



INTEGRATING STOP-MOTION ANIMATION INTO CHILDREN'S MATHEMATICS EDUCATION

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Abstract

Learning interest is a key determinant of children's motivation in mathematics. The main theme of this paper is to study the integration of stop-motion animation into children's daily mathematics learning, and to further develop the stop-motion animation format into a stop-motion game with interaction as a way to stimulate children's interest in mathematics in a non-traditional educational way. To test the viability and effectiveness of the theme, I designed an experiment with a sample of 30 children aged 5-6 years in kindergartens, and conducted follow-up questionnaires and interviews to collect feedback. The results showed that the integration of stop-motion animation into children's mathematical learning did have a positive effect on their learning of mathematics, increasing their interest and enthusiasm for learning. The use of interactive stop-motion games also provided positive guidance, but were not as effective as stop-motion animation, so further development of interactive stop-motion games is needed.

Keywords: Stop-motion animation; Children's Maths Learning; Learning Interests

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1. Introduction

In recent years there has been a growing body of research on new approaches to education (Ball, 1992), all of which aim to increase children's interest and enthusiasm for learning. The three most popular approaches are contextualised learning, playful learning and participatory learning, which are widely accepted by researchers and children alike. The starting point of these studies is to help children overcome their fear of learning mathematics (Pantoja, 2021) and to increase their motivation to learn. Some researchers have also suggested that active mathematical play for children can reduce children's mathematical anxiety (Alanazi, 2020) and thus influence their mathematical learning effectiveness (Stodolosky et al., 1991).

As children between the ages of five and six years perceive new things, their ability to process visual information gradually increases and they are better able to recognise, identify and remember different images and shapes. They begin to understand and manipulate spatial concepts such as position, direction, distance and relative relationships. They are able to use and interpret simple maps and directions. Children's short-term memory capacity increases and they are better able to retain and recall information. They also have improved attention and concentration and are able to focus on a task or activity for longer periods of time. And with independent thinking and problem solving skills, they are able to ask questions, offer solutions and think about the possibilities for outcomes.

In the area of mathematics they are beginning to understand and represent a certain number of objects. They can count and gradually learn to express quantities in terms of numbers. They can also understand simple concepts of addition and subtraction by adding or subtracting objects. They can use their fingers or objects to perform simple counting and manipulation. It is this cognitive characteristic that fits well with stop-motion animation, where changes occur frame by frame.

To further investigate whether the use of stop-motion animation in children's mathematics learning can positively guide children's interest in mathematics learning and influence their learning efficiency, and to find a better approach compared to interactive stop-motion games, this study collected literature on contextualised learning, mathematical game-based learning, educational theory, and children's cognitive characteristics. After justifying the research question and identifying the research problem, I designed a pilot scheme. For children aged 5-6 years, experimental tests were conducted in selected groups based on their usual grades and performance, and experimental data were collected through questionnaires and personal interviews.

2. Background

2.1 Learning based on multimedia technology

Multimedia technology is a technology that integrates multiple forms of media such as images, audio, video and text (Park et al., 2019). It makes it possible to create, edit, process, store and transmit various forms of digital media using electronic devices in digital environments such as computers and the Internet. Multimedia technology mainly includes aspects of graphics, audio processing, video processing, animation techniques and interactive design, which are all important components of the digital media field (Park, 2019).

Multimedia learning is the process of transferring information and knowledge through a variety of media (e.g. text, images, audio, video, etc.) to help learners better understand and master the learning content. Multimedia learning makes use of multiple sensory channels, such as visual, auditory and tactile, to enhance learners' perception and attention, helping them to better understand and remember learning content. In multimedia learning, learners can access information through multiple forms of media, such as images for visual information, audio for auditory information and video for both visual and auditory information, which can complement and coordinate with each other to create a more comprehensive and in-depth learning effect (Malik & Agarwal, 2012). In addition, multimedia learning can be designed to increase learner motivation and learning outcomes through interactivity and personalisation (Babiker & Elmagzoub, 2015). Compared to traditional teaching methods, multimedia learning has the following advantages :

Multimedia learning can present information in various forms such as images, audio and video, making the learning process more vivid and imaginative, and easily attracting learners' attention (Mayer, 2002). Multimedia learning can also be designed interactively to increase learners' participation and enthusiasm for learning, and to promote learners' interaction and thinking. It can present knowledge in a variety of forms, such as Power point, animation, simulation experiments, etc., which can be adapted to the learning styles and needs of different learners. It can also be achieved online through various channels such as the Internet, making it convenient for learners to study anytime and anywhere and improving the timeliness and flexibility of learning.

2.3 Stop-motion media technology and educational use

Digital media technologies have become an integral part of children's daily lives, even in early childhood (Donohue, 2015). Research has shown that these tools, when used effectively and appropriately in early childhood settings, can enhance children's development and learning (Ihmeideh, 2014). Stop-motion animation is a form of animation based on the frame-by-frame filming of objects or characters in the frame, and is distinguished by the realism of the animation scenes, the diversity of character expression and the unique use of lighting. As compared to other forms of animation, stop-motion animation has a vivid visual effect and is more involved in the production process, which allows children to participate in the process and effectively develop their creativity and hands-on skills. It is also highly educational, as stop-motion animation often conveys knowledge, values and life lessons

through the storyline, which allows children to receive inspiration and education as they watch the animation, which has a positive effect on their development (Purves, 2012).

2.2.1 The use of stop-motion animation in education

With the development of digital technology (handheld cameras and mobile phone photography), the stop-motion format (Hoban, 2005) has become a relatively simple mode of animation that allows students to more easily access animation in educational courses. SLOWMATION was developed in an educational course at an Australian university as a way to engage and explain scientific content to students (Hoban et al., 2011). The animation process is simple, laying the model flat in a way to facilitate capture and playing the image at 2 frames per second to create a slow moving image. Using this slow-motion stop-motion animation filming technique, according to a database linked to the project website, there have been over 15 million requests from users in 106 countries in the last 3 years and it is widely used in school and university classrooms precisely because stop-motion animation is a simple approach to animation that tends to be an everyday technique (Hoban, 2011).

Nowadays increasingly popular is digital media technology, which incorporates various media such as text, graphics, animation, video and audio. The use of this digital media technology can enhance the quality of education. The Malaysian Institute of Vocational Studies conducted a course development in the direction of industrial processing, as well as teaching through the element of animated video, and used a quantitative survey method involving 30 students to participate in the responses. (Jabarullah et al., 2019) The instrument used in the study was a questionnaire, calculated by Alpha-Cronbach. The data was collected and analysed using SPSS for descriptive analysis. The study found that the use of digital media technology for animation is very relevant and can improve students' imagination and visualisation.

Any child has a great deal of cognitive ability, it is only the knowledge base that makes them think in different ways.

Maria Montessori, an Italian kindergarten educator, divides children's development into three stages, with children aged 5-6 years belonging to the first sub-stage, and considers this stage to be the conscious absorbent mind (Montessori, 2013). The age range of 5-6 years is also the internationally medically defined early childhood age range, with most 5-6 year olds being in the preschool stage where they are managed by kindergartens. And preschool is a critical period for the development of the mind. From the age of 3, when children begin to perceive the world, their thinking patterns enter a phase of rapid development. Children at this age are curious, have a strong desire to explore, are more tolerant of new things, are not bound by too many rules and cause-and-effect approaches, are active in creative thinking and absorb new knowledge more quickly (Montessori, M. 2004).

Piaget (Boring & Werner, 1952) proposed four stages of cognitive development for children, and his theory has been fairly well established through repeated testing. Piaget's research method was qualitative in nature and did not involve the use of experimental groups and multi-person statistics that were popular at the time, but rather the continuous, detailed

observation of individual children (his daughter) in natural situations to record their intellectual responses to processing. Children between the ages of 5 and 6 are in the pre-operational stage of cognition, where they can already use language and symbols to represent external objects, do not retain concepts, are not reversible, are self-centred, can think but not logically, and cannot see the full range of things. Children at this stage learn mainly through imitation and play, as they construct symbolic imagery through internalised activities (Boring et al., 1952).

2.3 Interactive gamified learning

In recent years, with the widespread popularity of mobile smart devices and the rapid development of the Internet, as well as the increasing scale of children exposed to the Internet, more and more children's educational games are being used on mobile smart devices, and children's educational games have become a way to cultivate children's interest in subjects and knowledge acquisition. Digital teaching methods are making teaching less boring and monotonous, and the interactive and contextual nature of digital education compared to traditional education methods is better able to meet children's strong curiosity, desire to learn and other emotional needs in order to stimulate children's interest in learning and efficiency (Di Paola et al., 2013). Stories and games in digital media are gradually infiltrating children's lives, and the interactive interaction with things in the virtual world facilitates their perception of the world. Game-based learning is about transforming students' enjoyment of games into motivation to learn and can also multiply teachers' efforts, which is at the heart of game-based learning. Landers and Callan (2011) have conducted extensive quantitative research on gamification. The researchers created an online social software in which badges were used to motivate students to complete an optional online multiple choice test. At the end of the semester, students reported reactions to gamified learning, which on average they found interesting, enjoyable and beneficial (Lbid, 2011).

Children aged 5-6 are naturally playful, they are curious about the world and therefore find it more difficult to concentrate, so the aim of gamified learning is to let children learn and develop skills while having fun. Interactive games attract children's attention through nice scenes, interesting stories, vivid animations and sound effects to make it fun and educational.

2.4 Educational Theory

2.4.1 Handbook of Research in the Psychology of Mathematics Education

The Handbook of Research in the Psychology of Mathematics Education: Past, Present and Future (Gutiérrez & Boero, 2006) is the work of a number of scholars in the International Commission on Mathematical Education (ICMI) and the International Organization for the Psychology of Mathematics Education (PME group). Joanne Mulligan and Gerard Vergnaud present a study on 'The Development of Early Childhood Mathematics Teaching'. This section covers three main areas. Area I. Research on theoretical perspectives on children's mathematical development. Research findings from the first decade of mathematics educational psychology on children's early mathematical development include: intuitive models; the structure of learning outcomes; experiential and conceptual domains; early counting and reflective abstraction; the influence of constructivism; the development of cognitive structures; the process-object view and social constructivist perspectives and interactionist perspectives. Area 2, the content area of mathematics. This includes

researchers in the psychology of mathematics education who move beyond the traditional Piagetian concepts of categorisation, counting and cardinality. Researchers see classification, counting and cardinality as prerequisites for future mathematical learning, and begin to develop research on counting and computational skills, mathematical reasoning, etc. Area 3, Possible directions for future research. These include: research on early algebraic reasoning; research on the role of technology; and research on the development of early quantitative knowledge. The study of children's early mathematical development has been an integral part of the common research effort in the psychology of mathematics education from the beginning, particularly the theoretical underpinnings of the psychology of mathematical learning from a cognitive psychology perspective, largely detailed through the study of young children. Although there have been some changes in the subject matter, several areas of research continue to attract the interest of researchers. To some degree, the research on children's early mathematical development referred to in the book is now more often reflected in pedagogical practice. On the other hand, in contrast to the traditional subject content areas of mathematics, the focus of research has been extended to newer subject content areas, such as the potential contribution of mathematical psychology to modelling in the cognitive sciences, from a broader theoretical base (Richard & Colleen, 2019).

2.4.2 Principles of participatory teaching and learning

Today's education is increasingly concerned with the all-round development of students, especially the development of learning, communication and innovation skills, the core of which is the development of the child's subjectivity. A large number of teaching studies have shown that the educational philosophy used by some teachers is rather outdated and monolithic, and that the use of traditional educational concepts to organise teaching activities is not conducive to the growth and development of children, so changing teaching ideas has become an inevitable choice. It is within this context that participatory teaching strategies emerge. From the perspective of curriculum implementation, participatory teaching pays more attention to the cognitive characteristics of children and emphasises the use of children's existing cognitive experiences as the starting point for teaching. From a practical point of view, this form of teaching activity is more conducive to promoting children's participation and enabling children's subjectivity to be respected and their learning potential to be explored (Fernando & Marikar, 2017).

For children aged 5-6, who are in a stage of rapid psychological awareness development, being respected is an important prerequisite for children's active participation in learning activities. Conversely, it is easy for children to become resistant in their learning. Teaching and learning is a two-way interactive process, so it is very important to maintain communication in teaching. The timeliness and effectiveness of communication can have a direct impact on the teaching effect. In addition, in the teaching process, we need to pay more attention to the differences between children and adults in many aspects such as cognition, emotion, experience, personality and behaviour, so the importance of communication is even more prominent. In the participatory classroom, it is stressed that every child is equal and that dialogue and communication between the pedagogue and the child should also be on an equal footing. At the same time, close attention needs to be paid to the actual needs of the students, while fully respecting their opinions and ideas. In contrast to the "indoctrination" teaching method, participatory teaching is one of the most prominent problems that inhibits children's thinking in the past learning activities. The principle of subjectivity in participatory teaching is, above all, to shift the initiative of learning activities

from the teacher to the children, so that the children's initiative can be given full play. Using this principle facilitates a more profound learning experience for children (Fernando, 2017). A collaborative construction system is an important feature in participatory teaching. Compared to one-way indoctrination and independent thinking, cooperation can effectively broaden children's horizons, thus enabling them to develop a more comprehensive understanding and improve the efficiency of their learning. At the same time, collaboration provides children with a richer range of learning activities that enable them to gain relevant learning experiences. Every child is a complete and unique individual, so in learning activities, every child has his or her own shining point. Therefore, the principle of motivation should be followed in the teaching process to discover children's strengths and shining points in time and to create conditions to make the most of their strengths (McNicoll, 1999).

2.4.3 Maths anxiety

Anxiety disorders are one of the most prevalent mental health problems worldwide (Luttenberger et al., 2018). In educational settings, individuals may suffer from specific forms and manifestations of anxiety related to areas of knowledge. Undoubtedly, one of the most prominent of these is maths anxiety. Learning mathematics can be very difficult for some children and brings with it mathematical anxiety, which affects their confidence and attitude towards learning. The maths anxiety response is a product of a biological predisposition to anxiety, reduced numeracy, increased negative attitudes towards mathematics and deficits in working memory (Bech & Mazzocco, 2007).

Stodolosky et al. (1991) surveyed 60 students in the USA and found that the main negative feeling associated with learning mathematics was the fear of failure due to difficulties and challenges, leading to self-depreciation and anxiety. They usually worried about the difficulty of the problems, the accuracy of the answers, and their solutions. Only a few students found mathematics boring in terms of content. On the other hand, students enjoy mathematics because it is easy and fun and they can succeed in it (Stodolosky et al., 1991).

Alleviating mathematics anxiety is positively correlated with students' emotional factors, so it is essential to increase students' interest in learning mathematics and to develop positive emotions about learning mathematics. If students are interested in mathematics, they will be more willing to learn mathematics and more able to enjoy the learning process, thus reducing the symptoms of mathematics anxiety. Conversely, if students are not interested in mathematics, they may feel bored, helpless and even experience symptoms of mathematics anxiety disorder. In addition, if students encounter difficulties in learning mathematics and become confused and do not understand mathematics, they may be more motivated to solve problems rather than choosing to give up or feel frustrated if they are interested in mathematics. This may reduce their level of mathematical anxiety.

Children between the ages of 5 and 6 are at the stage of conscious absorption of the mind, and the age bracket of 5-6 years is also the earliest age range of children to be distinguished internationally. Children at this age are also in a critical period of rapid mental development. So I believe that the use of stop-motion animation for mathematics education for 5-6 year olds can be broadly divided into the following three parts:

1. Number learning: stop-motion animation can be used to present the concept of numbers, for example, by matching numbers to objects in the animation, so that children can learn the concept of numbers while watching the animation.

2. Geometry learning: stop-motion animation can be used to present the concept of geometry, for example, using different colours and shapes to represent different geometric shapes in the animation, so that children can learn the concept of geometry while watching the animation.

3. Mathematical problem solving: stop-motion animation can be used to present mathematical problems, for example, by presenting the solution and steps of a mathematical problem in an animation, so that children can understand and master the solution of a mathematical problem by watching the animation.

3 Problem

As one of the most popular art forms for young children, cartoons play an important role in their lives. A survey by Nanjing Normal University on the current situation of children aged 1-6 watching cartoons shows that 99% of children like to watch cartoons (Lin, Q et al., 2020), and 84.5% of children watch cartoons every day. From this data, we can deeply feel the "close relationship" between young children and cartoons. A large part of the reason why children like cartoons is that they give them a dynamic, audio-visual combination of images. For young children, such vivid images are in line with their level of thinking development.

During a previous placement, got the opportunity to watch an animated maths film with the children and the experience is still fresh in the memory. The children seemed to be enjoying it, and even the formerly fidgety children were glued to the screen, and after the cartoon had finished, the children referred to the maths animation from time to time as they played. This deepened my interest in mathematical cartoons for young children, and when I watched them again, I found that they were rich in educational value and that the way they were presented was consistent with the physical and mental development of young children, which led to the idea of doing research on them.

Researcher Burcu Turan (2013) suggests that the special audio-visual effects of cartoons are beneficial to children's interest in mathematics. The US Educational Measurement Institute has also conducted research on Sesame Street, which has shown that Sesame Street helps to improve young children's cognitive skills. At the same time, cartoons are also important for children's understanding of scientific concepts and concrete knowledge. In their study on the theme of mathematics and science, Donna Farland-Smith and Theodore Chao (2017) discuss the processual use of cartoons in mathematics and science and find that the analysis of data reveals that the cartoons Sid the Science Guy and Little Brother and Sister in Math City contribute to children's curiosity, inquiry, observation, reasoning, classification, measurement and communication skills, classification, measurement, and communication skills, and they provide children with powerful process skills experiences.

Stop-motion animation has a unique visual effect that may include cut-outs and combinations of distorted cardboard of objects, as well as special lighting effects. These effects capture the visual attention of children and stimulate their curiosity and imagination. The stop-motion animation changes frame by frame, as if by imitation, as one moment a whole apple becomes several petals the next, firmly capturing the child's attention and enhancing their interest in the maths term. Stop-motion animation also involves things that children are familiar with, such as toys, food, small animals and so on. These may hold children's interest and make it easier for them to relate to the storyline.

It is undeniable that stop-motion animation is a very time-consuming form of narrative, but it has irreplaceable advantages. In terms of visualisation, it has the same ease of dissemination as digital media, but it can also provide inspiration and potentially increase children's interest in learning. In terms of physical space, stop-motion animation has a very good practicability, children can be very real in the three-dimensional world in contact with the elements of stop-motion animation, rather than as other two-dimensional animation mode can only be viewed in the virtual world.

3.1 Problem statement

Multimedia technology is increasingly being integrated into children's everyday learning and many schools are choosing to incorporate new media technologies into their teaching processes to improve children's learning and to engage their interest in learning. However, the development of new media materials is very labour-intensive and time-consuming, so it is not yet widely available in schools. Stop-motion animation is a more accessible approach and because of its unique format is easier for 5-6 year olds to accept and they can participate in the production of stop-motion animation themselves, making it truly fun and educational.

With more and more tempting factors in the lives of 5-6 year olds today (McNicoll, 1999), more children find learning to be whether boring or not, and they prefer to devote their energy to playing games, so how to increase children's interest in learning becomes a very crucial issue, and the emergence of interactive animation brings into play the advantages of participatory learning, taking children's cognitive perspective, greatly increasing their participation in it, stimulating their learning potential and increasing their interest in learning.

The real aim of incorporating stop-motion animation, a digital media technology, into the teaching of mathematics to 5-6 year olds is to engage children in an active way in their daily learning and to transfer knowledge to them in a more vivid, visual way. The aim of this project is to produce a short film using stop-motion animation as a narrative to compare whether the use of stop-motion animation has an impact on the learning effectiveness of 5-6 year olds in mathematics? The short film was adapted to incorporate interactive games, using a participatory approach to teaching and learning, and to compare the use of a single stop-motion animation in teaching and learning versus an interactive game film. to see if it has a greater impact on the learning effectiveness of 5-6 year olds and whether it positively changes children's emotions towards learning mathematics. Which of these two approaches, when compared, can have a more positive impact on 5-6 year old children's maths learning?

4 Method

This paper uses a mixed research approach, combining both quantitative and qualitative research methods in order to gain a more comprehensive understanding of the problem. Experimental and observational studies from the quantitative research method were used in it. The experiment was conducted using the reference and comparison method, and the goal of the experiment was to investigate which teaching method was the most effective for 5-6 year old children between not watching any film, watching a stop-motion teaching video, and engaging in an interactive teaching game with stop-motion animation. During the experiment, the whole process was recorded by the professional staff, mainly including the children's testing process, their performance in doing the test questions and the time they spent on the test. Based on their performance during the test, the children's interest in the different teaching methods was analysed. This paper also utilises questionnaires and personal interviews from the qualitative research method. The questionnaire helped to gain a clearer understanding of the children's acceptance of stop-motion animated instructional videos and their ability to positively guide their enthusiasm for learning, therefore promoting their maths learning. The use of personal interviews can help to get a clearer picture of the differences in each child's acceptance of stop-motion teaching methods.

4.1 Propose a stop-motion shooting script

4.1.1 Styles of stop-motion animation

Children aged 5-6 years old are at a stage of rapid growth in creative thinking and logical thinking (Wadsworth, 1996), so they need innovative teaching methods to develop and nurture their minds, which requires the use of methods that can stimulate children's desire and enthusiasm for learning. It makes learning mathematics easy and enjoyable. The use of animation in the classroom can fully transform knowledge from invisible to tangible, stimulate children's enthusiasm for learning mathematics and improve the efficiency of the classroom, using multimedia animation to select different animation effects according to different content chapters, turning the invisible into tangible and the abstract into intuitive. The effects of multimedia animation can provide multi-sensory stimulation for children (Anderson & Pempek, 2005) and make the classroom more engaging. Multimedia teaching is now a new and highly flexible way of teaching and learning, and is an all-round reform of mathematics teaching, but how to make full use of multimedia animation for teaching mathematics is a subject worthy of study. It should be organically combined with the traditional teaching of the past to make teaching mathematics to primary school students more optimal and efficient.

Addressing the theme of mathematics and science, Donna Farland-Smith and Theodore Chao (2017) in their study addressed the use of cartoons for process in mathematics and science and found through data analysis that two cartoons, Sid the Science Kid and Little Brother and Sister in Math City, contributed to young children's curiosity, inquisitiveness, observation, reasoning classification, measurement, and communication skills, and can provide children with powerful process skills experiences. Therefore, for the stop-motion animations, I chose animal themes that are close to the children's hearts and that stimulate their interest in learning mathematics.

4.1.2 Teaching and learning content design

Alanazi's (2020) research shows that students' maths anxiety can be reduced through active and entertaining maths games. The script is therefore set in a very light-hearted and enjoyable way, using objects from children's everyday lives and presented in stop-motion animation.

In addition, instructional design needs to be appropriate to children's learning styles, and Mason and Rennie (2008) refer to some hindsight on the learning styles of young children (born after 2000) by summarising the results of several studies, which unsurprisingly differ from those of older generations, with younger students showing a desire for entertainment and stimulation. These studies show that young learners prefer to learn from pictures, sounds and videos as opposed to words. They also prefer interactive, networked activities to independent, individualistic learning. They favour experiential activities and learn in a non-linear way. On the other hand, these students have short attention spans and lack thinking skills. Therefore, the teaching content is designed to split the adult film into two short films, which enhances the children's interest in learning while ensuring a high level of attention span for a short period of time. This meant that the prototype needed to have a more interactive and entertaining value in order to hold their interest. The experiment involved a total of thirty students, two testers, and three kindergarten teachers, and was conducted and implemented in collaboration with Shanghai Century Anglia Kindergarten. The experiment made use of the LCD screens equipped in each classroom for the prototype presentation.

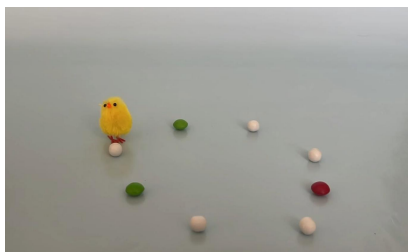


Figure1. Image text. How is the teaching content presented in stop-motion animation?

4.2 Ethical considerations

Data Privacy

The data from the survey and test results will not be identifiable to anyone other than the researcher. The anonymised data may be seen by the researcher's supervisor, subject to confirmation that the results of the study have been fully described in the research paper.

Autonomy and voluntariness

All participants were free to choose to participate without any pressure or coercion, and everyone had the right to withdraw from the study at any time without further data collection or analysis, and all existing data would be deleted.

Transparency

Deception and exaggeration were avoided throughout the research analysis and testing process. All data was collected from the experience of the testers. Any type of communication related to the study should be done in an honest and transparent manner.

5. Prototype description

The aim of incorporating stop-motion animation into the daily learning of 5-6 year olds is to reduce children's mathematical anxiety, increase their interest in learning mathematics and positively guide their emotions when dealing with mathematics. Therefore, children's feedback and mathematical learning enhancement is an effective test of the effectiveness of the prototype design. During the design phase, four components were included: the design of the short film narrative, the design of the test environment, the design of the test content, and the design of the follow-up questionnaire and individual interviews.

5.1. Short film narrative design

In order to make the content of the video more suitable for 5-6 year olds, according to Swiss psychologists' cognitive psychology (Wadsworth, 1996), there are two main developmental stages for young children: the perceptual-motor stage, when they rely on sensation and movement to understand the world; and the preoperational stage, when their thinking skills mature and they consider everything from their own point of view, but their understanding of the world around them is still relatively vague and they do not have the ability to fully understand and express things. They do not have the ability to understand and express themselves fully. Therefore, all the characters in the animated film become partners in their own play and communication, and the formal state of characterisation guides young children in their perception and understanding of the world. The protagonists in the short film are two strange, colourful triangular monsters that start a dialogue with the children. According to (Isa & Amin, 2015) research indicates that a good script can be a catalyst for excellence and can be good for teaching and entertaining. The design of the play first followed the cognitive and comprehension abilities of 5-6 year olds, taking into account the psychological and limited cognitive levels of the children, using simple and clear language, concise narratives and interesting scenes in order to better convey the teaching content. At first, the experiment selected fruits as the props needed for stop-motion animation because of their rich colours and very common in daily life, but in the initial experiment, the researchers found that fruits were not very convenient in the filming operation, and it could not change into various forms or have a specific story line. Therefore, we chose to make our own props for the filming process. The most basic and familiar example of a hen laying an egg is used to illustrate addition. The hen produces 10 white eggs at the beginning, and based on the uniqueness of the stop-motion narrative, and the fact that the sound effects change the colour of three eggs as if by magic, it is possible to work out that there are seven white eggs left, which leads to the mathematical problem "10-3=7".

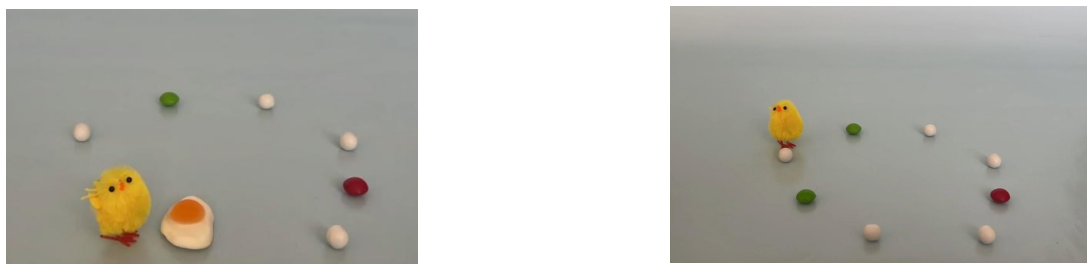


Figure 2. Narrative images in stop-motion animation.

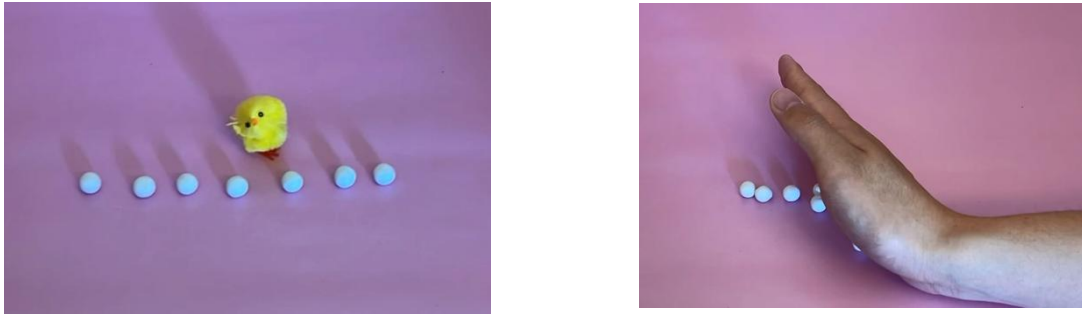


Figure 2. Narrative images in stop-motion animation.

Interactive stop-motion game design

The design of the interactive stop-motion game is based on stop-motion animation and I designed a lot of cute buttons to guide the children.

For example, the interactive buttons shown in the introductory section of the game are used to help remind children that the test is about to start.



Figure 3. Start button in the introduction section of the game

For example, the picture shows a number of buttons which are used to help guide children to the correct answer from a number of numbers.

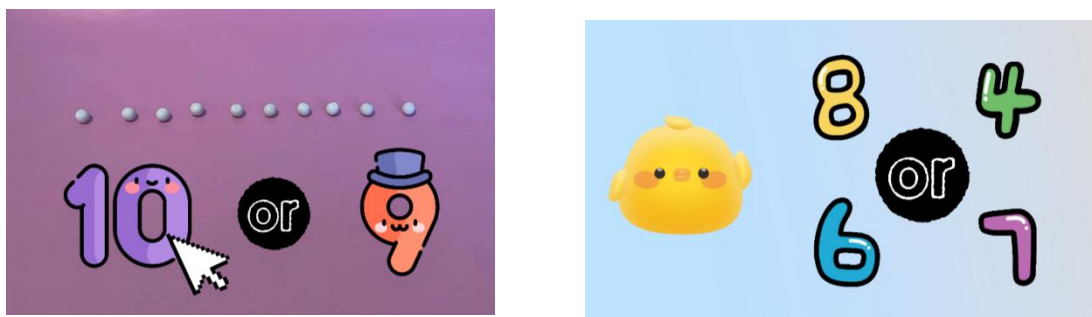


Figure 4. The button in the game during the question and answer session

5.2 Participant grouping design

The participants were drawn from a class of 42 children. From the teacher in charge of teaching mathematics in the class, I collected nine daily test scores from the students in the class, counted their average scores and divided them into five groups, ABCDE, three students in each group, which corresponded to three test groups with different test contents. Based on the above, the thirty children are numbered as follows. In subsequent experiments, numbers will be used instead of names.

	A	B	C	D	E
1	DINGYAO (A-1)	YIZHOU (B-1)	YUCHEN (C-1)	YIFAN (D-1)	JUNYAO (E-1)
2	YILIN (A-2)	HAOCHEN (B-2)	YIQIAN (C-2)	ZIMING (D-2)	HONGXUAN (E-2)
3	YINING (A-3)	YICHEN (B-3)	SIYUAN (C-3)	MOFAN (D-3)	ZHONGLING (E-3)

	a	b	c	d	e
1	ERQI (a-1)	XINYU (b-1)	CHENRUI (c-1)	ZILIN (d-1)	ZIHANG (e-1)
2	ZIFEI (a-2)	LEHAN (b-2)	YIFEI (c-2)	WANQING (d-2)	XINTONG (e-2)
3	JIAYAO (a-3)	JINGYAN (b-3)	JIASUI (c-3)	ANDI (d-3)	MO (e-3)

Table 1. Thirty students were numbered to Group 1, Group 2 and Group 3 in the test.

5.3 Test environment design

Children aged five to six are in the early stages of learning mathematical concepts and prefer a visual, playful and participatory approach to learning, but their attention span cannot be maintained for long periods of time. Therefore, when specifying a testing environment, it is important to choose one that is absolutely quiet and relaxed. Our tests were conducted in the first session of the afternoon after the kindergarten lunch break and each group was accompanied by two kindergarten teachers who helped to maintain order and calm the test participants. The children sit in rows and the teacher sits at the back of the children while the test is taking place so that the results were not affected. However, due to the inclusion of the teacher, the children's attention will be more engaged in the test than without the teacher, and the children will be more emotionally stable. Therefore, the development of subsequent programmes also needs to take into account the situation of children learning independently or out of the classroom environment. The test will be conducted in Chinese.

It cannot be ruled out that the inclusion of a teacher may affect the results of the test, but in the subsequent development of the programme, we will reduce the influence of the teacher and make the explanation of the programme more detailed. We will also allow the children to adapt to the learning environment, so that they can be independent and emotionally stable in stop-motion maths.

5.4 Test content design

The test was divided into three experimental groups, using a cross-over experimental approach. Group 1 was given the questions directly without any intervention; Group 2 was shown a short stop-motion video and then given the questions for testing, and Group 3 was given an interactive animation game first and then given the questions for testing.

Group 1: The number of people is 10, the ratio of male to female is 1:1, 5 boys, 5 girls, two kindergarten teachers are female teachers, after all the children are seated, the kindergarten teachers settle down and maintain order, the kindergarten teachers retreat and sit behind the children, the testers issue the test questions, the children get the test questions in turn, the testers leave the field, start counting down five minutes, the children can not see the remaining time, the time is up the testers prompt the children, stop the test, the testers collect the test results, the test is over.

Group 2: 10 people, male to female ratio of 1:1, 5 boys, 5 girls, two kindergarten teachers are female teachers, all children seated, by the kindergarten teacher to settle and maintain order, the kindergarten teacher back to sit behind the children, by the testers began to play a short stop-motion animation teaching, in the process of playing put testers behind the children to record the children's viewing and interaction, the film playback is over After the film is finished, the tester immediately hands out the test questions and after the children have been given the test questions in turn, the tester leaves the room and starts to count down for five minutes, the children cannot see the remaining time, when the time is up the tester prompts the children and stops the test, the tester collects the test results and the test is over.

Group 3: 10 people, male to female ratio of 1: 1, 5 boys, 5 girls, two kindergarten teachers are female teachers, all the children were seated, the kindergarten teacher settled and maintain order, the kindergarten teacher back to sit behind the children, the testers told the rules of interaction and began to play interactive game film, the kindergarten teacher organization together to learn, interactive part of the children raised their hands in turn to participate, in the process of playing. (Group 3's animation adds a number of interactive elements based on Group 2, such as buttons with cartoon elements, so that children are more free to master the animation learning process. When questions appear, children are presented with a variety of answers to choose from, which helps to provide them with a common guide to better focus their attention and improve their efficiency.) After the film is played, the tester immediately hands out the test questions, the children get the test questions in turn, the tester leaves the room and starts counting down for five minutes, the children cannot see the remaining time, when the time is up the tester prompts the children and stops the test, the tester collects the test results and the test is over.

The three test groups were cross-referenced and performed simultaneously. They are collected uniformly by the testers and analysed for correctness for each control group.

5.5 Follow-up questionnaire and individual interview design

After finishing the test, the three control test groups took a short break and then simultaneously entered the questionnaires, which were as follows:

1. Do you like watching animations?

A. Very much like

B. Like

C. General

D. Dislike

E.Hate

2.How do you usually watch animation?

A.TV

B.Recommended by friends

C.Cinema

D.Internet

E.School Promotion

F.Other

3.What style of animation do you prefer to watch?

A.Hot-blooded

B.Campus

C.Action

D.Gastronomy

E.Knowledge&Science

F.Other

4.Do you enjoy studying mathematics?

A.Very much like

B.Like

C.General

D.Dislike

E.Hate

5.Do you think that studying type animations like the ones in the test help you with your maths learning?

A.No help

B.Very helpful

C.helpful

D.A little help

6.How has watching the study type animation affected your learning of mathematics?

A.It will enhance further knowledge

B.Developing interest in learning

C.Stimulates imagination and creativity

7、 What is your favourite way of learning mathematics? (Sorting question)

A.1st place

B.2nd place

C.3rd place

D.4th place

E.5th place

8、 Do you like the stop-motion style of animation shown in today's test?

A.Dislike

B.Like

After the results of the questionnaire were tallied, the two children with the highest and lowest percentages of correctness were selected for each test question, and the questionnaire was combined with the questionnaire to find out specifically how the stop-motion video had affected them positively or negatively.

6. Experimental procedure and data recording

6.1 Documentation of the experimental process

Group 1: The experiment started at 1pm and all ten children were very cooperative and quietly engaged in the experiment. While working on the test questions, the E-1 children first showed a lack of concentration, playing with their fingers and looking out of the window, the e-1 children showed a pen-playing movement and the D-1 children showed a daze. These three children made movements unrelated to completing the test and were inattentive, the rest were quiet and attentive and all 10 children completed the test on time.

Group 2: The experiment started at 1.15pm with ten children, but the b-2 child showed a significant mood swing due to the arrival of the unfamiliar testers, but was calmed down by the teacher. During the experiment, all ten children were very attentive during the stop-motion video without any loss of concentration. During doing the test questions, child D-2 showed distracting behaviour of playing with pencils, the rest of the children were quiet and attentive, nine of them completed the test on time and the average time was shorter than Group1.

Group 3: The experiment started at 1:45pm with ten children. Two of the children, C-3 and d-3, showed a significant mood swing due to the arrival of an unfamiliar tester, but were calmed down by the teacher. During the experiment, all ten children were very attentive and active throughout the interactive stop-motion game, but the two children, C-3 and e-3, only listened and did not participate in the interaction. During doing the test questions, children e-3 showed distracting behaviour of playing with pencils, the rest of the children were quiet and attentive and all 10 children completed the test on time, with an average time shorter than Group1.

6.2 Test correctness statistics

The test consisted of five questions and each group was given five minutes to complete the test, out of a total of 100 points, with one question worth 20 points. Within the five minutes, only the D-2 child in the second group did not finish the test, while the rest of the children completed the test within the time limit. The statistics of the test attainment rate are as follows:

	A-1	80	A-2	100	A-3	100
	B-1	80	B-2	100	B-3	80
	C-1	80	C-2	80	C-3	80
	D-1	60	D-2	60	D-3	80
	E-1	40	E-2	80	E-3	80
	a-1	100	a-2	100	a-3	100
	b-1	100	b-2	100	b-3	100
	c-1	60	c-2	100	c-3	80
	d-1	60	d-2	80	d-3	80
	e-1	60	e-2	80	e-3	40
Average score		72		88		82

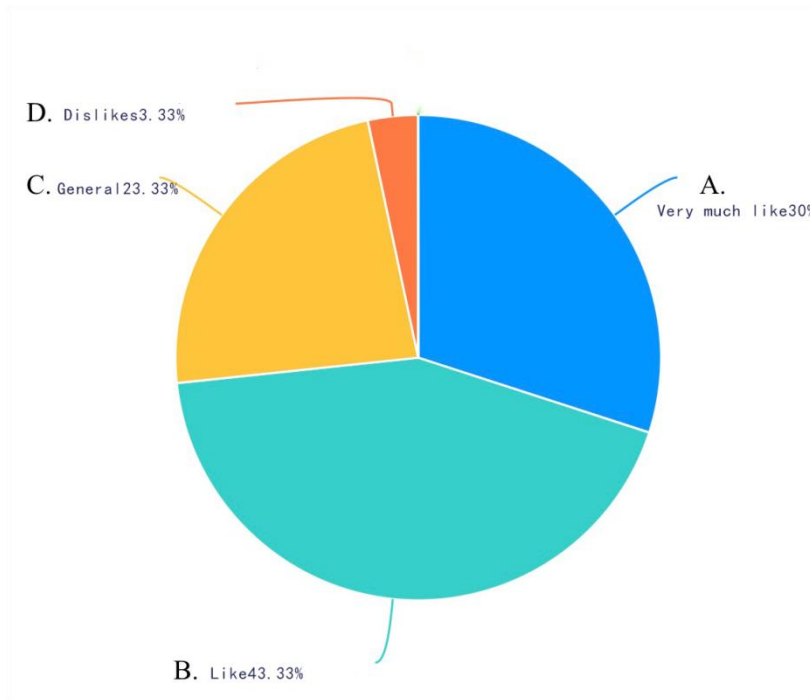
Group 1 Group 2 Group3

Table 2: Test results for each of the three groups of children

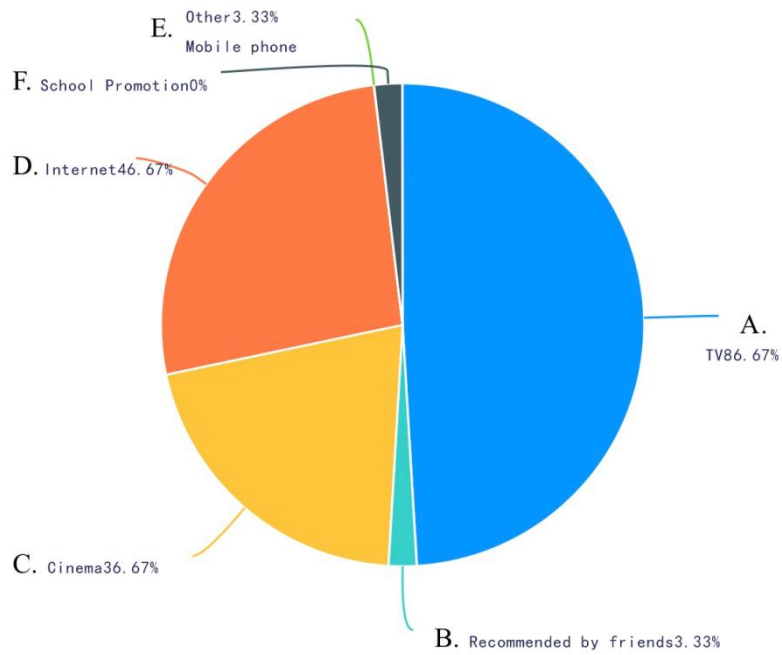
6.3 Statistics of questionnaire results

The questionnaire will be administered after the children in the three groups have completed the test questions, with a break for the children. The questionnaire took a total of 20 minutes to complete which was printed out and distributed on paper. All 30 children in the three test groups participated in the survey and completed the questions with 100% completion.

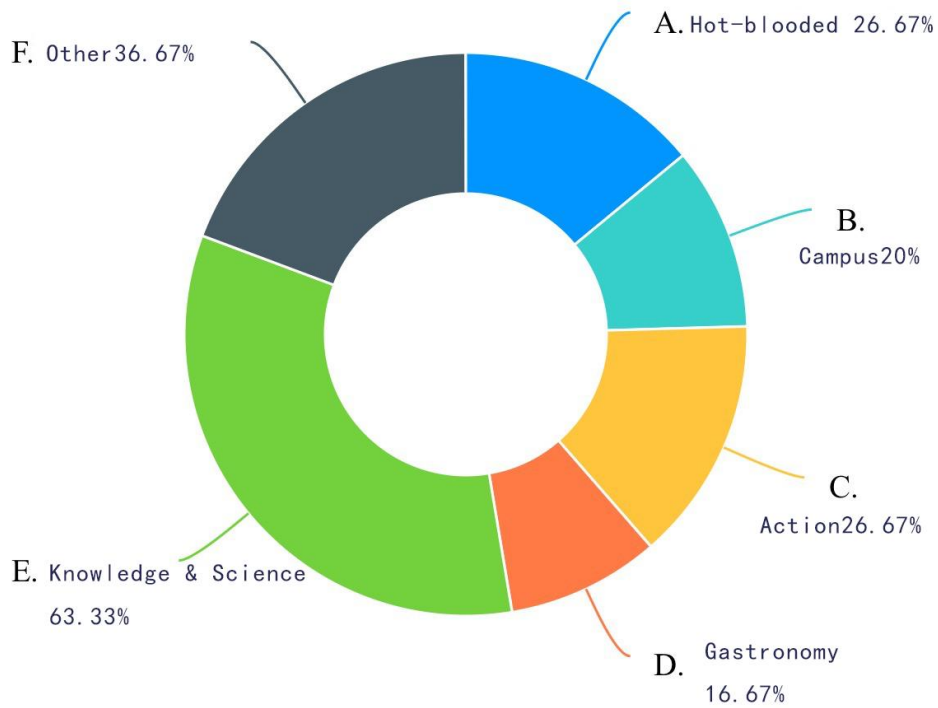
1. Do you like watching animations?



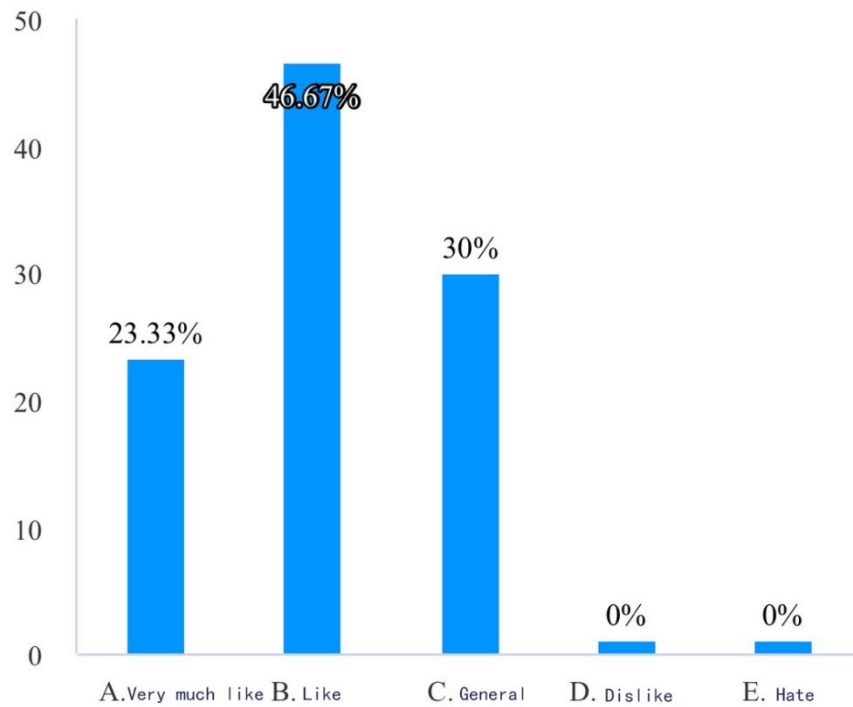
2、 How do you usually watch animation?



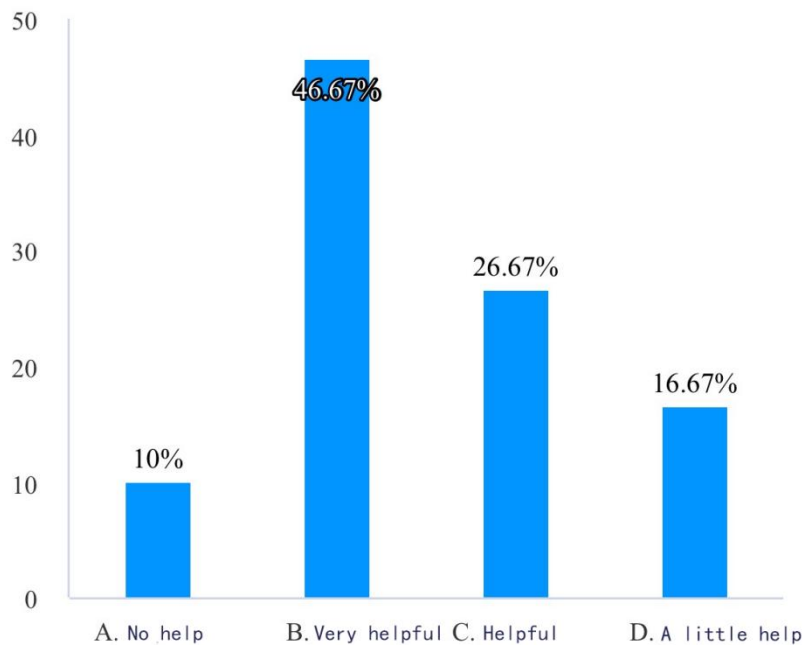
3、 What style of animation do you prefer to watch?



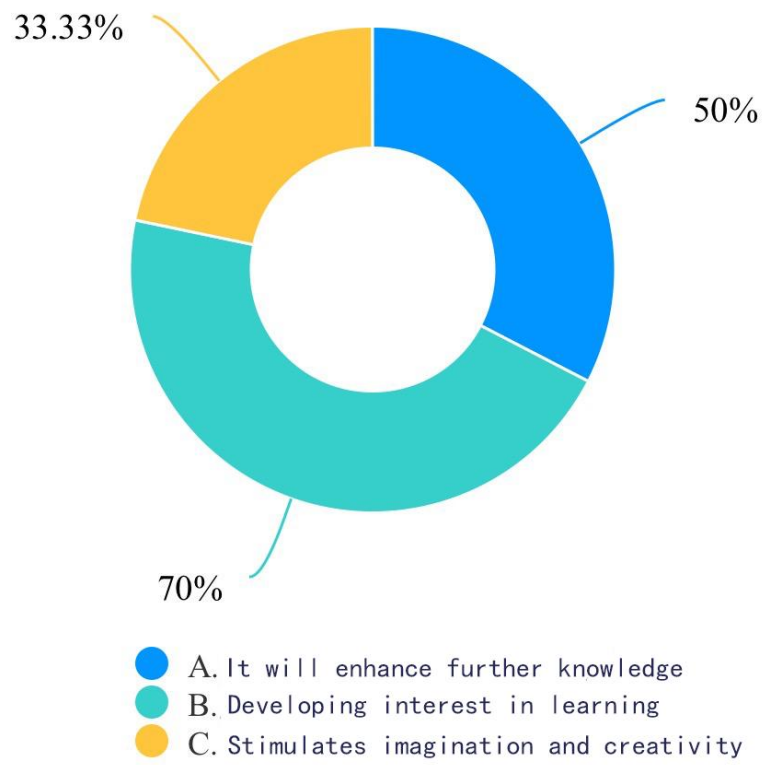
4、 Do you enjoy studying mathematics?



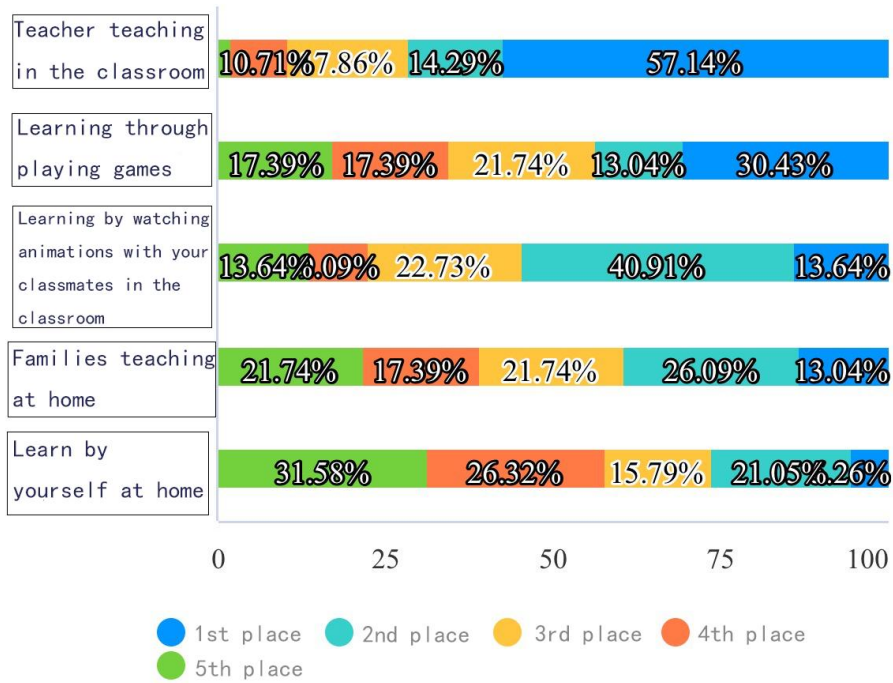
5、 Do you think that studying type animations like the ones in the test help you with your maths learning?



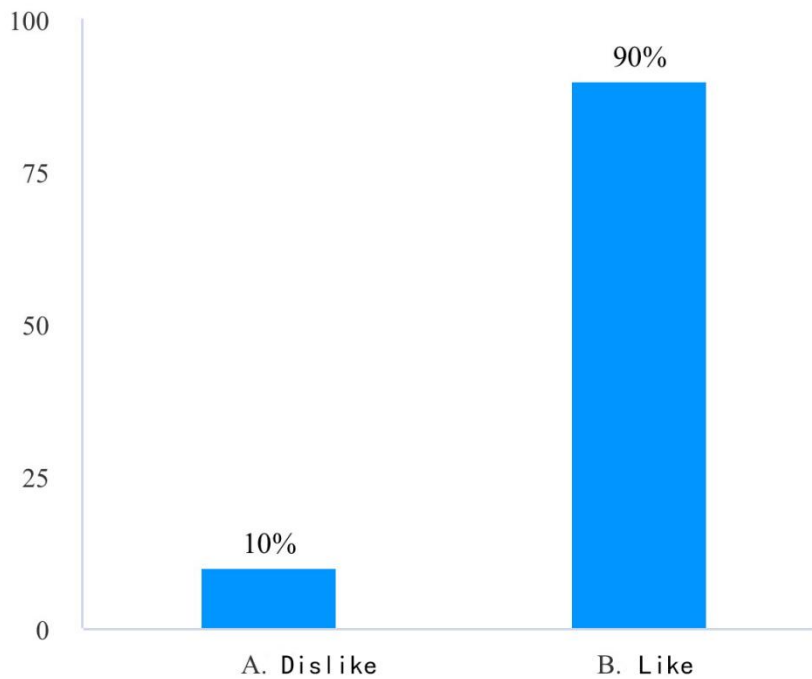
6、 How has watching the study type animation affected your learning of mathematics?



7. What is your favourite way of learning mathematics? (Sorting question)



8. Do you like the stop-motion style of animation shown in today's test?



6.4 Personal interview notes

The children in the three different test groups will differ according to the process and outcome of the experiment they are involved in so as to get more details about the experiment.

Group 1: The two children who chose to be interviewed individually were a-1 and E-1.

1、 How enthusiastic are you about learning mathematics? /How do you feel when you learn maths?

a-1: I really like learning maths and I have fun every time I have a lesson.

E-1: I don't like maths, I hate it.

2、 How can you add increase your interest in learning? What can you do to make learning maths more enjoyable?

a-1: I am already happy learning maths.

E-1: I don't want to learn maths, I like to play games.

3、 Do you think the way you learn maths now is boring?

a-1: It's okay, but sometimes it is.

E-1: It's boring.

4、 Are you willing to try new ways of learning?

a-1: Yes.

E-1: Yes.

Group 2: The two children who chose to be interviewed individually were A-2 and D-2.

1、 Do you find the current teaching style within the kindergarten boring?

A-2: A little bit, but I still like it.

D-2: Boring!

2、 Did you find the stop-motion method of learning boring today?

A-2: It felt very interesting, I watched it for the first time today.

D-2: So interesting! It's like magic!

3、 Has it increased your interest in learning? /Did it make you happy when you were learning maths?

A-2: Yes, it did.

D-2: Yes.

4、 Would you like to try this way of learning maths more often in the future?

A-2: Yes.

D-2: Yes.

Group 3: The two children who chose to be interviewed individually were a-3 and e-3.

1、 Do you find the current teaching style in kindergarten boring?

a-3: No, I like it.

e-3 : Boring.

2、 Did you think that the interactive freeze frame game in today's test was difficult?

a-3: No.

e-3 : A little bit.

7.Data analysis

7.1Children's experimental process performance analysis

There were two test persons in total, one was responsible for playing the stop-motion animation and distributing the test questions, and the other was responsible for recording the children's performance during the experiment.

The experimental records were taken, documenting the performance of three groups of children. The first group, which served as the control group, had the highest number of children displaying signs of distraction. In contrast, the second group of children exhibited the highest level of focus in the laboratory setting. The occurrence of distractions during learning activities in children mainly depends on the following factors:

- 1.Lack of interest: Some mathematical problems may lack appeal or become boring for children, leading to easy distraction and difficulty in maintaining focus.
2. Learning difficulties: Mathematics can be a challenging subject for certain children. When they encounter problems that are hard to understand or solve, they may feel frustrated and helpless, resulting in distractions and daydreaming (Ashcraft & Ridley, 2005).
- 3.Attention issues: Some children may have characteristics of poor concentration (Barkley , 2003), such as attention deficit hyperactivity disorder (ADHD). In such cases, they may be more prone to distractions and find it difficult to sustain focus while doing math problems.
- 4.External interference: Children may face external distractions while engaging in math4tasks, such as noise, other people's activities, or electronic devices. These disturbances can scatter their attention and make it challenging to concentrate.

7.2Testing question correctness analysis

During the experiment, the conditions were nearly identical across the three groups, with the only variable being the children's level of interest in learning. This indicates that incorporating stop-motion animation into children's daily math learning processes can positively influence their learning interests, thereby enhancing their motivation to learn. As for the effectiveness of interactive stop-motion games, it requires a comprehensive assessment combining test results, questionnaires, and personal interviews.

7.3Questionnaire data analysis

The first two questions of the questionnaire reveal that children have a strong preference for animation as a narrative medium. However, currently, their primary means of accessing it are through television, followed by the internet and movie theaters. Therefore, we should expand children's access to animation, both in the classroom and in their extra curricular activities.

The third question of the questionnaire indicates that children's favorite animation genres are knowledge & science and detective. These two animation genres share some common aspects.

1. Sparking curiosity and a thirst for knowledge: Both knowledge & science and detective animations have the ability to ignite children's curiosity and desire for knowledge. Educational animations present scientific principles, natural phenomena, or historical events in a vivid and engaging manner, stimulating children's interest in learning. Detective animations, on the other hand, encourage children to think and explore through the process of solving mysteries and reasoning, cultivating their powers of observation and logical thinking. In the case of 5-6 year old children, the most important thing they need to learn maths is to be interested in learning, and the use of this type of animation in the learning process shows that it can be effective in increasing children's enthusiasm for learning.
2. Combining entertainment and education: These two genres of animation aim to deliver knowledge while entertaining children. They use animation as a medium to captivate children's attention through vibrant visuals, music, and characters, making the learning process more engaging and interactive. Children can acquire new knowledge or develop cognitive skills while enjoying the animations.
3. Fostering problem-solving abilities: Both educational and detective animations require viewers to engage in thinking and problem-solving. Educational animations may present scientific puzzles or questions, encouraging children to think and search for answers. Detective animations typically involve a series of puzzles and deductive processes, stimulating children's logical thinking and problem-solving abilities. The improvement of logical thinking can help children to improve the effectiveness of children's maths learning, and in this way can effectively help children's maths learning.
4. Cultivating observation skills and critical thinking: Detective animations often emphasize the importance of observation and details, requiring viewers to carefully observe and reason. The cultivation of observation skills can also be seen in educational animations, such as observing experimental processes or natural phenomena. Additionally, these animations inspire children's critical thinking, teaching them to doubt and question, and nurturing their ability to think independently. And these skills will enable children to reflect on their maths learning, which is also very helpful.

The fourth question of the questionnaire reveals that currently, almost all children have a certain level of interest in and liking for mathematics learning.

The fifth and sixth questions of the questionnaire provide clear indications that children believe stop-motion animation positively guides their mathematics learning. They also generally enjoy this new format, and children perceive its primary role as sparking their interest in learning. Furthermore, they believe it helps them delve deeper into the subject matter, and lastly, it stimulates their imagination and creativity. This can help kids bring in better when watching stop-motion animation and unfold their imaginations to think further.

The seventh question of the questionnaire is a ranking question. In terms of learning preferences, the majority of children still tend to favor traditional teacher-led instruction, followed by learning through animation and then learning through games. Traditional teaching methods are irreplaceable and have their own reasons.

1、 Interpersonal interaction: Traditional teaching methods encourage direct interaction and face-to-face communication between teachers and students. Teachers can provide real-time answers to students' questions, offer feedback and guidance, and foster collaboration and discussion among students. This interpersonal interaction helps establish a strong connection between teachers and students, increasing student engagement and motivation. In this way it can be driven to engage children in gamified learning.

2、 Practical experience: Many subjects require students to engage in hands-on practice and real-world experiences. For example, in fields such as science experiments, art, and sports, traditional teaching methods provide opportunities for students to personally get involved and learn through practice. This hands-on experience helps students develop practical skills and cultivate creativity.

The eighth question of the questionnaire reveals that children have a high level of acceptance for the form of stop-motion animation. Therefore it is feasible to incorporate stop-motion animation into the learning of maths for 5-6 year old children.

7.4 Personal interview analysis

Most high-achieving children show a strong enthusiasm for mathematics learning, while the enthusiasm of children with average grades is relatively moderate. Children have a high acceptance of new teaching methods. Regarding interactive stop-motion animation game-based learning, it is important to categorize the difficulty levels of the games into different tiers and tailor them to match the individual learning levels of the children.

8. Conclusion

8.1 Summary

This article mainly explores whether stop-motion animation can play a positive and guiding role in the mathematical learning of 5-6-year-old children. The experiment proves that it does indeed have a positive effect, increasing children's interest in learning and improving their learning efficiency. Its several advantages can be summarized as follows:

Firstly, animation can present mathematical concepts and problems through vivid images, movements, and scenes, transforming abstract mathematical ideas into visible representations. This helps children better understand mathematical concepts and reduces the difficulty of abstract thinking. The experimental records show that especially in experimental group 2, the children's maths scores improved by 60% through the stop-motion video, and the highest one's c-2 score improved by as much as 40 points.

Secondly, animation often features engaging storylines and character depictions that capture children's attention and stimulate their interest in learning. Through the narrative and characters in animation, mathematics learning can be infused with entertainment and emotional elements, making the learning process more enjoyable and captivating. The questionnaires showed that the children were very interested in and did not reject stop-motion animation as a narrative method, and 70% of the children indicated in the questionnaires that the teaching animation increased their interest in learning maths.

Thirdly, animations can be watched and replayed multiple times, allowing children to learn at their own pace. They can deepen their understanding and memory of mathematical knowledge by repeatedly watching the animations according to their own comprehension and learning needs, enabling self-directed learning.

Fourthly, animations can illustrate the process of solving specific problems, guiding children to understand and master mathematical problem-solving methods and steps. Animations can also be used for problem analysis, explaining and demonstrating the process of solving mathematical problems through visuals and animations, helping children better understand and grasp problem-solving strategies.

Finally, animations can flexibly utilize various visual expressions such as charts, images, and dynamic transformations to help children understand mathematical concepts and relationships from different perspectives. Through diverse expressions, animations can provide a more varied learning experience, catering to the needs of different learners. Through the experimental data statistics, 1, 2, 3, 4, 5, level of children after watching the teaching video of stop-motion animation correct rate have some improvement, which belongs to the middle and upper levels of the children to improve the effect is most obvious.

While interactive stop-motion animation games did not show significantly better results than pure stop-motion animation teaching in experiments, they still had a certain positive effect. What appeals most to children is their unique interactivity. The advantages of interactive stop-motion animation games can be summarized as follows:

Gamified learning can ignite learners' motivation and interest. By incorporating game objectives, reward mechanisms, and competitive elements, learners are more motivated to

actively participate in the learning process and maintain continuous learning motivation. In one-to-one interviews with children, I learnt that interest is one of the most important factors in children's learning. Game-based learning can effectively and positively promote children's enthusiasm for learning and improve their learning efficiency to a certain extent. It can also offer immediate feedback and reward mechanisms, enabling learners to receive positive reinforcement when making progress or completing tasks. This positive feedback and rewards contribute to enhancing learners' confidence and sense of accomplishment, fostering a positive attitude towards learning and sustained engagement. Gamified learning creates virtual situations and scenarios in which learners can practice and apply their knowledge. This contextualised learning experience enhances learners' understanding and retention, and helps them to connect what they have learnt to real-life situations, increasing learning transferability.

Gamified learning is often interactive and collaborative, encouraging communication, cooperation and competition between learners. Learners can interact with other learners, share experiences and knowledge through games, promote mutual learning and growth, and develop teamwork and social skills. Children can ask each other questions and learn from each other to improve their learning efficiency. It also provides a personalised learning experience based on individual learner differences and learning needs. Through data analysis and feedback from the gamification system, the content, difficulty and pace of learning can be tailored to suit the learner, providing personalised learning support and guidance.

8.2 Discussion

Market data shows that game-based learning has been increasingly recognised by parents and schools (Ferrer, 2013). Gamified learning needs to be designed with richer and more varied content to better stimulate children's interest in learning. Incorporating stop-motion animation into children's daily mathematics learning is an innovative and interesting way to make learning more fun and engaging. However, successful implementation of this approach may require overcoming the following challenges: Firstly, the integration of mathematical concepts into stop-motion animation needs to be carefully planned and designed to ensure that the animation conveys mathematical knowledge clearly. The key is to translate mathematical concepts into fun and accessible animated scenes that allow children to understand the concepts accurately and to learn.

Secondly, stop-motion animation requires careful production, including animation design, script writing and animation production. To keep children interested in mathematics, the animation content should be exciting, engaging and capable of holding their attention. This requires a team of professional animators and educational experts to ensure the quality of the content and the effectiveness of the teaching. The stop-motion animation should be appropriate for the target age group to ensure that the content and presentation is appropriate to their cognitive level. The language and presentation of the animation should be simple, easy to understand and in line with children's learning habits and preferences.

When using stop-motion animation for mathematics learning, there is also a need to balance the entertaining and educational aspects of animation. While animation can hold children's

attention, the communication of teaching objectives and concepts remains paramount. Ensure that the content of the animation is both entertaining and educational so that children can actually learn mathematics while watching it. In order to successfully integrate stop-motion animation into mathematics learning, teachers also need training and support on how to use animation effectively to teach mathematical concepts. They need to learn to integrate animation resources into their lesson plans, guide students through the animations and provide relevant discussion and practice activities.

But there are some difficulties that need to be addressed when using stop-motion animation to incorporate the teaching of maths to 5-6 year old children. How to integrate stop-motion animation more relevantly into children's materials requires more time and more energy to devote to learning in it. The biggest problem facing us now is how to promote the teaching method of stop-motion animation, to get more children's acceptance and suggestions, and to get the shortcomings of the teaching method through practice, so that we can improve and continuously develop new teaching modes.

Participatory teaching and learning (Fernando & Marikar, 2017) is an educational approach that promotes students' learning and understanding by actively engaging them in classroom activities and learning processes. However, there are some disadvantages of participatory learning compared to traditional teaching methods, including : Participatory learning usually requires more time for group discussions, group activities, hands-on projects, etc. This can make it difficult for teachers to cover the full range of content in the limited time available, especially when more topics and concepts need to be covered.

Participatory learning often requires additional teaching resources and materials to support student activities and exploration. This can put pressure on school and teacher resources and budgets, and may result in the needs of all students not being met.

In participatory learning, the level of participation may vary between students. Some students may show initiative and active participation, while others may remain silent or less active in group discussions or group activities. This may lead to inequality and inequity among students.

Participatory learning requires teachers to act as guides and mentors to ensure that students receive the right guidance and support during the learning process. This requires teachers to have good pedagogical skills and experience, and to be able to adapt to the needs and learning pace of different students.

Traditional assessment methods may not be appropriate for participatory learning because student learning outcomes and performance are more diverse and individualised. Teachers need to develop innovative assessment methods to accurately assess student learning outcomes in participatory learning.

Despite these disadvantages, participatory learning is widely recognised as an effective method of teaching and learning that can stimulate students' interest, motivation and deeper understanding. By recognising these disadvantages and acting accordingly, the advantages of participatory learning can be maximised to provide a more productive and meaningful learning experience.

Comparing learning maths by watching stop-motion animation with learning by engaging in a stop-motion animation game with interaction, it is very surprising that the positive results of the experiments with direct viewing of stop-motion animated teaching videos were more significant than the experiments with the stop-motion animation game with interaction, although both methods had positive effects on the learning of maths by 5-6 year olds. I think the reason for this may be that the narrative of teaching maths in stop-motion animation alone would be more intuitive. For 5-6 year olds, they may prefer a more direct approach to accepting new things, and stop-motion animation has a clearer story line than other forms, making it easier for children to understand.

8.3 Future work

The integration of stop-motion animation into children's daily learning should also take into account its sustainability. It should be continuously evaluated and improved, collecting feedback and data from the children to keep abreast of their learning experience and learning outcomes. Teaching animations can be improved and optimised to continually improve learning outcomes and children's learning experiences. The benefits of gamified learning can also be taken advantage of to personalise learning and adaptiveness. Challenges and customised learning paths are provided at different difficulty levels based on students' learning levels, interests and learning styles. Through a real-time feedback and assessment system, the difficulty and content of the game is adjusted according to children's performance to ensure effective and personalised learning. And make sure that gamified learning has a strong connection to the real world. Combine learning content with real-world application scenarios so that children can apply what they have learned to real-world problem solving. This helps to increase children's interest in learning and the practical usefulness of the learning outcomes.

The use of stop-motion animation in maths teaching can effectively develop children's space think ability. Stop-motion animation has a sense of novelty and visual impact, through the two-dimensional reduction of three-dimensional space can be a good way to exercise the children's space imagination.

Teachers still have an important role to play in game-based learning. They should take on the role of mentor and guide, providing the necessary guidance and support to ensure that the learning in the game is properly understood by students and integrated with classroom instruction. Teachers can also act as consultants on game design, providing expert advice and feedback on gamified learning.

An innovative and diverse approach is needed when designing gamified learning. Consider different types of games, such as role-playing games, puzzles, competitions, etc., to meet the needs and interests of different students. Try to integrate new technologies such as virtual reality (VR) and augmented reality (AR) to provide a more immersive and interactive learning experience.

In the subsequent development of the programme, it is possible to move away from a teacher-centred approach to a child-centred approach, placing greater emphasis on the role of the child as a participant, not just in the viewing of stop-motion animation, but in the production of stop-motion animation. It is based on the uniqueness of the narrative method

of stop-motion animation that children can easily get to know the logic of mathematical problems in the process of production.

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