

Research on Educational Mobile Games and the effect it has on the Cognitive Development of Preschool Children

Qi Ni

Zhejiang University of Technology
HangZhou, China

Yonghai Yu

Zhejiang University of Technology
HangZhou, China

Abstract—Educational mobile games can not only stimulate a child's interest in learning but also can promote and increase language development, critical thinking, emotional development, intelligence, and imagination. Therefore, educational games could be seen as having an important role to play in a child's development. This paper is an in-depth analysis on the effects of educational mobile games and the application and use of said games at home and abroad as well as the research on the cognitive developments of preschool children. Using Piaget's theory of cognitive development as its foundation, this analysis summarizes the idea that the design of interactive games has an important guiding significance in children's cognitive development.

Keywords—Cognitive development theory; educational mobile games; user experience; interaction design

I. INTRODUCTION

With the development of computing and network technology, it is not only adults who are using technology to engage in a variety of work, educational and entertainment activities. The development of early childhood education applications has also become a trend, leading to more and more preschool children engaging with technology. Simultaneously, as a special group, preschool children (3 to 7-years-old) have their own behavioral characteristics and cognitive limitations which must be analyzed differently from those of older children and adults. Early childhood educational software predominantly takes the form of games, where the interactive simulation and educational aspects are initialized in the virtual world by intuitive game experiences^[1]. But issues surrounding this topic have arisen. For example, whether children should be playing educational mobile games, how educational mobile games should be played and how such games should be designed suitably for preschool children. These issues have become major concerns for both parents and educators. Therefore, according to the needs of children's cognitive development, it is of significant importance that game interfaces and experiences are suitably designed to include lively activities to aid the development of more efficient teaching strategies.

II. ANALYSIS OF THE STATUS QUO OF PRESCHOOL CHILDREN'S EDUCATIONAL MOBILE GAMES

To study the current state of preschool children's educational mobile games, we have to start from existing

education applications. After a comprehensive analysis of existing domestic and foreign educational applications, early childhood educational goals can be categorized into three major areas: cognition, emotion, and action skills. These three areas can be seen to cover the following: language information, intellectual skills, cognitive strategy, attitude, emotion, and action skills. A user's needs and existing solutions of various fields are shown in Figure 1:

Types	Learning results	Sub-field	Specific user requirements	Existing solutions
Cognitive field	Linguistic information	Language s	Learning words, pronunciation practice	Literacy cards, pronunciation feedback, etc.
		Reading	Children's stories and songs, Tang poetry, etc.	Audio reading, parent-child interaction
Cognitive field	Intellectual skills	Mathematics	Cognition and numerical concepts	Simulated identification of objects
		Cognition	Shapes, animals and plants, daily necessities, etc.	Object identifying cards, puzzles and sticker books
		Life Skills	Living habits, safety, common sense, etc.	Picture books, situational experiences
		Arts	Music, paintings, dressing up, etc.	Percussive instruments, coloring and roleplaying, etc.
	Cognitive strategies	Memorization	Instantaneous memorization abilities	Pairing, look through
		Observation	Discriminative ability	Looking for differences
		Imagination	Divergent thinking	Story deduction
		Logical thinking	Sorting, summarization abilities	Item classification, puzzles
Emotional	Attitude	Attitudes	Promotion	Picture books,

field	e		of social communica tion	situational experiences
	Emotio n	Families	Recording, Increase parent-child interactions	Growth record, interaction
Action skills	Action skills	Cooperati on	Study, cooperate and share	Games of simulated operation and development
		Full-body movemen ts	Balancing and coordination	Combining the applications with peripherals
		Precise movemen ts	Eye-hand coordination	Characteristics of touch screen

Figure 1. User needs and existing solutions of three major fields

Through research and analysis, it was discovered that, current early childhood education focuses mainly on the learning of language information and intellectual skills. In terms of image-identifying cognition, it mainly adopts methods such as object-identification cards, puzzles, and sticker books which can be classed as focusing on receptive knowledge. But there are shortcomings with the above solutions, which are: (1) As a special group, preschool children's cognitive thinking is still in its initial stages and the existing interaction interface is not in line with the cognitive characteristics and cognitive habits of children; (2) The interfaces of education applications have too many layers and are too complex, which lack visual centers making them difficult for children to use; (3) The direct transfer of the traditional early education mode to the digital platform does not take full advantage of the platform's features and benefits.

Therefore, the experiences of preschool children with image-identification educational mobile games is an area that is worth our exploration. The goal of cognitive development is to prepare children for their future challenges and roles. The interactive scenes of images, sounds, animations and other media make the image-identification more like play, which stimulates children's interest in learning, enriching a child's experience so as to achieve the purpose of teaching through lively activities.^[2] At the same time, open interactive scenes also exercise children's imagination and creativity, turning the traditional receptive knowledge into expressive knowledge.

III. INSPIRATION OF COGNITIVE DEVELOPMENT THEORY ON THE IMAGE-IDENTIFYING EDUCATIONAL MOBILE GAMES

Traditional early childhood games are developed extensively, both in theory and in practice, and the development process takes into account the game's use and value in preschool education, educative quality, innovation and other aspects. The aim of educational mobile games is to provide an immersive learning environment which is in line with the requirements of children's physiological and cognitive psychological development; and they use simple interactive methods to stimulate children's interest in learning so as to let the children explore and cognize the world at their own pace.

A. The cognitive development of preschool children

The cognitive-developmental theory was first put forward by developmental psychologist Jean Piaget. He used four basic concepts - schema, assimilation, adaptation and balance to elaborate the activity process of an individual's cognitive structure. The core concept - schema, i.e. the cognitive structure, has the functions of sorting, concluding, transforming, and creating objective information to make the main body adapt to the environment effectively. The construction of cognitive structure is carried out through assimilation and adaptation while balance is the essence of adaptation.^[3] As is shown in Figure 2, the psychological development of children is essentially the development from schema of low level to that of high level through constant improvements, so that the psychological structure constantly changes and innovates, forming development stages of different levels.

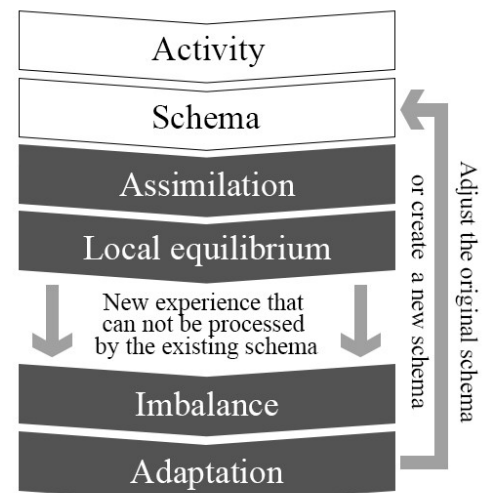


Figure 2. The development process of children's psychological

Piaget divided a child's cognitive development into four stages:

- Sensorimotor stage, 0-2 years old: The main cognitive structure of a child at this stage is perception motor schema, which helps coordinate sensory input and action reaction, i.e. adapting to the environment through actions.
- Pre-operational stage, 2-7 years old: children internalize sensory actions into images, establish the symbol function and can use psychological symbols (mainly the images) to think, which is a great leap in terms of thinking ability.
- Concrete operations stage, 7-11 years old: Children's cognitive structure evolves from the image schema of pre-operation stage into operation schema, which is a preliminary logical thinking ability. This phase is characterized by conservativity, de-egocentricity and reversibility.
- Formal operations stage, 11 years old and above: Children's thinking reaches the level where they can

think using abstract logic and they are able to seek solutions to problems systematically.

Based on the four stages of cognitive development theory, it can be concluded that a child's perception and ability structure are different from those of adults. Therefore, educational mobile games should be designed according to the psychological characteristics of a child's psychological structure and the different stages of development; and interfaces and interactive modes should be presented in a way which suits the characteristics of children at different ages ^[4].

B. Effects of games on children in the field of development

Playing games is an important way for children to socialize and has a very important influence on a child's development. Its significance is to stimulate intelligence, sense and emotion, improve imagination, and creativity while supporting the all-round development of physical, mental and social attributes.

The renowned Chinese educator, Chen Heqin once said, "Playing games is the life of children", it can bring children happiness, experience, knowledge, ideas, and health, which play important roles in education and should become the main way to educate children. The materials, plots, and actions in a game can arouse a child's interest and attention, and let them practice thinking throughout the course of the game while also learning how to behave properly. Piaget's game education theory pointed out that the essence of games is the surpassing of assimilation over adaptation. Games are not independent activities, but are one part of greater of intelligence activities. ^[5] Therefore the development of games are driven and restricted by the cognitive development and are in line with the cognitive development stage. Each game has its own characteristics in regards to psychological structures, representing different development stages of the psychological levels of children. He divided the intelligence level of preschool children into two stages- perceived action stage (0-2 years old) and pre-operation stage (2-7 years old), and summarized the main forms of children's games at these two stages.

(1) Perceived action stage - games for practicing: in this type of game there is always a new function that needs to be mastered. (2) Pre-operation stage - symbolic games: It is the typical form of children's games, and is also the characteristic of self-centered games during the characterization activity period, which is that assimilation surpasses adaption and begins to dominate. Children establish contacts subjectively between signals and objects being signalized and organize activities without considering about specific things and the real environment.

Mobile digital learning is the trend of the future for education, and will also become an important auxiliary for preschool game education. Thus we should fully grasp this unique learning method - games and design interfaces which suit their habits according to their psychological features and let children really immerse themselves in these interactive experiences.

IV. STUDY OF THE USERS OF PRESCHOOL CHILDREN'S EDUCATION GAMES

The object of studying preschool children (refers to children of 3-7 years old) who are in the pre-operation stage is that their permanent consciousness of objects are consolidated and a large number of actions are internalized. With the rapid development of language and preliminary development of thinking, children frequently represent external things with symbols; they pay attention to the external activities, which is an important advance in children's intelligence.

A. User characteristics of preschool children

The characteristics of a child's cognitive development at the pre-operational stage are categorized through the literature research on children's physiological and cognitive development theory, which are analyzed from four latitudes – cognitive thinking, visual perception, spatial perception and memory, as is shown in Figure 3:

Types	Progress	Typical performance
Cognitive thinking	Animism	All objects have life, and human consciousness and motivation is often extended to inanimate things
	Egocentrism	Can only perceive the world from their own point of view, and find it difficult to understand the ideas of others
	Lack of hierarchy concept	Cannot straighten out the relationship between the whole and the part
	Irreversible thinking	No conservation concept, and thinking is irreversible
	Lack of conservation	Conservation is to grasp the essential feature of the concept, they experience difficulty in seeing the essence through the surface
Visual perception	Color cognition is from life	Frequent contacts can deepen the impression of those colors that are commonly used in life
	Identifiable degree is affected by hues	The retina is still in the developmental stage, its acceptance is high for warm colors and low for cold colors
	Men and women have different color preferences	Differences are beginning to emerge between men and women, boys and girls.
Space perception	Can distinguish shapes of objects	The cognitive ability of the switch increases with age
	Basic judgment on the direction	Can basically distinguish vertical and horizontal directions, for self-centered children
Memory	Good temporary memory	Can not only remember specific things, but also can remember abstract things that are heard and said by themselves
	Mechanical memory dominants	Repeated mechanical memorization is needed, understanding memory gradually develops
	Image memory dominants	Memory comes from intuitive, concrete, visualized and vivid things

Figure 3. The characteristics of children's cognitive development at pre-operation stage

B. Behavior characteristics of preschool children

The preschool phase is the critical period for children to form their own behavior characteristics. Children from 3 to 7 years old have their own behavioral characteristics.

- Click, drag and drop is the most popular mode of operation at mobile devices. For preschool children, the multi-touch interactive mode of mobile devices should be designed more closely to daily life such as click or drag with different visual and sound effects.
- Because children's nervous system is not fully mature. They cannot focus for as long as adults. So when they have to stick to a job, feedback and reward should be given often and in a timely manner.
- Imitation is the main way for preschool children to learn. They imitate the behavior of others to grasp and study the experience of others.
- Prosocial behavior level grows with age. The study found that level of preschool children's prosocial behavior showed a trend of rising and enhanced performance for a sense of cooperation.

C. Analysis of preschool children's needs

The user experience and user needs are intrinsically linked, the user experience is an expression that the user demands are satisfied, while the ultimate aim of the design is to meet the needs of the users. [6] User demands are in a hierarchy, corresponding to the level of demand and the design tasks can essentially interpret the design from the view of demand.

Professor Donald Norman took three different dimensions of design - instinct, behavior, and reflection as the basis and put forward the emotionalized layer theory of product design. [7] His emphasis is that product design and innovation starting from these three layers may bring surprises to consumers and cause impulse buying. Among them, the instinct layer refers to the sensory stimulation brought to the users, which are shown in the design of the interface, visual language, and feedback which meets user needs. The behavior layer refers to users being required to master the skills, which is embodied in the design as the maneuverability and friendly interactive experience. Lastly, the reflection layer refers to the complex emotions caused by the intertwining of deeper emotions, awareness, understanding and many other internal factors. These would include individual characteristics, a sense of achievement etc. reflected in the use of the product.

Comprehending the characteristics of children's cognitive development at the pre-operation stage and the core needs of preschool children are summarized in the following three aspects of instinct, behavior and reflection:

- In terms of sensual and intuitive experience: The hierarchy dictates that simple, intuitive and concrete images are often used; colors are usually those which can be commonly seen in daily life, such as warm colors; timely audio feedback to attract people's attention.

- In terms of specific functions: Learning step by step from simple functions to difficult ones so as to make progress; there are personification interactions throughout the game and reminders are offered timely; creating an open ended experience through free choices.
- In terms of final emotional goal: It is worth showing off to turn traditional receptive knowledge into expressive knowledge.

V. EXPERIENCE AND INNOVATION OF PRESCHOOL CHILDREN'S IMAGE-IDENTIFYING EDUCATION GAMES

The experts and scholars' research in the field of children's psychology show that children's games are already fairly mature, and mobile digital interaction design is also in rapid development. But these two remain in their own fields and lack mutual exchanges and studies, which is a bottleneck of educational game experience and current innovation. Simply relying on visual, auditory, tactile and other expressive effects will not meet the needs of modern children's cognitive psychological development anymore. Therefore, we must begin from the demands of the development of preschool children and explore interactive experiences which suit children's cognitive psychology.

A. Design concept of preschool children's image-identification education games

Playing games is within children's inherent nature and is a good way to promote children's psychological development. Games are a social activity and help children develop their imaginations. All that counts is what they can accurately feel about their own life experience and interpersonal relationships. At the same time, educational mobile games are composed on the basis of educational purpose.

They help to develop children's cognitive development and behavior.

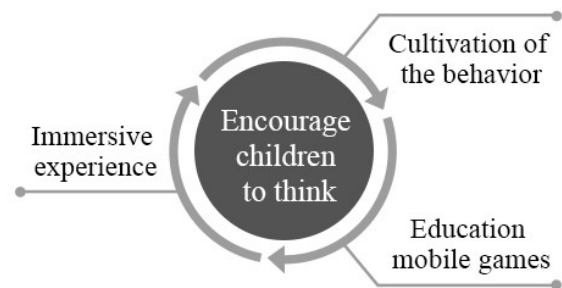


Figure 4. Design concept of preschool children's image-identification education games

Image-identification educational mobile games use the design concept which combines stories and interactivity. The creative point is to "encourage children to think" and "play resistance", which provide a kind of immersive educational experience with role-playing mechanisms (as shown in figure 4). Exploration is an important thing for preschool children. They play their own roles, give themselves meaning, and

through this, begin to understand the world and their place in it. They start to understand rules and restrictions, reasons and influence. Educational mobile games should accept the development of these areas, and create the right environment and encourage curiosity.

B. Interaction design of image-identifying education mobile games for preschool children

Mainly, humans receive information from the outside world by through their sensory system. Through the research above about education mobile games for preschool children, we found the three key points for image-identification educational mobile games are cognitive thinking, visual perception and interaction. Correspondingly, they have an organizational framework of interface, presentation method of information and the interaction experience of games.

As shown in figure 5, this article summarizes the interaction design ideas of image-identifying education mobile games:

Types	Specific requirements	Detailed ideas of design
Organizational framework of interface	Simple hierarchy structure	Number of layers should not be too many, usually 2-3 longitudinal layers is enough
	Clear navigation	Navigation is clear and simple, and path can be traced back
Presentation method of information	Information classification	Classify the information reasonably according to different concepts and dimensions
	Visualization of information	Replace the texts with visualized expressions (graphics, videos, etc.)
	Rich colors	Mainly warm, light colors of high purity
	Delicate pictures	Real and concrete physicality approaches
Interaction experience of games	Animation effects	Integrating sounds, shapes and colors to attract the attention of children
	Simple operation mode	Take clicking and dragging as the main forms
	Timely operation feedbacks	All operational results are visible, and feedback will be sent in an encouraging way if there is any mistake
	Scene interaction	Setting of life scenes can enhance children's sense of immersion, and also functions as a rehearsal of real life
	Interaction of cartoon characters	There are audio players throughout the game, helping them learn and grow.

Figure 5. Interactive design ideas of preschool children's image-identifying education games

As shown in Figure 5, this paper sums up the interactive design ideas of preschool children's image-identification educational games, which are divided into three major aspects - organizational structure, and information presentation and interactive experience:

- Organizational structure of the interface: The lack of hierarchy concept determines the simplified hierarchical structure of interface. Combined with clear

navigation, it helps to reduce the interference of interface elements on children's operation, so that their attention can be more concentrated on the storylines of the educational games.

- Presentation method of information: In order to meet the demands of children's cognitive development, presentation methods such as information classification and information visualization are adopted which helps to improve their cognitive level. In addition, light colors, personified graphical interfaces and animation effects can stimulate a child's strong interest and satisfy their need for happiness, and trigger the development of a child's unintentional attention at the same time.
- The interactive experience of games: Life scenes and interactive communication lets children have a stronger feeling of presence, and stimulate them to understand and explore the learning content more, achieving the effect of active learning. A good interactive experience and feedback make children more relaxed and let them learn from the games they participate in more easily, achieving the effect of teaching through lively activities.

In short, the preschool children's image-identification educational mobile games take cognitive development theory as the basis, make reasonable use of the multimedia features and interactive characteristics of digital mobile platforms, and make image-identification activities more like games through scene interaction so as to stimulate children's interest in active learning. It provides a valuable reference for the design of interactive image-identification educational games in the future.

References

- [1] Meng Xiaoli, Zhang Yibing. Investigation and Analysis of the Status Quo of Children's Educational Game Software [J]. Management and Technology of Small and Medium-sized Enterprises, 2012.
- [2] Juan Pablo Hourcade, Thomas.E.Hansen. Multi-Touch Displays to Support Preschool Children 's Learning in Mathematics, Reading, Writing, Social Skills and the Arts, 2013.
- [3] Liu Changcheng, Zhang Xiangdong. The Piaget Children Cognitive Development Theory and Its Enlightenment to Modern Education [J]. Contemporary Education Science, the 1st issue in 2003.
- [4] Ren Chunhua. The Fact of Different Cognitive Developments on Teaching - On the Similarities and Differences Between Piaget's and Vygotsky's Cognitive Development Views [J]. The Teaching Forefront, the 10th issue in 2006.
- [5] Wu Yeqin. Games _ Major Media of Infant's Thinking Development [J].Journal of Southwest Normal University, the 3rd issue in 1998.
- [6] Zhang Ying. User Needs Based on the Experience--Study on the Conversion Method of Product Attributes [D]. Beijing Institute of Clothing Technology, 2010
- [7] Written by Donald A Norman and translated by Fu Qiufang, Cheng Jinsan. Emotionalized Design[M]. Publishing House of Electronics Industry, May, 2005.