inside the home as well as outside. When children were interacting with our system, they performed really well. They were able to physically move, without restrictions, and they easily grasped the idea of tapping over objects with the use of a smartphone with our edutainment system's hardware part. Our M-learning edutainment system allows children to expand and enhance their knowledge, increase their social interaction, improve their cognitive abilities as well as physical force. Moreover, from our experimental

sessions we observed that children were excited when they were using the system and they enjoyed playing with a smartphone to learn about different entities around them. They liked to enrich their knowledge in an effortless and efficient manner.

While playing with the Tap and Learn edutainment system, when children successfully tapped over objects, they received a variety of different responses from well-organized output media, based on these objects that our system effectively detected an ID tag for. Based on the conversations, questions and discussions of the children during the Alphabet game, we noticed that they were comfortable with the game and were being very creative. We also noticed that they were having a good time while interacting with the system. In the Find a Match game, children were collaborative and helpful, particularly when a child needed to find and match an object that her\his friends, parents or teachers had asked for. Finally, children were excited to tap over different entities around them. We also noticed that social communication between the children themselves and/or between them and their parents, increased. They really seemed to enjoy their time and learn without difficulties. Also it should be mentioned that our M-learning edutainment system allows parents to personalize and control the game media content, and change levels to suit their child's requirements and wants.

We have evaluated all two game scenarios in our Tap and Learn system. These games were played by fifteen young children, 7 males and 8 females. The results show that young children liked the idea of moving and tapping over diverse objects, numbers, and letters of the alphabet, by using a smartphone as an input that they could easily interact with. Furthermore, children enjoyed playing and learning via the Tap and Learn system, and they were excited and performed well during our experimental sessions. During these sessions, we observed them

without blocking their natural and physical abilities, as well as without forcing anything upon them.

## 6.2 Future Work

To conclude, we identified some additional aspects that should be studied in order to guide future work; incorporating more than one language, and providing other features to enhance the system's effectiveness, for example supporting personalised learning styles. We would also like to study the possibility of adding an Internet component where children who like to share what they have learned and thought with other friends could do so online. They would be able to engage anytime and anywhere and therefore enrich their experiences through online collaboration and activities. Additional thought should also be had surrounding the idea of making the system more challenging for children in a way that increases their social communication and collaboration, their ability for discussion, and their competitive skills, without making them feel uncomfortable or interrupting their attention from the learning task. We should examine the educational goal further by conducting a long term study where children use our system daily and are tested before and after using our Tap and Learn system, in order to make concluding remarks about their educational development. Finally, additional special features should be added to make it suitable for children with disabilities, as we believe these children can benefit from our edutainment system.

We hope that this research will attract consideration from other researchers, and be helpful in exploring the educational and entertainment opportunities for Mobile-learning in young children, in order to make learning more fun, fascinating and enlightening for the next generation.

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# APPENDIX A

## M-learning Questionnaire for young children

Q1- What is your child's gender?

- Male  Female

Q2- What is her/his age?

- 2 - 4 Years Old  5 - 7 Years Old  Above

Q3- Has she/he ever used a smartphone?

- Yes  No

Q4- If yes, how has she/he used the smartphone? (Check all that apply).

- Basic learning  
 Playing games  
 Listening to music

Q5- (Children will learn about new objects from their environment by just tapping a smartphone on those objects), do you think such a learning system could enhance children

(Check all that apply).

- Spelling Skills
- Reading Skills
- Writing to Skills
- Intellectual Skills

Q6- Do you believe that a learning system without parent's assistance (while their children utilize it) is more efficient for enhancing their learning skills?

- Yes  No

Q7- Do you think that providing several kinds of media such as, audio, video, image and text will make a learning system more efficient?

- Yes  No

Q8- Do you think that physical movements (e.g., moving, walking) is important while children are using a smartphone and learning?

- Yes  No

Q9- Do you believe that repetition of the learning material assists children memorise?

- Yes  No

Q10- As a parent, do you think that having control over the media, which is going to be

presented to your children while they are using a smartphone, will make you feel comfortable about what they are learning about?

- Yes  No

Q11- What kind of learning environment do you think is more effective for children?

- Indoor environment  
 Outdoor environment  
 Both of them

Q12- Do you think that a system which offers a touch screen interface is easy to use?

- Yes  No

Q13- What kinds of learning method systems do you prefer for your child?

- Purely education  
 Educational and Entertaining

Q14- Do you believe that educational systems that promote social interaction are more beneficial than those that do not encourage such interactions?

- Yes  No

Q15- From your opinion, what are some of the important learning features that should be provided in future smartphone based learning tools for children? (Check all that apply),

- Simple user interface
- Providing simple concepts with objects(Cat, Dog, etc.)
- Supporting different levels of knowledge and difficulty
- Inexpensive (less than 1\$)
- Attractive and joyful
- Assisting children in their learning skills(reading writing, etc.)
- Interactive

**Q16- From your experience, what kind of media does your child prefer? (Check all that apply).**

- Text
- Image
- Animation
- Speech
- Video
- Music
- Vibration

**Q17- Please provides any further suggestions or concerns you have regarding the subject or smartphone based educational programs?**

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# APPENDIX B

## Coding And Scoring Grid For Child's Self-Regulation

Self-Regulation	Child's Strategies	T1	T2	T3	T4	T5	T6	T7	All Tasks
<b>Identification of Objective</b>	+Identifies the objective (begins the activity, refers verbally or gesturally to the objective)  /Listens to or asks for explanation or approval of the objective  _Does not identify or forgets the objective								
<b>Exploration of Means and Planning</b>	+ Planning, anticipation of means displayed  / Trial-and-error exploration  _Child performs actions when								

	instructed by the adult, no spontaneous activity	
<b>Socio-communicative self-regulatory strategies of joint attention (looking, gestural or verbal pointing, questioning, commenting)</b>	+ Initiates and responds regularly to joint attention  /Initiates and responds sometimes to joint attention (2–3 times)  _Loses in interest in initiating or responding to joint attention	
<b>Socio-communicative behaviour regulation self-regulated request (request for help, approval, or explanation)</b>	+Makes rare and absolutely necessary requests (<2 times)  /Makes some requests which are necessary (2–3 times)  _Makes very regular, or even excessive, unnecessary requests (>3 times)	

<p><b>Self-regulated attention</b></p>	<p>+Manages his/her attention (no lapse of concentration)</p> <p>/Manages his/her attention moderately (&lt; 2 lapses of concentration)</p> <p>_Does not manage his/her attention (&gt;2 lapses of concentration)</p>	
<p><b>Self-motivation</b></p>	<p>+ Regularly expresses his/her pleasure or self-reinforces or maintains his/her motivation</p> <p>/Moderately or sometimes expresses his/her pleasure or self-reinforces or maintains his/her motivation</p> <p>_Does not express his/her pleasure or does not self-reinforce or does not maintain his/her motivation</p>	

<b>Self-evaluation</b>	+Identifies his/her errors and adjusts or corrects them  /Asks help or approval to correct self-identified errors  _ No personal self-evaluation	
<b>Over All</b>		

Note: T = task; 1-7 = Number of the task.