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The Value, Principles and Paths of Gamification in Early Childhood Mathematics Education

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Abstract

Early childhood mathematics learning can lay a good foundation for in-depth learning in other fields, but there is a problem of less games and lack of fun in early childhood mathematics education. The gamification of early childhood mathematics education has the foundational value of opening up mathematical awareness, improving aesthetic ability, developing mathematical skills, and developing mathematical application ability and the developmental value of promoting young children's cognition, emotion, willpower, and interest in mathematical learning. In the process of concrete implementation, educators should follow the developmental principles of age-appropriate, scientific, and subjective and the motivational principles of life, fun, experience, and personalization. On the basis of following the principles, educators explore the practical path of gamification of early childhood mathematics education by creating a living mathematical game situation, adopting diversified mathematical game teaching means, implementing a hierarchical mathematical game teaching mode, and creating an interactive mathematical game teaching method in four aspects.

Keywords

Early Childhood Mathematics Learning; Early Childhood Mathematics Education; Games; Game Situation.

1. Introduction

Kindergarten is to play as the basic activity, and education is in all activities, and gamification of mathematics education can help young children to know the world in an easy and pleasant way. However, there are typical problems such as less games and lack of fun in early childhood math education [1]. The Guideline for Kindergarten Education (for trial implementation) states: “Feel the quantitative relationship of things from life and games and experience the importance and fun of mathematics”[2]. Therefore, this paper aims to discuss the value of gamification of early childhood mathematics education, the principles of its implementation, and the path of its practice, so as to lay a good foundation for in-depth learning in other fields.

2. Connotations of Gamification in Early Childhood Mathematics Education

Early childhood science education encompasses both scientific exploration and mathematical cognition. The Learning and Development Guidelines for Children Aged 3-6 states that the contents and objectives of the mathematics field for young children are described around three main areas: initial perception of the usefulness and interestingness of mathematics in life; perception and understanding of number, quantity, and the relationship between quantities; and perception of the relationship between shapes and space [3].Early childhood play is a comprehensive practical activity for young children, and it is an instinct of young children's life, and all contents that are related to young children's experience and development can be the content of play [4]. Gamification education is a play-based learning approach that emphasizes

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the use of play as a medium to facilitate learning and knowledge acquisition. Throughout the existing studies, some researchers believe that gamification of early childhood mathematics education is to integrate games into teachers' mathematics teaching and young children's mathematics learning [5], and it is to apply games to kindergarten mathematics education to further stimulate young children's motivation in mathematics learning and enhance their learning effectiveness [6]. On the basis of existing research, combined with practical teaching experience, this paper defines gamification of mathematics education for young children as: gamification of mathematics education for young children is an educational method that integrates the goals, contents, and requirements of mathematics education into games, aiming to enable young children to perceive, experience, and accumulate knowledge and experience about mathematics through the fun, interactivity, and personalized learning support of games.

3. Implications of the Value of Gamification in Early Childhood Mathematics Education

Early childhood math education provides a good foundation for other areas of learning. Playfulness comes from play, which is an important medium for promoting the development of young children and is a positive psychological quality with a facilitating effect [7]. The gamification of mathematics education utilizes gamification education, and young children are able to actively participate in mathematics learning in an enjoyable learning environment. The gamification of mathematics education for young children has the foundational value of opening up mathematical awareness, improving aesthetic ability, developing mathematical skills, and developing mathematical application ability and the developmental value of promoting young children's cognition, emotion, willpower, and interest in mathematics learning.

3.1. Seminal Value

3.1.1. Unlocking Mathematical Awareness

Consciousness is the awareness of human beings of external stimuli and internal stimuli, and it is an advanced level of mental activity. Early childhood mathematical awareness is the attitude and consciousness of young children who can intuitively perceive, comprehend, and use numbers, measures, shapes, mathematical symbols, and simple mathematical methods in life [8]. The gamification of early childhood mathematics education focuses on the integration of young children's mathematics and games, in the form of games to realize the content of numbers, quantities, shapes, mathematical symbols, and so on, young children in the activities of the free, independent, pleasurable, and creative experience, and through the initiative of learning mathematical knowledge to obtain their own development, so as to open the mathematical consciousness. Mathematical awareness of young children is an important quality needed in modern society and has a far-reaching impact on the future development of young children.

3.1.2. Improvement of Aesthetic Skills

There are three levels of mathematical aesthetic ability: feeling, appreciation and creation, and how to enhance the aesthetic ability of young children through mathematics education is a problem that is being explored in both theory and practice [9]. Early childhood math education has various forms of existence such as symmetry, simplicity and harmony [10]. The integration of math education related content into the game can improve the aesthetic ability of young children. For example, in the process of mathematical games, young children use colorful and differently shaped pictures to count and compare or use beautifully patterned puzzles to learn geometric shapes. Therefore, mathematics education games can not only attract the attention

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of young children, but also inadvertently cultivate their aesthetic ability to colors, shapes and patterns.

3.1.3. Development of Mathematical Skills

Zhongliang Feng divided the formation of general mental skills into three stages: the stage of activity pattern orientation, the stage of activity pattern manipulation, and the stage of activity pattern internalization [11] .Mathematical skills are an important part of mathematical learning content [12]. Early childhood math skills include counting, calculating, classifying, sorting, identifying shapes and patterns, and understanding time and space concepts. The gamification of early childhood mathematics education helps young children to use games to deepen their understanding of mathematics in a more natural way, such as hand-to-mouth counting, jigsaw puzzles, and building for young children.

3.1.4. Cultivate the Ability to Apply Mathematics

The unique characteristics of early childhood mathematics education require that the content of mathematics education comes from the life of young children as much as possible, while not neglecting mathematization [13]. Young children apply the learned math skills to real life through the form of games, and then improve the ability of mathematical transformation and application. In game-based mathematics teaching, teachers combine mathematics with practical problems by designing game-based activities. For example, in the supermarket shopping math game, young children can play the role of customers or shopkeepers, calculate the price of goods in the form of games, make change, etc., and use the mathematical content to solve practical problems in life, so as to cultivate young children's ability to apply mathematics.

3.2. Developmental Value

3.2.1. Promote the Cognitive Development of Young Children

Cognition is a variety of mental activities carried out by young children in the process of recognizing things, mainly including: sensation, perception, attention, imagination, thinking and so on [14]. When young children solve math game problems, a series of activities from understanding the requirements of the topic, searching for known conditions, deducing the answer, practicing and verifying the results are cognitive activities. Sensory development can be facilitated by young children seeing numbers and performing hand-to-mouth counting. Children's perceptual development is facilitated by the production of numbers in the brain through the use of various senses and knowledge experiences. Children develop attention by pointing and focusing on math games. The mental process of processing and transforming the stored representations to form a new image in the mind of young children is imagination. For example, young children can promote the development of their imagination by visualizing the number “2” as the image of a duckling. Young children's thinking is characterized by concrete image thinking, mathematics education in the form of gamification provides young children with concrete and interactive mathematical experience, thus effectively promoting the development of their mathematical thinking. For example, in a math maze game, children can use mathematical knowledge such as size comparison and shape recognition to choose the correct path.

3.2.2. Promote the Development of Young Children's Emotions

The essence of the math learning process is the process of communication and discussion between young children and teachers and peers [15]. Emotional development plays an important role in the gamification of mathematics education for young children. Gamification of mathematics education provides opportunities for young children to interact and cooperate with peers to solve problems through multi-player cooperative games or role-playing games, cultivates their sense of cooperation, teamwork and social skills, and promotes the development of young children's emotions. For example, in math games, young children can

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cooperate with their peers to complete math game tasks, experience success and failure, feel the joy of cooperation, and promote emotional development.

3.2.3. Promote the Development of Willpower of Young Children

The development of willpower plays a decisive role in the formation of good habits in young children, and even has a positive effect on the lifelong development of young children [16]. In the process of gamification of early childhood mathematics education, young children will encounter various difficulties and challenges. When facing these difficulties, teachers should consciously guide young children to keep patience and develop their persistence. Not only that, when toddlers follow the rules of math games, it helps to develop toddlers' self-control. Young children will inevitably encounter frustration when solving math game problems. For example, toddlers make mistakes in calculations and so on. Teachers guide toddlers to look at failure correctly, encourage them to learn lessons from failure, constantly adjust their learning methods, and develop toddlers' will quality.

3.2.4. Motivating Young Children's Interest in Math Learning

Play is the interest of young children in itself and is generated by internal motivation [17]. Mathematics gamification can stimulate young children's interest in learning and motivate them to learn by playing. Dewey pointed out from empiricism that “interest is a person who becomes one with a prescribed activity and provides means and obstacles to its realization” [18].When young children learn mathematics through games, once they fall into a state of fascination, young children's interest and motivation in mathematics learning arises. In the environment of gamification of mathematics education, young children can experience through role-playing, situational simulation and other games while gaining relevant mathematical knowledge. Children can personally participate in the game activities to become the protagonist of the game, and this sense of participation and interactivity makes children more actively involved in learning and enhances their interest in learning. Gamification of mathematics education also creates a positive atmosphere of competition. Through the ranking and record-keeping in the game, children can compare themselves with others and stimulate a sense of competition and aggressiveness.

4. Implementation Principles of Gamification in Early Childhood Mathematics Education

The effective implementation of gamification in early childhood mathematics education should be based on meeting its educational value, and at the same time ensure that its implementation is in line with the laws of physical and mental development of young children. The implementation of the gamification of mathematics education for young children should firstly meet the developmental requirements of young children, and be considered from the principles of age-appropriate, scientific and subjective; secondly, it should pay attention to the stimulation of young children's intrinsic motivation and emphasize the implementation of the principles of liveability, interestingness, experientiality and personalization.

4.1. Developmental Principles

4.1.1. Age-appropriate Principle

Young children are independent individuals who embody different cognitive characteristics at different ages, and as educators should fully respect this developmental process from small to large and from weak to strong [19]. There are limitations in the cognitive development level of young children, and their knowledge of mathematical concepts and mathematical symbols is limited. The gamification of mathematics education for young children should be based on the age characteristics and psychological development level of young children to choose the appropriate content. Teachers should pay attention to the design of the content of the math

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game, the creation of the environment, the arrangement of materials and other aspects of the targeted selection, from shallow to deep, from simple to complex arrangements for small, medium and large classes of all ages, taking into account the children's existing experience and ability, so that the children in the original basis for better development. For example, for small children, simpler math cognitive games can be designed, such as shape cognition; for middle children, slightly more complex math concept cognitive games can be designed, such as quantitative classification; for older children, more difficult math problem solving games can be designed, such as addition and subtraction within 10 operations, and so on.

4.1.2. Scientific Principle

The principle of scientificity is an important symbol that distinguishes it from other aspects of education for young children [20]. First, the goal of gamification of early childhood mathematics education should be scientific. Scientific objectives are a prerequisite for the gamification of early childhood mathematics education. In the Guidelines, different requirements are put forward for children aged 3-4, 4-5 and 5-6 respectively. For example, 3-4 year olds can perceive and distinguish the size, length and other characteristics of objects; 4-5 year olds can perceive and distinguish the thickness, thickness, lightness and other characteristics of objects; 5-6 year olds can initially understand the relativity of quantities. Secondly, the content of gamification of early childhood mathematics education should be scientific. Pre-school education is the initiation stage of young children's math education, and the knowledge learned at this stage will lay the foundation for the in-depth learning of math knowledge in the future. Teachers should pay attention to the actual starting point of young children, respect the law of cognitive development of young children, and design the content of math games based on mathematical knowledge, while taking into account the interest of young children in learning. Third, the methods and forms of gamification in early childhood mathematics education should be scientific. According to Piaget's stages of cognitive development, we can conclude that young children's cognitive development has gone through four stages: schema-assimilation-conformity-equilibrium, and young children's understanding of things is characterized by intuitive image, and their understanding of things relies more on perceptual awareness. In terms of educational methods, teachers should follow the cognitive laws of young children and guide them to use multiple senses such as sight, hearing, smell, taste and other senses to directly perceive things and gain concrete image knowledge. In terms of form, teachers can use a variety of game forms integrated in early childhood math education.

4.1.3. Principle of Subjectivity

Teachers are the leaders of educational activities, is the main body of teaching, young children are the main body of learning activities, the main body of development [21]. In math education game activities, teachers should fully recognize that young children are independent individuals, have their own thoughts, feelings and needs, and guide young children to direct perception and personal experience. Not only that, teachers should pay attention to the interests, needs and characteristics of young children, give full play to the initiative and enthusiasm of young children, give young children more opportunities to explore, and formulate reasonable mathematical goals according to the developmental level and needs of young children, so as to promote the comprehensive development of young children.

4.2. Principle of Dynamism

4.2.1. Principle of Life

The growth of young children's life is accomplished by focusing on the reality of life in the present [22]. Life is the first driving force of young children's life growth, and what kind of life there is, what kind of young children's life growth there is. The principle of life emphasizes that young children's life experience, in the game of natural contact, experience and understanding

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of mathematics. It has been proved by practice that with the things that young children can see, touch, experience and feel as the content of education, young children can generate interest in observing and recognizing life, and it is also easy for young children to understand and master [23]. Teachers should make full use of familiar and interesting things in children's lives to educate children, learn knowledge and accumulate experience in life, and put education in children's lives. For example, when teachers design shopping games, older children play the role of customers in the game, selecting goods, calculating prices, etc., in the actual operation of the children naturally master addition and subtraction and other mathematical knowledge.

4.2.2. Principle of Interest

Mathematics education for young children should choose the things that young children are interested in as the objects of learning and exploration [24]. The principle of fun emphasizes the design of attractive and interesting mathematical games from the interests and needs of young children, in order to improve the enthusiasm and initiative of young children in learning mathematics. The ancients also said, “Those who know are better than those who are good, and those who are good are better than those who are happy.” Interesting math games can attract young children's attention and have an important role in promoting young children's learning. One of them is the fun of the context. Teachers can create attractive math game situations in which young children naturally come into contact with, experience and understand math. Children can integrate abstract mathematical knowledge into concrete game situations, learning mathematics in a relaxed and pleasant atmosphere. The second is the interesting nature of the problem. Teachers design challenging and interesting math game problems to stimulate young children's thinking and desire to explore. The third is the fun of teaching means. Teachers can use virtual reality technology, artificial intelligence technology, digital twin technology and other meta-universe technology to present abstract mathematical content to young children in an intuitive and vivid way.

4.2.3. Experiential Principle

Young children's understanding of figurative things far exceeds their understanding of abstract things, and young children know themselves through direct experience [25]. When young children play math games, they need to perceive and understand mathematical knowledge through personal experience. Early childhood mathematics education is not only the mouth of education, but also exists in the hands of education, young children will experience the fun only if they actually feel the mathematical manipulation materials, make specific related behaviors and get good results. Experiential learning enables children to build mathematical concepts in intuitive and concrete play activities. For example, when children get to know numbers, teachers can design interesting number games and provide rich mathematical materials so that children can learn the order and size of numbers in the games.

4.2.4. Principle of Individualization

The development of young children's personality plays an important role in forming good interpersonal relationships and realizing comprehensive and coordinated development [26]. In the process of gamification of kindergarten mathematics education, teachers should pay attention to the age characteristics of young children and individual differences, and consciously arrange the content of different levels of difficulty, so that young children with different personalities have the opportunity to participate in the activities and have the experience of success. First, promote the individuality of children in the corner activities. District activities are the main form of activities for children in the school, teachers should pay attention to the use of mathematical areas, operating materials, the flexible role of the game through the rules and the integration of play and other ways to promote the development of young children's personalities. Secondly, collective activities promote the individuality of young children. Teachers should pay attention to the characteristics of each child and give them

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different ways of education in the collective activities of math games. Third, promote the individuality of children in life activities. Kindergarten life includes eating, drinking, washing, toileting and so on, during which teachers can penetrate the relevant contents of math educational games.

5. Practical Paths of Gamification in Early Childhood Mathematics Education

Teachers should focus on guiding children to learn through direct perception, hands-on experience and practical operation. When carrying out the gamification of mathematics education for young children, teachers should adopt the creation of a living mathematical game situation, the use of diversified mathematical game teaching means, the implementation of hierarchical mathematical game teaching mode, and the creation of interactive mathematical game teaching methods for implementation.

5.1. Create a Living Mathematical Game Situation

Xingzhi Tao believes that life education is the life of the original, the life of the self-support, the life of the necessary education, life and education is the same thing, is the same process, education can not be separated from life. Education should be carried out through life, and the contents and methods of education should be based on the needs of life. First, the use of mathematical elements in life. Young children's lives are full of mathematical elements everywhere, teachers can guide young children to pay attention to the mathematical content of life, in the form of games into life. Second, the creation and simulation of mathematical game scenes in life. Teachers can create mathematical scenes that simulate life, prompting young children to experience the practical application of mathematics in the simulated situation and enjoy mathematical games. Third, teachers provide feedback and encouragement. Teachers can provide timely feedback and encouragement according to children's performance in life-like math games, so that children can experience the fun of learning math.

5.2. Adopting Diversified Teaching Methods of Math Games

Teachers use diversified game teaching means to attract children's attention, stimulate children's interest in exploration, and help children better understand and master mathematical knowledge. First, the use of the natural environment. The natural environment provides rich learning opportunities for young children. Teachers can organize young children to use the natural environment for mathematical games. For example, teachers can organize children to observe the shapes and sizes of flowers and trees. Second, the utilization of technological means. Teachers can use meta-universe technology to create virtual scenes related to math education games. For example, in the meta-universe math game situation world, digital stand-ins allow young children to create role-playing identities, and young children can really take on the role of a princess and build their own situations and virtual partners to interact. Third, the use of role-playing. Teachers can integrate math content and requirements into the game so that children can learn math by playing the roles in the game.

5.3. Implementing a Hierarchical Math Game Teaching Model

Teachers should fully respect the age and individual differences of young children, and should take into account the level of young children's existing experience in math games, and design different levels of game activities according to the characteristics of young children in order to meet their learning needs. First, the understanding of individual differences of young children. Teachers can learn about each child's cognitive development level, learning style and interests through observation, communication and assessment. Second, the design of different levels of play activities. According to the individual differences of children, teachers can design different

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levels of play activities to meet the learning needs of children in small, medium and large classes. Third, individualized guidance and support. Teachers provide personalized guidance and support according to each child's performance in math games to increase children's interest in math learning.

5.4. Creating an Interactive Math Game Teaching Style

The interactive game teaching method requires teachers to observe carefully, make correct judgments, and interact at the right time. First, teachers should carefully observe children's behavior during math game activities to understand their points of interest, challenges and confusion in the activities. Second, teachers look for the right time to interact. Teachers can interact when children have nothing to do or always repeat a certain game action; when children have conflicts with their partners and cannot solve them by themselves; and when children's game behavior is dangerous and may hurt themselves or others. Third, the expansion of math game content. Teachers can expand the content of math games according to children's interests and abilities, increase the depth and complexity of the game as an interaction.

6. Conclusion

The combination of math education and games creates a relaxing and enjoyable learning environment for young children. This educational approach effectively solves the problem of the lack of games and fun in traditional early childhood math education, and has important foundational and developmental values. It helps to improve young children's mathematical awareness, cultivate aesthetic ability, enhance mathematical skills and improve the ability to apply mathematics. In the implementation of this educational method, we should follow the principles of age-appropriate, scientific and subjective, and effectively promote the comprehensive development of young children in various aspects by creating teaching situations close to their lives, utilizing diversified teaching methods, implementing hierarchical teaching modes and carrying out interactive teaching.

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