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Young Children's Photographs of Addition in the School Environment

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Abstract
Young children often face difficulty in acquiring Mathematics concepts. This study examined how photograph assist young children to understand the concept of early number and engage in addition activities within classroom learning. The study employed case study research design and involved six children (aged six years) in one preschool centre. Data was collected using observation, informal interviews and analysis of photograph produced by the focus group whilst engaged in various addition activities. The findings showed that photographs function as visual mathematical representations that facilitate and reinforce young children's understanding of addition concept. The study implicated that young children's creation of visual mathematical representations is an essential learning approach among young children and could be best assisted by the use of information technology and communication applications.

Introduction
Representation is vital in teaching and learning mathematics. Mathematics educators worldwide utilize various forms of representations including physical and virtual manipulatives, number lines, pictures, written and spoken symbols (Ahmad, Tarmizi, & Nawawi, 2010; Elia, Gagatsis, and Demetriou, 2007). As a result, students use various types of representation to access mathematical ideas and solve mathematical tasks. The study by Mohamed & Johnny (2010) reporting on students' heavy reliance on a particular form of representation (i.e. symbols) raise concern among mathematics educators; because researchers strongly put emphasis on the link between children's facility in a variety of representation and their mathematical understanding (Lesh, Post, & Behr, 1987).
Research highlights the positive impacts of multiple representation use (including physical, verbal and written symbols) in mathematics teaching and learning: by supporting communication of mathematical thinking, understanding of concepts and the solving of various mathematic problems (Elia et al., 2007). Despite the positive function of multiple representation use as reported in a number of studies, little is

reported about visual representations created in early year's mathematics (Crespo & Kyriakides, 2007; Woleck, 2001) particularly with regards to the use of photographs that gave insight into young children's understanding of addition concepts.

Research Background

Zarzycki (2004) indicate the importance of visualization in teaching and learning mathematics. "We could not even imagine introducing many mathematical concepts without illustrating them by pictures, drawings, graphs, etc." (Zarzycki, 2004, p. 108), especially to young children who are more visual than adults. Presmeg (2006) suggested that visualization involves the creation of visual images which guide the creation of mathematical representations.

The advancement of technology enables both teachers and students to benefit from technology (Lokman, Nasri & Khalid, 2019; Khalid, Karim & Husnin, 2018; Ruhil Amal, Nor Fariza & Affendi, 2017; George & Archontia, 2013; Khalid, Nawawi & Roslan 2009). In particular, technology assisted learning has been found useful to enhance children's learning (Bakar & Nasri, 2018). For example, digital cameras, which offer an aid to the quick generation of visual images when teachers incorporate them into instruction and children utilize them to explore various mathematics concepts. The purpose of including visualization with technology in classrooms is to provide visual representations that facilitate communication about important mathematics concepts to help students develop deeper understanding. Since this technological device is associated with many special features, it offers unlimited opportunities to be integrated into the learning environment to help students "see the beauty and excitement in mathematics" (Cuoco & Curcio, 2001, p. xiii)

A large number of studies related to digital camera usage, photography and visual imagery in the early learning environment have documented that integrating photographs with learning has positive impacts on children. For example, combining photography with literacy is helpful in developing language and literacy skills (Britsch, 2010; Byrnes & Wasik, 2009; Marinak, Strickland, & Keat, 2010). Researchers found that photographic activities encouraged meaningful discussion (Marinak et al., 2010) and led students to use longer sentences to describe pictures (Britsch, 2010). Therefore, more studies using digital cameras should be conducted to identify their utility in other subject areas.

Researchers are increasingly encouraging various photographic activities to enhance learning of mathematics among students of all ages (Bragg & Nicol, 2011; Furner & Marinas, 2012; Northcote, 2011; Orr & Suh, 2013). Problem-posing and problem-solving using photographs helped develop students' awareness of mathematics in everyday objects around them as they were searching for images to create the questions and problems (Bragg & Nicol, 2011; Orr & Suh, 2013). In fact, capturing outdoor images is a useful way to bring the mathematics found outside of the classroom into the learning space. Such activities provide a more meaningful way to make useful links between mathematical concepts and objects in the surrounding areas (Northcote, 2011) rather than being dependent on teachers to show the connection (Furner & Marinas, 2012). Exploring mathematics through photography permits students to realize and understand that mathematics is related to their everyday lives (Bragg & Nicol, 2011), therefore, enabling students to experience the

beauty of mathematics (Cuoco & Curcio, 2001). Moreover, photos captured by students are often familiar objects found within their educational setting, thereby lessening the cognitive load related to understanding unfamiliar objects. Photography provides great opportunities for children to be active and explore the objects as well as various everyday phenomena in the environment. Further, the photo-taking activities can assist in making learning relevant and natural to the children. In taking their own photos, they are deciding what is important and constructing their own meaning of their experiences (Piaget, 1955). This is important in providing them with the opportunity to optimize their learning experiences. These experiences are imperative in the process of learning mathematical concepts.

Researchers emphasize the importance of developing children's arithmetic skills in the early years of instruction (Patel & Canobi, 2010; Resnick, 1992). Skills learned in the early years of school are important knowledge for use in many aspects of everyday life as well as for use in future learning and life. Children's early counting experiences provide an important base towards understanding addition concepts (Gelman & Gallistel, 1978). Since teachers reported that their pre-schools' children faced difficulties understanding the addition concept and continued struggling with this basic operation in Year One (Tyng, Zaman, & Ahmad, 2011), it is important to discover if visualization can help facilitate understanding of the addition topic in similar ways that it facilitates students understanding of other topics such as geometry.

The Study

This study aimed to examine how visual mathematical representations assist young children to understand the concept of early number and engage in addition activities within classroom learning. The study was underpinned by the significance of visual representation in mathematics learning and the necessity to use technology tools in classroom learning of young children. Although researchers have been investigating children's representation usage for mathematics learning, researchers have focused mainly on examining either a particular form or neglected the utilization of visual representation. Furthermore, the inclusion of technological tools in this study (digital cameras) is essential to equip children with new and dynamic ways of learning and being prepared for the challenges of life in the 21st century.

Specifically, the study explored the ways in which young children used photographs to portray addition concepts by addressing the following research questions:

1. How do young children use photographs to represent numbers and addition concept?
2. In which ways and to what extent do young children's photographs portrayed their understanding of numbers and addition?

Methodology

This study was conducted in a 'pre-school' in Malacca, Malaysia. Six children (aged six years old) from the same classroom were selected to participate in this study. The researcher worked only with this group of children throughout the study, and the teacher continued lesson with the other children. For the past two months, the children had been learning how to count. They had not been taught the concept of

addition. For this study, the researcher acted as the teacher to this focus group. At the beginning, the researcher introduced and modelled the addition processes using concrete materials. Then in the practice task, the children together with the researcher modelled addition situation using various objects. Next, the children were prompted to produce photographs that represent their ideas relating to addition concept. By prompting the children to represent their own meaning of addition through photographs, children were actively exploring and building their own understanding rather than passively receiving knowledge from the researcher. As Goldin and Shteingold (2001) state, internal and external representations are linked to each other, and internal representations may be inferred through their externalization - in this study, in the form of photographs.

Based on the constructivist theory of learning, children were provided with the experience of communicating their mathematical ideas using the photos they captured in the school surrounding. Digital cameras were introduced to the children as a quick and easy way to produce photographs; an alternative visual representational form. Having digital cameras in the classroom was a completely a new experience for the children. They were given ample opportunity to familiarize themselves with photographing various objects. Children were asked to practice framing objects and taking pictures. Having shown some improvement in taking pictures, they were asked to represent the quantity 'three' visually. Next, children were required to take photos to represent addition situation that they created themselves or found in the surrounding. There was no limitation on the number of photos taken and no restriction on subjects to photograph.

During the children's search for subjects to be included in their photographs, the researcher directly observed what the children were doing and took notes of what was happening. At certain times, the researcher followed the children to different locations and asked questions about what they were looking for and the plans they had. A large part of the data collection for this task was the photographs taken by the children, as these photographs were evidence of the children's ideas about addition.

Data collection included observations, artefacts (children's photographs), field notes, conversations with children, and video recording. Initially, children's photographs were analysed. Video analysis of children during the photographing processes exhibited different ways of manipulating and counting the objects to represent numbers and addition concept. Observation of children during the photography activities as well as conversation with them helped clarify the thinking involved for completing the task. The data were summarised and organised by compiling a table annotating each child's photographs and behaviours, together with the events and associated talk that informed their thinking relating to numbers and addition. By using such tables, a child's photographs could be linked across various data that provide detail information about his/her photographs. Also, the table allowed for comparison of photographs and thinking among the children. The photographs, together with the processes involved provided rich picture about the children's understanding of numbers and the concept of addition.

Findings

Digital cameras were introduced to the children to provide them with a new and different way of visual representation. Through the photographing activities, the children's perspectives of number and addition were explored.

How do young children use photographs to represent numbers?

It is important to note that the children had experience representing various numbers (quantities) concretely, hence their visual representations using digital cameras were influenced by their experiences using the previous form of representation. In photographing the quantity 'three' as requested by the researcher, all children had similar images for their first few photos. As can be seen in Figure 1, they simply used the materials they had worked with previously. Both Norman and Aimy took the cubes they worked with during the practice task, placed them on the mat and had them captured (refer Figure 1a). Similarly, Qaisya and Ali captured their three cubes (refer Figure 1b). While Norman and Aimy photographed their construction after moving it to a preferred location, Qaisya and Ali captured it at its original place. Like other children, Nadia's and Rozy's pictures were restricted to the linking cubes that corresponded to the quantity. Both did not photograph their previous construction but chose to make a new one. They took three cubes from the basket, attached them to each other horizontally and captured the construction (refer Figure 1c). She photographed another picture to represent the quantity by repeating the same procedure, but linking them vertically using different colored cubes. They varied their construction of the cubes, but the quantity of cubes remains to correspond to the requirement of the task.

(a) Capturing 3 cubes used previously (by Norman and Aimy)

(b) Capturing 3 cubes previously constructed (by Qaisya and Ali)

c) Capturing 3 cubes linked horizontally (by Nadia and Rozy)

d) Capturing 3 cubes linked vertically (by Nadia and Rozy)

Figure 1: Photographing 'three' cubes

While all children had the cubes as the only concrete materials to represent the required quantity, Ali and Qaisya photographed an additional object for the task.

Qaisya pulled out three pencils from her case (refer Figure 2), placed them carefully on the table and pressed the shutter release button.

Figure 2: Photographing other objects to represent 'three' (by Qaisya and Ali)

In which ways and to what extent do young children's photographs portrayed their understanding of numbers and addition?

The children were required to take photos that represented addition concept. Despite most children were restricted to using cubes to represent quantity, the selection of subjects to photograph for the addition task varied among them. While some children manipulated physical materials that they were familiar with, other children chose to use new objects to complete the task (refer Figure 3). Norman and Rozy chose items they had been working with previously. Norman used coins as his subject (see Figure 3a), while Rozy linked cubes together to make buildings she defined as hotels (refer Figure 3b). Qaisya and Aimy selected picture cards (ice cream picture cards) made by the researcher (see Figure 3d and 3f). Nadia and Ali found kernels on the ground when walking around the school and decided to include them in their photographs (see Figure 3c and 3e).

a)Capturing 4 coins (first addend), 2 coins (second addend) and 8 coins (total) – by Norman

b) Capturing 4 cubes (first addend), 4 cubes (second addend) and 8 cubes (total) -by Rozy

c) Capturing 7 kernels (4 kernels as the first addend and 3 kernels as the second addend) –by Nadia

d) Capturing 3 ice creams (1 ice cream as the first addend and 2 ice creams as the second addend) - by Qaisya

e) Capturing 2 kernels (1 kernel as the first addend and another kernel as the second addend) –by Ali

f) Capturing 4 ice creams (first addend), 2 ice creams (second addend) and 6 ice creams (total) – by Aimy

Figure 3 Photographs captured by children to represent addition situation

When photographing pictures for the addition concept, the majority of the children first manipulated the objects and later captured what they had created. They often acted on the objects in order to form the quantities necessary for the addends as well as the totals. The children sometimes moved the objects and relocated them in other places. This happened when a child needed to extract a number of objects from its group to arrive at a particular quantity. On other occasion it was necessary to combine the objects to form a quantity. For example, Norman took four coins from the basket and then lined them one by one in a row. He then took another two coins and carefully placed them beside the first row he created previously, leaving a gap between the two lines (see Figure 3a). Rozy took out some linking cubes from a basket and simultaneously counting "1,2,3,4", linking four cubes together to build a structure. She grasped the same number of cubes, counting "1,2,3,4" and built a similar structure. After she successfully manipulated the objects to form the addends, she *counted all* to get the total "1,2,3,4, …5,6,7,8",…. "8". After feeling satisfied that she had created the correct addition situation, she photographed her creations (refer 3b). Nadia, Qaisya, Ali and Aimy manipulated the physical materials in the same manner as the previous children. While both Nadia and Qaisya did not provide any obvious counting gestures, Ali and Aimy counted loudly their first addend, continue *counting one-by-one* the second addend and *counting-all* to ensure the correct total. They photographed each creation after manipulating the objects to form the first addend, then the second addend, and finally the total. It is important to note that all children included appropriate context for addition and a correct answer. They also used a variety of contexts involving real-life examples for their stories.

Discussion of Findings

The findings from the data indicated that the young children's use of representations provided insights into their understanding of numbers and addition concepts. The photography activities that required the manipulation of various objects had facilitated their understanding of numbers and addition.

Because understanding could not be easily defined, it was inferred through their creation and use of representation. As the children's construction of representations reflected their internal representation, it is appropriate to determine their understanding based on what they created.

Representation of Numbers and Addition

The children's manipulation of concrete objects during the construction of various quantities during the photographing process provided evidence of their understanding of quantity. When creating sets of items using various concrete materials, the children demonstrated the one-to-one principle as they pointed to each manipulative and simultaneously verbalized the number names. The children's concrete construction of quantities reflected their understanding of cardinality, in which the last number represents the total quantity (Batchelor, Keeble, & Gilmore, 2015). By imaging the quantities both as a set of objects as well as in a line, the children knew that the final number of the set indicates the total number of objects (i.e. expressions of cardinality).

Throughout the study, the children showed a stable understanding of quantity. In working with concrete materials, they had no difficulty in representing small numbers (below 10). The construction of quantities in different formation (objects in a line and in groups) provided further evidence of their stable understanding of quantity.

Children's Early Understanding of Addition

As this study focused on children's conceptual understanding rather than procedural knowledge, it is important to clearly sort evidence of concept formation. The children's behaviors that followed their counting helped to determine whether they simply completed the tasks by following a few steps or whether their constructions came with conceptual understanding.

The results of this study demonstrating that the children had an understanding of addition, is consistent with those in the study conducted by Hughes (1981), which suggested that young children have the ability to perform simple addition prior to formal instruction. Similarly, Ibarra and Lindvall (1982) reported that kindergarten children are able to perform simple addition prior to formal education. It is clear that, regarding the process of addition, the children in this study had some procedural knowledge related to the concept. Furthermore, they may also possess conceptual knowledge of addition, especially involving small quantities. It is likely that their everyday experiences have contributed to this initial knowledge. As asserted by Anghileri (2000), everyday situations that involved manipulating objects (while counting) have helped children to develop knowledge of addition. Providing the children with further addition exploration using digital cameras to photograph addition situation in the surrounding indeed beneficial in their understanding of addition.

Counting-all to Add

Since counting is the key foundation in performing and understanding addition (Baroody, 1987a), and since counting and adding are interrelated when performing addition, it is equally important to differentiate between the two mathematical actions in this study to be able to identify children's understanding of the concept of addition.

As Butterworth (2005) asserts, counting forms a basis for arithmetic skills. Moreover, counting activities that involve children in combining sets of objects and counting them to find the sum, is helpful in building students' understanding of addition as an incrementing process (Baroody & Wilkins, 1999). Furthermore, as highlighted by

Eisenhardt et al. (2014), 'counting is a developmental foundation for fluent addition' (p.501) and children will gradually be able to build on concepts and skills from meaningful counting activities. As observed in this study, the children's ability to *count-all* the objects to find the total is not surprising, as Hughes (1981) asserts, children come to school with addition knowledge. They already have an intuitive understanding of addition, as did the children in this study.

Despite the construction of a variety of real objects, the children's constructions alone did not completely exhibit their thinking regarding addition. Hence, their verbal counting that accompanied the construction was analyzed. As both counting and adding involved finding the cardinality of a set of objects, children's verbal counting would be helpful in determining whether the children were merely counting, or whether they counted to add the objects. The children were observed to be employing *counting-all*, in which they started counting from the first group, then followed by counting the second group, and finally obtained the total (e.g Rozy, Ali and Aimy). This addition strategy showed some signs of addition knowledge. Evidently, the children did not merely count, but they counted to add. As identified by Siegler and Jenkins (1989), there are eight strategies used by young children to solve addition, in which five of them involve counting. Considering that the children had only recently introduced to addition, it is possible that they began with *counting-all* and used this strategy on almost all occasions, as this is one of the simplest strategies used by young children (Baroody, 1987b).

Conclusion, Implications and Recommendations

This study explored how photographs assist young children acquire understanding of early number and engage in addition activities in the school environment. The study found that students' capability of making sense of addition concepts is enhanced through the creation of visual representation assisted by technology tools. The study also identified that photographs provide insight into both children's stability in understanding of quantities and basic addition strategy and principles. The study further highlighted the importance of valuing and supporting the early development of children's creation of visual mathematical representations to facilitate their understanding of mathematics concepts. The findings from this study clearly shows students' capability of making sense of addition concepts through creating visual representation (with the help of technology tool). The exploration of children's representations of numbers and addition demonstrated important aspects of the children's knowledge. The findings of this study demonstrate that the children's knowledge of numbers was critical for their understanding of the concept of addition. Encouraging the children to explore mathematics in a broader surrounding (i.e. outside the classroom) had widened the children's thinking. Their understanding of quantity extended, from being limited only to objects they manipulated previously to quantifying other real objects found in the surroundings. For the concept of addition, the manipulation of concrete materials facilitated their early understanding of addition. As they explored and manipulated more objects found in the surrounding, the children slowly demonstrated greater knowledge of addition. Although the findings demonstrated that children possessed an early understanding of addition (as evidenced by their limited strategies and addition principles), this is valuable

knowledge that demonstrates a good basis on which to build as the children had only recently been introduced to the concept of addition.

This study has implications for the constructivist theory of learning. The children's active self- exploration of the learning environment permitted the children to make sense of the addition concept rather than receiving the knowledge passively. Further, the act of manipulating various objects in their surroundings helped facilitated children's understanding of addition. There is a need for curriculum developers and classroom teachers to apply constructivist learning theory in the development of Mathematics learning content, approaches and assessment for young children.

The findings from this study showing students' capability of making sense of mathematical concepts through creating visual representation (during photography activities) has implications for the way teachers teach and assess arithmetic in classroom learning. Children might be in disadvantages when instructions or assessments relied on one particular representation form (i.e. symbols). What about children who have not yet transitioned to the abstract level, who require alternative representation forms? (e.g. able to explore, grasp and communicate concepts better with the help of visual form). Hence, teachers should attend to the differences in knowledge, skills and learning styles in order to help children gain the most in learning as well as understanding. It is a common practice among Malaysian teachers to employ traditional instructions such as emphasis on use of symbols, more focus on correct solutions in problem-solving than on strategies and processes, and expecting children to follow the representations and strategies demonstrated by teachers with little encouragement for children to develop understanding themselves using multiple ways. However, according to the recent Malaysian curriculum document for pre-school education (i.e. The National Standard Preschool Curriculum), children are expected to develop their own understanding and make sense of mathematical concepts through real life examples.

Additionally, various learning approaches that are assisted by latest information technology and communication tools are suggested to aid the teaching and learning process of preschoolers including meaning-making and developing concepts with the help of various representation forms using various application available on the internet to prepare children towards the 21st century learning.

Future research should include teaching intervention that supports students in choosing and then using various forms of representation effectively, taking into consideration the influence of classroom culture. This is particularly important in the Malaysian context, since many aspects of Malaysian children and teachers' daily life (including classroom practices) are tied to culture, and hence have implications for both the teachers' instructions as well as the children's learning.

It is also hoped that this study will encourage teachers to examine their current practices particularly involving the use of representations and how they can expand on that use, so that both teachers and students in mathematics classrooms see representations as a frequent occurrence and learning means, and hence obtain optimum benefits from representation use.

An important note is that both teachers and students should value all forms of mathematical representation, for teaching and learning, as it is helpful to use as alternative form when learning new mathematics concepts. For students to be

successful in mathematics they need to make sense of the mathematical concepts, and effective use of representations assists students to comprehend and solve mathematical tasks successfully.

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