

Game-based learning and Gamification to improve skills in early years education *

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Abstract. Early childhood education has become a prevalent public policy issue. It has a serious impact on the child's personality, upbringing, education, socialization, development, and academic success from the preschool period to the university and beyond. In general, traditional teaching methods usually have a fixed learning structure which disables the child to be motivated, creative and innovative. Learners receive theoretical rather than practical instructions, which discourage them from keeping and recalling concepts and information more quickly. Moreover, traditional teaching usually lacks attracting the full attention of learners which decreases their interaction, engagement and investment in the content. Thus, the development of innovative approaches offering better education is an effective way to address this problem. On the other hand, recent researches in the fields of cognitive science and educational neuroscience show that play-based learning is a promising approach to use in early childhood education. Four key success factors for learning have been identified to strengthen children's skills, namely attention, active engagement, feedback, and consolidation. Thus, the proposed approach presents a digital play-based learning approach deploying serious games augmenting the pedagogical aspect of the Montessori approach. Our purpose is to improve children's skills in their early years education through play-based learning and gamification. It aims to provide children with a rich variety of serious gaming activities and challenging experiences in an interactive environment. We developed several serious games based on Montessori pedagogical principal and the four pillars of learning. For the evaluation, we have chosen a representative sample of children from rural regions.

Keywords: Early childhood education, Serious games, Gamification, Educational neuroscience, Pillars of learning.

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1. Introduction

Several studies have reported that early childhood education has a high impact on the child's socialization, development, and academic success. It also significantly impacts the socioeconomic outcomes of individuals. Indeed, early childhood is a critical and important stage where children acquire and develop their social and cognitive skills, self-esteem, and perception of the world. Early childhood education is an important and fundamental stage of learning. It is considered as one of the most effective ways of providing future generations with necessary skills and competencies needed to succeed in future labor markets.

Cognitive science claims [13] that learning requires being attentive, engaged, receiving and consolidating information, and giving immediate feedback. However, the basic traditional education does not respect these basic concepts. For example, it is insufficient in terms of direct learning. Also, it decreases the child's motivation by enforcing a preset program and a fixed learning structure to follow. Consequently, the children are not given the choice to take the lead in choosing the content to be learned. Therefore, it decreases the child's motivation, creativity, innovation, then their attention which implies less engagement and knowledge acquisition.

It is more difficult to motivate the education of children living in rural areas of Morocco. Young girls are more deprived of schooling than boys living in disadvantaged areas due to the difficult living conditions (the lack of basic infrastructures, schools located far-away from the residential areas, etc.), poverty and lack of knowledge in their familial environment. Our challenging project ties in with many Moroccan organizations working to combat child school dropping by motivating their early education and raising awareness in rural areas. In fact, children intuitively learn through playing and interacting with others in a stimulating environment. It maintains their motivation, increases their interactions and their choice making.

Actually, recent educational neuroscience researches show that the best way to teach children is through playing, getting their attention, their engagement, receiving feedback and consolidating their skills [12]. Early years education should provide children with a rich variety of play activities and challenging experiences in a stimulating environment. Indeed, play is an essential activity for children to enhance their creativity and learning skills. The Playful behaviour can be considered as an exploratory and knowledge-building element [1]. Besides, playing at a younger age improves our capabilities to deal with real-life situations and interacting with the real world [2]. For children, playing is the natural way to improve their future skills starting from their early age [3]. When they play, they use plenty of their senses to capture and acquire diverse information and extend their knowledge about their environment. Moreover, children will develop new skills and abilities (e.g., talking, thinking, etc.) through playing. Also, playing provides children with the opportunity to boost their attention span, learn to get along with others, cultivate their creativity and address their social, emotional and cognitive needs. But also, it develops children's main academic skills like language and mathematics. In fact, learning through playing is a pedagogical strategy that is increasingly used in education [37]. The play mechanics create interactive and fun experiences for the learning player. Indeed, playing allows children to choose their activities and establish their own ways of doing things. Consequently, it enables them to control their learning and making new challenges.

Nowadays, the evolution and development of Information and communication technologies (ICT) improve the quality of education. It enables a broadcast of the same content through internet. In our case, it will rapidly widespread the diffusion of digital pedagogical materials and allow teachers and learners to access them online especially those living in rural areas. Serious games, IoT, virtual reality, cloud computing and many other emerging technologies offer the possibility to develop innovative learning solutions like the mobile and pervasive learning systems.

Our aim is to make use of ICT emerging technologies to develop a playing-based learning approach that relies on the fundamentals of neuroscience and Montessori pedagogical principal. In the conventional learning approach, teachers and students are attached to two separate worlds (the pre-digital generation and the digital generation). This explains the children's preference for digital games than traditional ones. In this regard, our aim is to make use of digitalization and emerging technologies to augment serious games based on the pedagogical aspect of the Montessori approach.

This paper presents a methodological approach that uses serious games based on the cognitive of playing and Montessori educational method in order to offer a research-based solution that makes playtime more stimulating and educational for children.

The rest of the paper is organized as follows: the early childhood education benefits are described in Section 2. Section 3 provides explanation where educational neuroscience meets early childhood. Section 4 depicts the concept of learning through play including the Montessori educational approach. The gamification and serious games based learning for early childhood containing our proposed approach are described in Section 5. The implementation and the experimentation results of our developed serious games are described in Section 6. Finally, the conclusion and future directions are delineated in Section 7.

2. Early childhood education benefits

The preschool prepares young children for the elementary education. It is considered an instructive period in the grounding of concepts and constant ideas [32]. During this phase, different experiences influence outcomes across the entire course of an individual's life. Children, who grew up in a rich and supportive environment, are more likely to achieve their full potential and achieve optimal physical, cognitive, linguistic and socio-emotional development. In addition, young children mostly benefit from childhood enrichment program of intellectual activities, emotional reactions, and behaviors. Consequently, an early childhood education quality can provide essential experiences for the child's brain development, therefore, have a direct effect on his cognitive abilities and future learning capacities [6].

2.1. Long-lasting benefits of preschool

Nowadays, studies conducted in the United States [9, 10] and in the United Kingdom [11] have shown a positive relationship between childcare quality and child's development outcomes. These studies have assessed the quality, quantity, and the type of childcare at regular intervals. The Cost, Quality, and Outcomes study found that there

is a positive relationship between preschool quality and children's language and mathematical abilities. The results of the NICHD ECCRN study, covering over 1,300 children from 10 sites from birth, indicated that high-quality care is related to better cognitive outcomes, less impulsivity, and better social competencies at 4.5 years of age [10]. The preschool phase helps the children to strengthen the beginning of learning and success. One of the main good education practices:

- *Socialization*: It represents a serious matter to familiarize children with others and strengthen their exchanges. It also allows children to overcome their shyness and increase their social interactions.
- *Concept of Cooperation*: It enables sharing, coordinating, and adopting a comfortable learning condition.
- *Passion for Lifelong Learning*: Lessons should be given in a fun and stimulating way that cheers children up to be more attentive and engaged on their learning process.
- *Confidence and Self-Esteem*: It offers positive thinking and confidence for children.
- *Develop literacy and numeracy skills*: children learn by tuning in to stories, discussing pictures and drawing shapes. For example, they learn numeracy abilities by singing and playing music. The proficiency and numeracy abilities in the preschool affect the child's scholastic achievement.

3. Where educational neuroscience meets early childhood

Neuroscientists have shown that the brain has a great capacity to adapt to the demands of its environment: Plasticity [7]. Neuroscience includes all the fundamental disciplines necessary to explore the anatomy and functioning of the nervous system, and more specifically, the brain. Over the past fifteen years, this new discipline has continued to progress in understanding the functionalities of the brain and its surroundings. In fact, while brain sciences deal with the processes underlying learning, education aims to apply them in real life and more particularly in school life. However, although there are obvious bridges between these two disciplines, neuroscience is in the process of being used in the education realms. Neuroscience synergizes with other disciplines, have broadened our understanding of the brain in a way that is highly relevant to educational practices [12]. Cognitive science has identified at least four key factors as pillars of learning processes and pedagogical strategies [13] [14]. Actually, good learning involves attention, active engagement; feedback and consolidation (see Fig.1).

Attention mainly modulates brain activity. It is the gateway for learning that enables children to be focused on choosing and processing relevant information. In the play-based learning approach, the materials should avoid children to stay stuck and be distracted from their primary tasks. The main objective is to capture and draw the child's attention on relevant levels through ludic, ergonomic pedagogical materials. The

challenge, therefore, is to focus the attention of children during their learning by inhibiting undesirable behaviours.



Fig. 1. Foundations of the proposed approach.

A passive learner does not learn. The active engagement of the learner underscores his curiosity and denotes his abilities to be maximally attentive, active, and predictive. Thus, we should take into account making learning conditions reasonably challenging that are neither easy nor difficult but adequate to the learner's context. This should paradoxically lead to increase engagement and cognitive efforts, which means improved attention. As a matter of fact, preserving commitment means that the teacher must avoid giving a long lecture, but involve the children, test them frequently, guide them while allowing them to discover certain aspects by themselves, and reward systematically their curiosity rather than discourage it.

During the learning activities, the child should have the possibility to test himself the reliability of his knowledge. The feedback of information is essential and the difference with the made prediction generate an error signal that would contribute to correct and to improve the following prediction. Indeed, to err is human. Far from being a fault or a weakness, the error is inevitable but also necessary and fertile even indispensable in learning situations. Better an active child who is wrong and learns from his mistakes, than a passive child. Further, the consolidation considered as knowledge automation where the brain achieves automation. Consolidation is the act of passing from conscious treatment with an effort, to automated unconscious treatment and the challenge is to accomplish the transfer from explicit to implicit.

Correspondingly, the child learns by his emotional intelligence [15] [16], then develops a link with his teacher, which makes him learn more words and operations. As

soon as it grew, he should be initiated at the intelligence logic, which must be implemented by single organizations and visual methods.

4. Learning through Play

4.1. Play in different ways

There are different types of play that correspond to each stage of a child's learning progress.

Exploratory play: using physical skills and sensations to learn about materials and their properties.

Constructive play: using objects and materials (e.g., blocks, playdough, collage materials, sand and water) enhances their creativity, recognition and solving problems.

Creative play: using open-ended materials such as art materials and natural materials to encourage fluency, flexibility, originality, imagination, and making novel connections.

Socio-dramatic play: involves interaction and verbal communication with one or more play partners regarding the play event.

Physical locomotor play: a range of fine or gross motor skills are practiced involving all kinds of physical movements.

Language or word play: incorporates rhyme, wordplay and humor.

Play in early childhood performs an important role in learning. It is significant in cognitive, psychomotor, emotional, social development, and so on. The most commonly applied pedagogies are Piaget's constructivism [2] and Vygotsky's Zone of Proximal Development [17]. For the Piaget's constructivism, a child is motivated by their curiosity to acquire their knowledge through their experiences and other's influences. Moreover, the co-operative social interaction of children with adults, promotes cognitive, and affective development. The Zone of Proximal Development (ZPD) as proposed by Vygotsky [17] enables problem solving under adult guidance or collaboration with more skilled peers. One of the main approaches using play to learn is Montessori. Actually, many applications of constructivist and learning discovery mainly use Montessori materials.

4.2. The Montessori educational approach

The Montessori educational method has been created by Dr. Maria Montessori in a poor neighborhood in Rome in 1907. Maria Montessori (1870–1952) was qualified among the first women to a medical doctor specialized in psychiatry and pediatrics in Italy. She worked with children with intellectual disabilities, she had an important insight that they did not require medical treatment to learn but rather an appropriate pedagogy. She achieved fostering her pupils' self-construction and learning on several stages of development by engaging with self-directed activities within a prepared environment.

She continued improving her pedagogy based on a scientific approach of experimentation and observation for 45 years. Since its initiation, the Montessori approach has attracted international interest and has spread around the world [37].

Montessori's educational method has two important aspects: The learning materials; And the self-directed nature of children's engagement with those materials [37, 38].

- Each piece of material covers a concept to be learned, containing a self-correction control, and having a learning process starting from the concrete to the abstract concepts.
- The learning material triggers a self-directed nature of the child's engagement with those materials to enhance the learning process under the teacher's expert guidance. For example, the child-led manner is expressed through his self-selection and repeated engagement.

This method potentially benefits from enhancing the development of the learning process compared to the teaching of the conventional classroom [39]. Arguably, Lillard and Else-Quest [40] is the most robust evaluation of the Montessori method so far [37].

When the Montessori educational method is rigorously implemented in a school, it fosters social and academic skills equally or better than those fostered by non-Montessori schools [40]. The authors [44] conducted a study of 172 children in Montessori and conventional school classrooms, where the Montessori classrooms performed best on a wide array of social-emotional and academic dimensions. Indeed, well-implemented Montessori classrooms have superior outcomes than conventional ones [45].

4.3. Benefits of Play

A review of more than 40 studies found that play is significantly related to creative problem solving, co-operative behaviour, logical thinking, IQ scores, and peer group popularity. Play enhances the progress of early development from 33% to 67% by increasing adjustment, improving language and reducing social and emotional problems.

Playing occupies a considerable amount of children's daily time and energy. Some of benefits of play are listed below:

Building imagination and ability, during play, kids typically mimic adults and build make-believe games that widen their imagination.

Psychological feature Growth, free play has an effect on confidence, intelligence and communication.

Group Interaction, Group play develops the necessary skills improving self-control and group integration.

5. Gamification and Serious Games Based Learning for Early Childhood

5.1. Gamification and Serious Games

Gamification aims to transform systems, activities, organizations, and services to a system that uses the characteristics of game elements [33]. Gamification is a well-known technique in education, organization engagement, crowdsourcing, commerce, information retrieval, and so on [34, 35]. It is practical to improve learning processes especially the learners' motivation [36]. Gamification techniques are benefiting from advances in ICT. Applications of gamification span a wide range including healthcare, marketing, management and recruitment, as well as learning and teaching. The relation between education and gamification is on the rise by making use of learning activities as a subject to gamification.

The intention is therefore to motivate and involve learners in becoming active participants in their own learning process. In essence, the pedagogical experience is transformed into an educational challenge by the use of badges offered in case of achievement, scoreboards, progression levels and missions. All of these game elements are integrated to support the learner in achieving their goals and learning objectives. In summary, gamification uses game mechanics to transform the educational experience into an effective learning process.

A serious game is a computer application that combines with consistency, both serious aspects such as learning, or communication intent, with playful springs from the video game like collaboration, competition and strategy [26, 27]. Actually, their main use aims to improve users' skills, engagements and performances [28, 29].

The term "serious gaming" has been used since the 17th century. Serious games were introduced in the 1970s due to the efforts of pioneers like Clark Abt. The author [52] published a book entitled *Serious Games* where he describes the possible uses of games to learn and simulate situations. He uses the term with reference to card and board games and role-playing games.

Three main criteria, "G/P/S model", are used for serious games classification [30]:

- G: Gameplay that incorporates all the mechanisms used through the game rules, player and the game connection, challenges, and so on.
- P: Purpose represents the hidden information on the functions that go beyond the entertainment provided by the designed games.
- S: Sector, the areas of applications covered by the "Serious Game".

Relevant serious games applications have recently been developed in different domains including education, training, well-being, advertisement, cultural heritage, interpersonal communication, and healthcare. Advances in gaming technologies allow the real-time interactive visualization and simulation of realistic virtual heritage scenarios, such as reconstructions of ancient sites and virtual museums [18]. Many research contributions are directed towards taking advantage of the success of video

games and using them for the benefits of the educational domain [19]. Also, there are a few research studies and projects that use serious games in the context of preschool to develop the children's abilities and academic skills in mathematics and languages [20, 21].

In fact, serious games have been used in several domains such as, Tourism [47] to add value in tourism marketing and management; Energy assumption [48] to positively influence consumers about their energy assumption. Education [46] where using games shows positive effect during the learning process by gathering a survey of players using only two learning games. The authors [49] propose the use of didactic games to improve the arbitrary memory for preschoolers. Other authors [43] introduce an intervention program that uses voices and detects gestures to teach colors and shapes to preschoolers. Another research study [50] aims to use online gamification to promote academic dissemination. Recent approaches [41, 42, 43] consider applying serious games on education, our proposal also considers the children's cognitive developments through playing. Indeed, Montessori educational fundamentals are supported by the current psychological research [45].

Based on Montessori pedagogical principal and the four pillars of learning, our aim is to develop a proposed approach that provides children serious games in rural areas.

5.2. Proposed approach

As it was mentioned above, one of the motivating challenges is to elaborate pertinent solutions addressing the problem of dropping out school in early childhood. In this context, we have initialized a project aiming to develop innovative solutions to deliver an accessible early childhood education. Our goal is to eliminate the inequality in the matter of education and create real opportunities for children, in particular young girls, in rural areas to have access to education.

The pedagogical method we adopted within our project is based on Montessori approach [22, 23,24]. It states that the purpose of early childhood education is to raise the motivation of children in learning.

The Montessori approach distinguishes five categories of activities and skills to develop (see Fig.2). We aim to develop some serious games enhancing the child's learning, such, mathematics and science skills, reading and spelling and so forth.

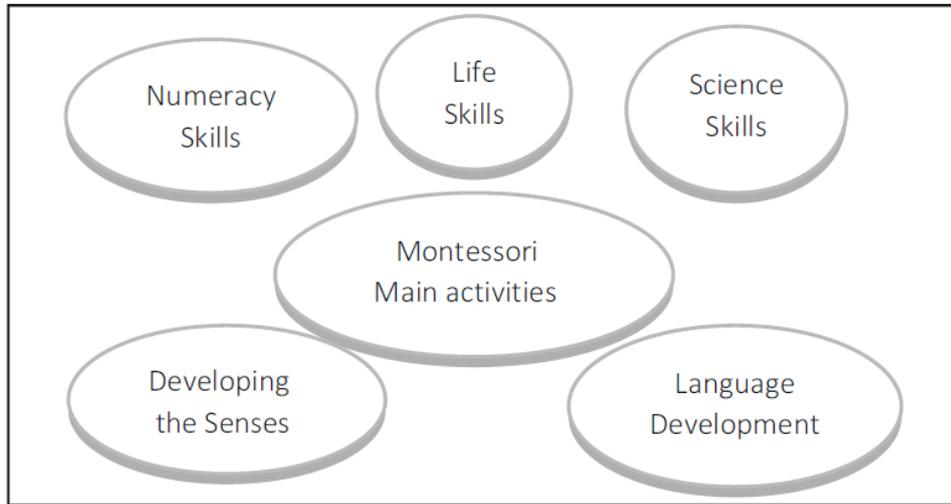


Fig. 2. The montessori approach main activities and skills.

This approach proposes the main learning activities and skills. During learning activities, the child should be autonomous and be mainly motivated by its natural curiosity. The fundamental principles of our approach are described as follows:

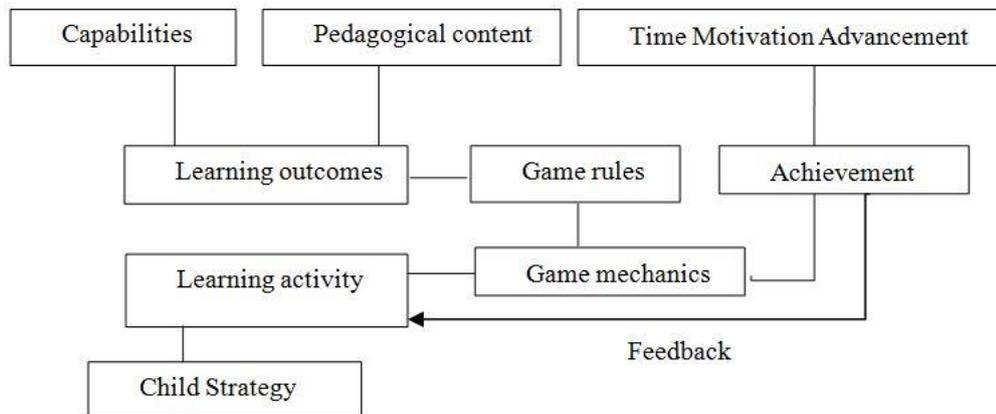


Fig. 3. Proposed approach structural diagram.

* The child's activity is initiated by his own will and not by his companion's instructions.

* Repetition of manipulation allows the child to respond to his curiosity and his personal pursuit.

* The most important part is to learn by doing. The child is encouraged to learn by practicing.

* The child absorbs the impressions given by his environment by offering a rich atmosphere of experiences.

Furthermore, the serious games developed in our project are aligned to the Montessori approach and with respect to the pillars of learning reflecting the educational cognitive science point of view. Indeed, errors are considered as phases of the game and do not prevent children from acquiring skills. In addition, immediate feedback ensures the quality of what they have learned, which is a very important factor for effective learning.

6. Implementation

6.1. Architecture and application

The developed serious games can be used in a group of children either in the context of online learning or blended learning that joins traditional classroom methods. They are accessible using a mobile device like a smartphone, a pad or a desktop (see Fig. 4). Presently, we have implemented more than twelve serious games integrating different Montessori Approach's main activities and skills. Below, we present some examples of developed serious games (Tables 1, 2, and 3). Our proposed play-based solution offers a pervasive learning within mixed aged children.

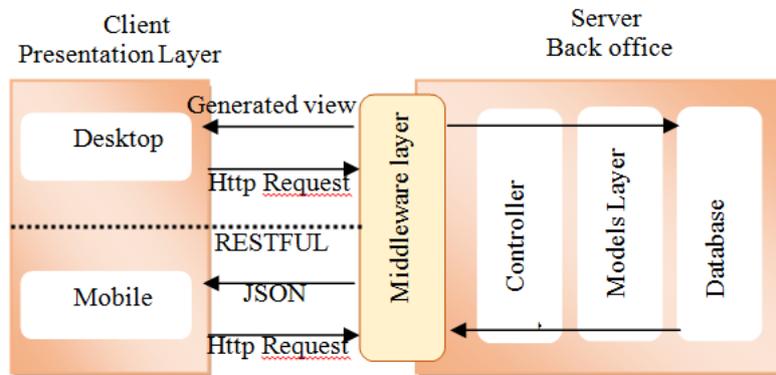


Fig.4. Main Architecture.

Table 1. Serious games concerning the language and the numeracy skills development.

Activities and skills : Language Development	Activities and skills : Numeracy Skills
	
<p>Game goal and Guidelines: This game help kids recognizing a letter, numbers shapes, and associate them with phonic sounds, and put apply some basic mathematical operations their alphabet knowledge to use in fun with quantities (using fruits). This game has exercises. It has the same pedagogical goal and it is aligned with the entitled games “The phonetic alphabet” and “Identifying alphabets” in Montessori .</p>	<p>Game goal and Guidelines: This game is about numbers and how to use them and apply some basic mathematical operations with quantities (using fruits). This game has the same pedagogical goal and it is aligned with the entitled game “Addition using numerals” in Montessori.</p>

Table 2. Serious games concerning the senses and the life skills improvement.

Activities and skills : Developing the senses	Activities and skills : Life Skills
	
<p>Game goal and Guidelines: This game teaches the kid the colors, their spelling and their phonic sound. This game has the same pedagogical goal and it is aligned with the entitled game “Discovering colors” in Montessori theory.</p>	<p>Game goal and Guidelines: This game shows the child the importance of brushing teeth. It has the same pedagogical goal and it is aligned with the entitled game “Cleaning teeth” in Montessori theory.</p>

Table 3. Serious games concerning Science and geography skills development.

Activities and skills : Introducing geography	Activities and skills : Introducing language
	
<p>Game goal and Guidelines: This game teaches the child the continents, the countries and their location by making their first experience of geography as concrete and fun. This game has the same pedagogical goal and it is aligned with the entitled game “Introducing a globe and map “ in Montessori theory.</p>	<p>Game goal and Guidelines: We can use this game as a starting point to introduce and practice several things at once (how to say the names of the letters and about all the sounds of each letter, etc.). Children learn by observing, listening and imitating.</p>

6.2. Evaluation

We have focused on integrating points explained bellow to develop a set of interactive serious games. The first one concerns the cognitive development by considering the children’s activity to enhance their intelligence progresses.

The developed serious games promote learning through the children’s experiment, exploration, learning from mistakes, then understanding and repeating. Experiencing new way of leaning triggers and activates their neurotransmitters. We have applied our developed serious games on a group of children having different ages (4 – 6) from different rural areas as shown below in Table 4.

Table 4. Experimental results.

Identified factors		average	Motivation
Numeracy Skills	<ul style="list-style-type: none"> Recognizing letter, numbers shapes, and associate them with phonic sounds. 	4.2	3
	<ul style="list-style-type: none"> How to use numbers to apply some basic mathematical operations. 	4.3	3
Life Skills	<ul style="list-style-type: none"> Teaching the correct way to brush their teeth. 	4.1	4

Child's speech and language development	• Introducing basic French vocabulary, such as the alphabet, colours, names, and so on.	4.2	3
	• Correcting the alphabet spelling.	4.4	2
Geography development	• Teaching children the names of continents.	4.8	4

The evaluation has been conducted evaluating 30 children (40 % girls and 60 % boys). Thereafter, we have collected the serious games' scored tracking in order to analyze the results. At the meantime, and to obtain their reactions, a "stakeholder feedback session" has been done.

The evaluation considers the instruction of the research study [25]. We have targeted two indicators. The first is the amount of work performed (it is measured based on the number of completed games' levels) and the second one is based on the accumulated knowledge (resulting from each feedback session). We focus on a certain learning topics; we developed our solutions including the learning activities and skills. For the evaluation, we used a scale from 1 to 4, where {1 = "boring"; 2 = "so-so"; 3 = "fun", and 4= "awesome"} to measure the children's learning skills and feedback to the serious games. Based on the results and tracks gathered during the "feedback session", we were impressed by the final rendering, a perfect understanding of the content in a short period.

A score is assigned at each accomplished game's level, varying from 1 to 5, in fact, the game does not display scores but rather a reward, which is represented by an interactive cartoon character.

7. Conclusion and Perspectives

Play is crucial to the development of social, emotional, linguistic and intellectual child's abilities. It is a great way to discover the world and flourish. In reach of playing, the child flavour more confident, autonomous and have more pleasure to acquire new academic skills (mathematics, language, etc.) and social aptitudes (confidence, communication, etc.). All along playing and doing fun actions, he would be more motivated and curious to discover the world around him while adopting a positive attitude towards action.

In addition, play contributes to the shaping of the child's identity through creativity. Playing is exploring the world outside, having the freedom to decide. It's the place for unique experiences, area of innovation and inventiveness. It's also, consociates children with their imagination, parents and their surroundings.

Education through play, also known as edutainment, is a combination of education and amusement. The idea is to enlighten and empower the child by incorporating learning into various forms of diversion such as television programs, computer games, and multimedia programs or even through music. The over-the-top decade has seen a tremendous increase in digital game-based learning, with the flourishing and rising

prevalence of smart phones and tablets reshaping learners' expectations. As a result, the use of digital pedagogical materials offers stimulating learning environments are becoming increasingly desirable.

Nowadays, African countries present a significant number of dropping out of school, in particular in preschool. This is due to several reasons, such as poverty, growth tuition fees as well as the lack of security. Learning starts at birth, and the first six years are for discovering and exploring. Indeed, a strong beginning in the early years provides individuals with the best and fairest chance to reach their fullest potential. Therefore, it would be essential for gathering all efforts to find innovative solutions to deliver an accessible education allowing a gapless learning. Correspondingly, the use of Serious Games by advantage of their specificities (amusement, divertissement and interactivity), in both formal and informal curriculum, presents encouraging results. It would impact classical learning methods, especially in early childhood education.

In this paper, we have presented our propositions and contributions to assure the development of the children's early learning, in particular in rural areas. In fact, access to preschool is the main factor for individuals' school success and thus social and economic development of the countries. For early childhood, we propose a Montessori's Method based serious games solution. We developed several serious games according to an agile method. We have identified some factors for the assessment of our solution, and respectively, the experimentation is carried out on a specific children group from different regions, in order to evaluate the acceptance and usefulness of our approach.

What we expect in the near future, is that our approach and solution will have great flexibility and will meet the needs of a large scale of children. Another challenge that we try to face is about the youth unemployment problem in Northern Africa. To treat the scourge of youth unemployment, we project to capitalize on the outcomes of the actual project to develop a pervasive collaborative system to enhance Northern African youth entrepreneurship through gamification [31].

In future perspectives, we aim to construct an educational recommender system [51] that uses child-players feedbacks for suggesting learning pathways of serious games that fit in as much as possible with the profile and motivation of the learners. As well as working on other evaluation aspects, e.g. evaluating the children's reasoning improvement.

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