PSYCHOLOGY AND EDUCATION (2021) 58(5), ISSN 1553 - 6939
Article Received: 22th November, 2020; Article Revised: 26th March, 2021; Article Accepted: 26th April, 2021

Young Children's Use of Digital Cameras to Represent Addition Story

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ABSTRACT

Learning mathematics is often challenging for students at all levels of education, including young children. To help students acquire the abstract mathematical concepts, teachers introduce representations to aid children in comprehending the concepts and solving mathematical problems. This study explored young children's representations (aged 6 years old) in addition activities in their first term of school. Three children from the same classroom were selected as participants. Initially, a pre-test was administered. Next, children were introduced to the addition concept and were required to solve addition problems independently. Following the children's success in employing multiple representations to solve the practice tasks, the final tasks were posed. Analysis of the children's artefacts, in combination with their behaviours and informal interviews revealed insights into the children's understanding of addition concepts. The study implicatesthat developing visual representationiscrucial in facilitating children's understanding of mathematical concepts and assisting solution of problems.

Introduction

It is a natural part of children's lives where most young children use technology (Selwyn, 2003), as various technological devices can be found in their homes and are frequently used by the parents and other family members (Zevenbergen, 2007).Fascinatingly, children are capable of using numerous technology tools quickly,easily, and independently(Couse & Chen, 2010). Children are confident users of technology, as they are frequently exposed to different types of technological devices in their daily lives.Hence, it is vital to make it available and accessible in the school environment. These days, many school settings are allocated with a large range of technology tools including laptops, tablets, smart boards, digital cameras, and iPads. Such devices are useful for teaching and learning,by engaging childrenin the learning activities(Madhavi, 2012).

Previous studies focusing on digital camera usage, photography, and visual imagery creation by young children have acknowledged that incorporatingvisual images including photographs with learning has impacted children's learning. For example, photography activities supportthe development of language and literacy skills of young children (Britsch, 2010; Byrnes & Wasik, 2009; Marinak, Strickland, & Keat, 2010), by means of encouraging meaningful discussion among them (Marinak et al., 2010). Previous study also reported that such photography activities stimulated students to use lengthier sentences when describing the pictures in hand (Britsch, 2010). In addition to functioning as a stimulus for language learning, Britsch (2019) also reported that documenting science experiments using cameras had inspired the children to redesign the procedures to ensure that their investigationswerebeing communicated clearly. Although, previous studies have reported the positive impacts of photograph usage in supporting science learning as well as language and literacy skills, little is known about the role of utilising photographs in early learner's mathematics classrooms. Hence, studies incorporating digital camera usage in facilitating other skills such as mathematics should be administered.

Research background

Researchers defined visualization as "the process of producing or using geometrical or graphical representations of mathematical concepts, principles, or problems, whether hand drawn or computer generated" (Zimmermann & Cunningham, 1991, p. 1). Previous studies highlighted the association between visualization with the understanding of various mathematicalconcepts including numbers, operations,and algebra (Yerushalmy, 1991; Zahner & Corter, 2010). Not surprisingly, increasing numbers of researchershave allowed children to photograph objects and scenes (Clark & Statham, 2005),as these visual images permits the researcher to have a deeper understanding of the children's thinking and understanding. Educators are increasingly fascinated in gaining a better understanding of the various aspects of children's use of visual tools (Bakar, Mohamed, Yunus & Karim, 2020, Byrnes & Wasik, 2009; Dockett & Perry, 2003; MacDonald, 2012).Therefore, the present research attempted to familiarizeyoung children with a portable technological tool- the digital camera - to produce visual representations that has the potential ofproviding insights into the children's experiences, ideas, and understanding.

Technology Usage in Early Childhood Education

In response to the drawbacks of technology to children, Clements & Sarama (2002) recommended exposing them to technology in a developmentally appropriate way. This is crucial to ensure that young children's learning can be facilitated by providing them with various educational experiences and opportunities (Bauer & Kenton, 2005).

The innovation of cameras beginning from traditional film cameras to disposables and recently to digital cameras,affordsboth the teachers and learners a large range of benefits. The rapid development of technological

innovationshas made digital cameras smaller in size yet powerful in function. More importantly, digital cameras nowadays are made affordable and practical to use even for those who are not experts,compared to the traditional film camera. These digital cameras require no specific photography skills; enabling most people to capture images using digital cameras after being familiarized with the camera operation and functions. Further, there are child-friendly digital cameras, permitting young children to be photographers. The digital camera's strength is emerging (Van House, 2011). Deprived of any cost, by clicking on the button, pictures can be taken,retaken, and viewed immediately. Further, unwanted photos can easilybe erased.Stored images can be printed as photographs or photo-booklets (Britsch, 2010). Nowadays, other devices such as iPads, tablets and mobile phones are also equipped with camera functions, allowing images to be captured instantly and easily.

Researchers highlighted that children are capable photographers, and that this technology tool is easy to use even by young children(Barker & Smith, 2012; Orr & Suh, 2013). They learned to operate cameras through peers, adults, as well as through play and self-exploration (Husbye, Buchholz, Coggin, Powell, & Wohlwend, 2012; Bird, Colliver, & Edwards, 2014). Having enormous features with the potential to facilitate students to "see the beauty and excitement in mathematics" (Cuoco & Curcio, 2001, p. xiii), digital cameras should be integrated into the teaching and learning activities in the classrooms.

Using Digital Camera in Early Childhood Classrooms

Digital cameras have often been used in limited capacities. Educators frequentlycapture photosof students' work and during excursions for documentation purposes and to assess students' learning (Byrnes & Wasik, 2009; Fasoli, 2003). Researchers highlighted the positive impacts of integrating photograph activities on children's learning. For instance, photography activities hadbeen found to help facilitate students' literacy and language skills (Britsch, 2010; Byrnes & Wasik, 2009; Marinak, Strickland, & Keat, 2010). When engaged in a combined photographic and literacy task, students tend to involve in meaningful discussions and use more vocabularies and complex sentences in their explanationand led students to use longer sentences to describe pictures (Britsch, 2010; Marinak et al., 2010). Consequently, studies should be conducted to ascertaindigital cameras'utility in other skills and subject areas.

Combining photos with interviews is beneficial as photographs may aid to recall memory and serve asa visual language that may help children to communicate their thinking and experiences. Photographs may also supplement children's expression. This is especially helpful as young children frequentlygrapple to verbalize what they have in mind, specifically, for those havinglimited memory and verbal language (Cappello, 2005). Previous studies highlighted that photo interviews (Cappello, 2005; Zartler & Richter, 2012), photo elicitation (Pyle, 2013) and "photo talks" (Quigley & Hall, 2014; Serriere, 2010, p. 62), are helpful in aiding children to communicate ideas and experiences with adults.

Students are often encouraged to produce various authentic mathematical examples (Northcote, 2011) that can be beneficial for teaching and learning purposes. Hence, digital cameras can be used in creative ways to help create teaching and learning resources. Furthermore, using child-created learning materials may spark children's interest in learning (Cook & Hess, 2007). An increasing number of researchers are integrating photographyinto classrooms activities at all levels,to improvemathematical learning (Bragg & Nicol, 2011; Furner & Marinas, 2012; Northcote, 2011; Orr & Suh, 2013). Photography activities aided students' awareness of mathematicalconcepts in their surrounding as they were capturing various objects in the environment (Bragg & Nicol, 2011; Orr & Suh, 2013). Moreover, discovering mathematics through photography activities enables students to recognize and understand that mathematics is correlated with everyday routines (Bragg & Nicol, 2011), hence, permits students to experience the magnificence of mathematics (Cuoco & Curcio, 2001).

Addition Concept

Researchers put emphasis on the prominence of developing basic arithmetic skills among children during their first years of school(Gelman & Gallistel, 1978; Patel & Canobi, 2010). This is because knowledge and skills obtainedduring early learning in schools are crucial for future learning and life. Addition is among the earliest and important arithmetic concepts that is introduced to children in school. In Malaysia, The Mathematics Curriculum for young children, aged four to six years, aims at supporting preschool children to acquire addition concept by using counting strategies, everyday language to describe addition, symbols to write number sentences, and solving everyday problems involving addition (Kementerian Pelajaran Malaysia, 2010).
Counting lays a foundation for addition skills (Butterworth, 2005). Children's engagement in counting activities (combining groups of objects and counting altogether to get the sum) assists them to develop the understanding of addition concept. With meaningful counting experiences, children will later be capable to develop skills and concepts of addition(Eisenhardt et al., 2014). Next, children will learn and explore other addition strategies such as counting on and recall strategies.

The Study

The aim of this study was to explore the means children embodiedin their understanding of addition. This study was conducted in a public school in Malacca, Malaysia. The participants comprised of three children from the same classroom. This group of children was selected to represent different levels of mathematical performance. Since the study was conducted during the first term of school, a pre-test was administered to assess the children's mathematical achievement. The test item focused only on counting skills (including addition and subtraction tasks). Despite not present in the pre-test, it is vital to state that all children

noticeably improved their basic number skills resultingfrom the engagement and exploration in the addition tasks.

In thelarger part of this study, the children's understanding of addition concept wasinferred via the utilization and creation of various representation forms. Based on the constructivist theory of learning, meaningful and rich learning experiences and environments were providedfor the children to encourage the exploration of addition concept using multiple representations. It is through provoking the children to make their own sense of addition that the children were actively exploring and building their own understanding. However, for this paper, only the representations created by using the digital cameras are reported.

Prior to conducting this study, the teacher familiarized the children with counting. They practiced counting various items in the classroom and were able to recognize and write the number symbols correctly, although sometimes they made mistakes when writing large numbers. It is important to note that the teacher has not taught the topic of 'addition' formally, in the classroom. The researcher served dual functions: as a researcher and asthe teacher to this focus group. Firstly, the children were introduced to the addition situation by demonstrating the addition process using cubes, counters, and other concrete materials. Then the children practiced by representing addition with drawings and writing down the number sentences.After having enough practice creating addition situation with various types of concrete materials and drawing, children were given digital cameras to enable them to create an interesting and diverse way of producing visual representation. The children were introduced to the camera functions and ways to operate the cameras correctly and how to capture pictures.After sufficient practice, and the researcher was satisfied that the children could independently produce their own pictures using the digital cameras, the task of 'My Addition Story' was posed. It is through the children's usage of digital cameras and photographing processes that the children's understanding of numbers and addition were investigated.

Data Sources and Analysis

Data collection included children's artefacts, observations, conversations with the children, and audio and video recordings. Initially, the pre-test data were analysed. Then, the researcher analysed the children's artefacts (i.e.,the photographs). Analysis of the photographspresented various ways of exhibiting the addition concept. Next, the conversations with the children were transcribed. The researcher carefully summarized and organizedthe data collection into a table form, which containseach child's pre-test score, representations and accompanied talk, including the observation of their behaviours and important incidents that occurred while completing the tasks. These data played a crucial function in describing and representing the children's thinking about the addition concept. Further, the table enables a child's representation form to be linked with other data sources and thus,helps informed each child's representations. Also, the table portrays the similarity and differences in representation forms and thinking among the children. The representations, combined with the processes involved in constructing them (recognized through conversations and observations),described the children's thinking and understanding of the addition concept.

Findings

This study aims to answer the following research question:

i) How do young children (aged six years) represent their understanding of addition using photographs?

Children's Usage of Digital Cameras

The children were introduced to addition concept using various representation forms. Only after having enough practice creating an addition situation usingconcrete materials and drawing, children were requested to use digital cameras to represent their creations. Digital cameras were introduced as an interesting and alternativeway of generatingvisual representations. The children's creation of photographs and the photographing processes were explored to help inform the researcher about the children's thinking and understanding of numbers and the addition concept.

Children as photographers

The children's photographing activities were observed to shed light into their perspectives on numbers and addition. During the initial observation, it seemedthe children faced several challenges when handling a new digital tool. Amy referred to the researcher a few times as she could not find the images she captured previously. The researcher suspected that she might not have pressed the button hard enough to capture the objects. Rozy also requested help from the researcher as she found that her images were missing from the camera. She might have accidentally pressed the delete button, hence, the researcher reminded her to be careful with the button and requested her to retake her objects. After several attempts and following numerous trials and exploration, as well as with a little supportgiven both by the researcher and their peers, the children finally succeeded to create photographs that were considered useful.

The children were posed with the task, 'My Addition Story', that required them to produce self-created addition story based on the photos they captured. The children were encouraged to plan about the objects that they were going to capture and the story behind it. This permitted the children to carefully plan the objects they were going to photograph and the related addition story.

The choice of objects being captured for the addition task varied among the children. Some children manipulated familiar concrete materials, while the otherchildren picked new objects to work with on the given task. Norman and Rozy chose objects that are familiar to them. Norman selected coins as his subject, while Rozy used connected cubes to create structures she called as hotels. As for Amy, she decided to use the picture cards that contain ice cream images as her photography subjects.

When setting up for the photographs, it was important that the children constructed the correct quantities. Equally important, was framing the objects accurately. For example, Amy was observed to modify the position of her cards several times to ensure they fitted nicely into the frame. The children seemed to be consciously focusingon constructing

the correct quantity and then capturing the imagescautiously. The children were observed to be moving forward several times and going backward a few times. For instance, Ruby moved forward when she noticed that she was too far from her cubes. However, she was not satisfied with the captured images she viewed on the camera, hence adjusted her distance a few times until she was satisfied that the image was the one she wanted.

Addition as separate addends

This study found that children demonstrated the addition concept as involving two different sets of objects. The children produced a gap between the two groups of objects. The space that they created between the first and the second group of objects was anticipated to distinguish between the two addends, expressing addition as comprising of two distinct groups.

Given the addition task, Norman took four coins from the basket and lined them in a row. He grabbed two more coins and put them next to the row he created before. Notice that he left a gap between the two lines of coins. There were no counting gestures observed, but when asked the total coins he photographed, he answered with the correct total.

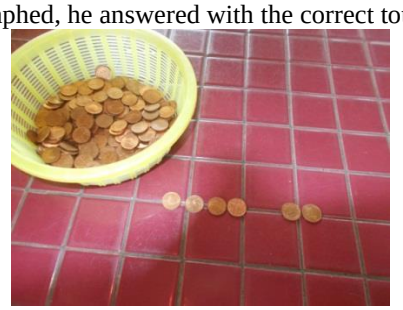

Figure 1: Norman's photograph: 4 coins and 2 coins make 6 coins.

As for Rozy, she carefully took out several cubes while counting them one by one and linked them together. She then positioned the linked cubes vertically to form a building. Next, she repeated the same process to create another structure with the same appearance she generated before (Refer Figure 2). Noticing that the researcher was observing her work, she softly described the structure she created as a hotel. She then continued her building work. After ensuring that the cubes were linked securely, she clicked the shutter release button to capture her construction. In her construction, Rozy too placed a distance between the two hotels.

Figure 2: Rozy's photograph: 4 and 4 make 8.

When presented with various objects in front of her, Amy was quite confused in making her selection of objects. After thinking for quite a while, Amy grasped the pictures of ice cream (Refer Figure 3). Cautiously, she picked the cards and counted them one by oneand positioned them on the table. She moved the cards until she was satisfied that the cards were lined in a straight row. Next, she took two more cards and placed them below the first row of cards. After repositioning the cards several times, carefully but confidently, she captured the image of the cards using the digital camera. Amy ensured that the first line of cards was separated from the bottom cards. The researcher observed that the children were quite careful in counting and were focusingtheir attention on the objects when manipulating them (to ensure the first and the second addends were positioned correctly). They also counted the total that they formed by counting them all together starting from '1' until they reached the number for the last object as the total.

Figure 3: Amy's photograph: 4 ice creams and 2 ice creams make 6 ice creams.

Discussion of Findings

Children are Capable Photographers

This study found that young children are capable photographers,as evident in their ability to produce useful photographs. Despite making a few mistakes and facing a small number of difficulties in operating the cameras, they managed to operate the cameras independently after practising to capture the objects in their surroundings,establishing young children's capability as photographers (Barker & Smith ,2012). The children's ability to quickly learn to operate the digital cameras successfully supported the notion that this technology tool can be used with ease (Orr & Suh, 2013). More interestingly, this study found that children were active explorers of technology. They did not only use the camera function showed to them, but explored more advanced functionsthrough trial and error. The children's self-exploration of the camera functions permitted the children to overcome obstacles in composing the images, hence, enabling them to complete the tasks using various means.Thus, technology tools such as digital cameras that assist students in creating visual images (easily and quickly) should be integrated into the school environment. More importantly, photography activities are beneficial in facilitating the students to "see the beauty and excitement in mathematics" (Cuoco & Curcio, 2001, p. xiii).

Children's Early Understanding of Addition

The children's ability to perform the addition item correctly (although not all of them), during the administration of the pre-test, ascertained the claim made by Hughes (1981) that young children can perform simple addition prior to being taught the addition concept formally. Similarly, Carpenter et al., (1981) and Ibarra and Lindvall (1982) found that this

situation is also true for students in their studies. Obviously, the children in this study possessed the basic knowledge of addition. The children's experiences and exposure to various addition situations in their daily lives may havesupported this knowledge. As affirmed by Anghileri (2000), daily routines that intricatechildren's activities of manipulating objects (while counting), have indeedaided children to build the knowledge and skills of addition. Engaging the children with rich addition experiences using various forms of representations is certainlyvaluable in developing their understanding of addition.

The children in this study appear to exhibit the acquisition of basic addition principles.They comprehend addition as comprisingof two different groups and counting all the objects to acquire the sum(Carpenter & Moser, 1982; Gray & Tall, 1994). The notion of exhibiting addition as containing two different groups was also observed in the study by Polly et al. (2014). When creating their addition stories for '3+2=5', the childrencould easily include in their stories both the addends and the total. However, there were no signals of combining the groups to arrive at the total. Similarly, the photographs created by the children in the present study containedgaps between the two sets, signallingthese sets as two distinct groups. In the study by Polly et al. (2014), when required to represent the addends using concrete materials to: i) find the total for 5+3=? and ii) to demonstrate the addition processes of 3+1=4; the children could easily complete the first task but struggled to represent the addition process for the latter task. Having in mind that the children in the current study had only been recently exposed to the concept of addition, it was acceptable that they struggled to represent the entire addition process in comparison to merely manipulating the objects to get to the total.

In contrast to this study,Manches and O'Malley (2016)reportedthat the participants they observed in their study frequently combined the objects and swapped over groups when solving addition tasks; demonstrating their fluent addition skills. In another study by Changsri (2015), the participants made various efforts and marks to demonstrate the notion of addition as combining by inserting arrows and adding circles into their drawings. More advanced understanding of addition was also portrayed by the participants in Changsri's (2015) study in which some children included the '+' symbol between the drawing of two groups of objects while others added the number sentence to their drawings. Such marks were intentionally made to exhibit the necessity of combining the addends when performing addition. The absence of combining act to exhibit the addition process could be explained by the differences in the context of the tasks given between this study and the previous studies. If theresearcher had clearly requested the children to demonstrate the addition process in their addition story, it is likely that the children will combine the groups of objects prior to capturing the total objects.

Conclusion and Implications

Despite the challenges that occurred when operating the digital cameras, the children succeeded in producing photographs to complete the given tasks. This successful use of digital cameras and the composition of good photographs by these young childrensuggested that with proper support, instruction, and preparation, young childrencan becomegoodusers of technology tools and are capablephotographers.

The creation ofphotographs for the addition story exhibited the children's early understanding of the addition concept. The findings from this study are in agreement with various studies whichsupported the notion that addition concept is mainlyestablished from children's everyday experiences and informal knowledge of addition, including counting various collections in their surrounding environment. Hence, children may require guidance, direction, and support from the teacher to develop further understanding of the addition concept. Moreover, it is essential to afford children with rich experiences and ample practices to help build their knowledge, skills, and understanding of addition.

More research is required to determine effective instructions, learning environment, and tools, as wellas experiences that will cultivate young students' capability in creating and using mathematical representations to support meaningful learning and effective problem solving. Furthermore, the various responses from a single group of children demands for a teaching and learning approach that could be tailored to address individual differences and help enrich the children's skills and knowledge, hence, preparing them for future learning and life.

Acknowledgment

This research was supported by grants provided by the Faculty of Education, Universiti Kebangsaan Malaysia (GGPM-2019-011) and (GG-2019-061).

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