**ME - 17**

# MENTAL COMPUTATION STRATEGIES BY 5TH GRADERS ACCORDING TO OBJECT-SPATIAL-VERBAL COGNITIVE STYLE

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**Abstract**

The purpose of this study was to investigate mental computation strategies by fifth grade elementary students with different cognitive style (object-spatial-verbal). Seventy six fifth grade students in one of elementary school in Jember (Indonesia) participated in this study. All of the students were tested on Children's Object-Spatial Imagery and Verbal Questionnaire (C-OSIVQ). Nine children were chosen, based the test result, as subjects of the research. They were classified as 3 students with object imagery, 3 students with spatial imagery, and 3 students with verbal ability. The students were tested in a oral mental computation test. The test contains 15 items for additions, subtractions, multiplications, and divisions in whole numbers, fractions, and decimals. Findings were analyzed with qualitative methods. At the end of the research, students with spatial imagery achieved much better results than object imagery and verbal ability. When computation strategies were analyzed, it was found that the students with verbal ability were heavily influenced by written algorithm meanwhile students with object and spatial imagery used more variety ways and efficient strategies in performing mental computation.

**Keywords :** mental computation, thinking strategies, 5th graders, cognitive styles.

## 1. INTRODUCTION

Mental computation is a process of producing an exact answer to a computational problem without any external computational aid (Reys, 1986). The benefits of mental computation are numerous and cover student's thinking, creativity, and problem solving skills (Reys, 1985; Reys 1984). Furthermore, children who encouraged to formulate their own mental computation strategies, they learn how numbers work, gain a richer experience in dealing with numbers, develop number sense, and develop confidence in their ability to make sense of number operations (Reys, 1984; Kamii & Dominick, 1998). Mental computation also emphasis as computational strategies that student should develop over the years of schooling (NCTM, 2000).

Despite the fact that mental computation is important, a study revealed that elementary students in Indonesia have a greater tendency to use standard written algorithm (Herman, 2001). There is a little research base, however, that describe mental computation strategies of students from individual perspective. The ways of individuals react to different situations can be identified as cognitive style. Cognitive style describes consistencies in using cognitive processes. This include stable attitudes, preferences, or habitual strategies that distinguish the individual styles of perceiving, remembering, thinking, and solving problems (Saracho, 1997). Some study revealed the relationship between various cognitive style dimensions and mathematics learning (Shi, 2001; Spagnolo & Paula, 2010). Cognitive style can be considered to understand children's differences and to use the understanding to improve the learning activities provided to children (Saracho, 1997).

When children compute mentally, they are recognizing symbols such as numbers and operation signs. They will visualize it or form mental images in their head. The kind of cognitive style that related to these were called cognitive style visualizer-verbalizer. A recent study proposed a new three-dimensional cognitive style model of visualizer-verbalizer cognitive style (Blazhenkova & Kozhevnikov, 2009). This study developed on the basis of modern cognitive science theories that distinguish between object imagery, spatial imagery and verbal dimensions. Other studies (Anderson, et al, 2008; Kozhevnikov, et al 2002; Chrysostomu, et al, 2013) examined the effects of students' cognitive styles on their mathematical learning, using a new approach to the visual-verbaliser cognitive style dimension.

On the contrary, there is lack information of students mental computation strategies related to their cognitive style. Because of this limitation, what are the strategies employed by object visualizers, spatial visualizers and verbalizers in mental computation test? Through this research, the question would be answered. Thus, the aim of this current study was to describe elementary students strategies in mental computation, include their differences and strategies. This study would consider students cognitive style to explore their mental computation strategies. This perspective is expected to understand students differences and use this to improve teaching and learning activities.

## 2. RESEARCH METHOD

### 2.1 Design Research

This research use qualitative research that describe mental computation strategies of elementary students with cognitive style. The researcher used Children's Object–Spatial Imagery and Verbal Questionnaire (C-OSIVQ), mental computation test, and interview to investigate the description.

### 2.2 Subject of the Study

The participants in this study were seventy six students from two classes of grade fifth students in Muhammadiyah 1 Elementary School Jember, East Java. Nine students were chosen, based C-OSIVQ result, as subjects of the research. They were classified as 3 students with object imagery, 3 students with spatial imagery, and 3 students with verbal ability.

### 2.3 Procedures

Seventy six fifth grade elementary students who were studying at the Muhammadiyah 1 Elementary School Jember participated in the study (47 boys and 29 girls). A self-report cognitive style questionnaire were administered to all the participants. The questionnaire was used to measure participants' spatial, object and verbal cognitive styles. The children were given this questionnaire during school-time. They were given approximately fifteen minutes to complete the questionnaire. For each participant, the fifteen item ratings for each factor were averaged to create object imagery, spatial imagery and verbal scale scores. Based C-OSIVQ result, nine students classified as 3 students with object imagery, 3 students with spatial imagery, and 3 students with verbal ability. Then, mental computation test were administered to these students to elicit the use of mental strategies. The subjects were individually interviewed concerning their strategies in mental computation. The interview of each subject was conducted by the researcher in a class during regular school days. All the interviews were recorded on tapes and summarized in document scripts analysis. All of the interviews which had been tape-recorded were transcribed and categorized in such a way that was appropriate for interpretation.

### 2.4 Instrument

#### 2.4.1 Self-Report Cognitive Style Questionnaire

The self-report cognitive style questionnaire, which was a translation of the Children's Object-Spatial Imagery and Verbal Questionnaire (C-OSIVQ) (Blazhenkova, Becker and Kozhevnikov, 2011) was used to assess participants' cognitive style in respect to spatial, object and verbal cognitive styles. Participants were asked to read 45 statements and rate each item on a 5-point Likert scale. The response choices are strongly disagree (1 point), disagree (2 points), cannot decide (3 points), agree (4 points), and strongly agree (5 points). Fifteen of the items measured object imagery preference and experiences, fifteen items measured spatial imagery preference and experiences and fifteen items measured verbal preference and experiences. The items assessing object-imagery cognitive style included statements about vividness of mental imagery, photographic memory, preferences for painting with colours, ease of image maintenance, and elicited imagery (for example "When reading a book, I can usually imagine clear, colourful pictures of the people and places". The items assessing spatial-imagery cognitive style included statements about 3D geometry, schematic mental imagery, mechanical inclination, and spatially intensive games (for example "I am good at solving geometry problems with 3D figures". Verbal cognitive style items were statements referring to the speed of reading, ease of writing, fluency in expressing thoughts and ideas verbally, and storytelling (for example "I am good at expressing myself in writing" (Blazhenkova, Becker, & Kozhevnikov, 2011: 282).

#### 2.4.2 Mental Computation Test

Mental computation test is the adaptation of mental computation test that constructed by Yang (1997). This test contained 15 items for the four operations (addition, subtraction, multiplication, and division), including whole numbers, fractions, and decimals. The mental computation test individually administered by the researcher/instructors with twenty second intervals per item. The oral items were read twice with a short pause (2-3 seconds) between readings followed by a 20 second waiting period between items to let students answer the questions (Reys, 1985). Test administered orally because it is expected that oral test can invite student to use invented mental algorithm than written test (McIntosh, Nohda, Reys, and Reys, 1995). Students were given an answer sheet and not allowed to record anything except the exact answer.. The examiner was read the general instructions aloud for the MCT and answer any questions from students. Students were advised to listen carefully because each oral question will be read aloud and repeated only once. Immediately after these instructions, one practice questions were provided.

#### 2.4.3 Interview

A semi structured interview was provided in the study. The interview was used to gain deeper insight into the kinds of mental strategies and factors that possibly effected strategies. The interview concerned with students strategies in mental computation. Fifteen items of interview were directly drawn from the mental computation test. The items represented all the four operations, including whole numbers, fractions, decimals, and percent. Each interview item was followed by six questions about students mental strategies in performing that item.

## 3. DATA ANALYSIS TECHNIQUE

Transcriptions was elicited from recorded interviews and summary in the document script. This made to make categorization of each strategies that used by each subject when compute mentally. This transcript will categorized for interpretation and the result will discussed further with the teacher as an advice.

## 4. RESULTS

In order to assist analysis and discussion, the variety of students procedures in computing mentally is categorized into two group of strategies: the first on addition and subtratction, and the second on multiplication and division.

### 4.1. Strategies on Addition and Subtraction

To the addition and subtraction items which were found mental image of paper and pencil strategies. This method were like paper and pencil algorithm but were done mentally without paper and pencil. The process of computation was usually showed digit by digit from right to left or left to right. This strategy was used by all students with verbal ability and one student with object imagery. The transcripts presented in Extract 1 illustrates the mental image of paper and pencil strategy of student with verbal ability.

Extract 1

| | | |
|---|---|---|
| Researcher | : | Can you tell me the answer for thirty three plus ninety nine? |
| Aida | : | One hundred……, thirty……., two. |
| Researcher | : | Are you sure it is correct? |
| Aida | : | Yes, thirty three. |
| Researcher | : | Can you explain what you did? |
| Aida | : | Yes, three plus nine is twelve, we write two and put one. Then, three plus nine is twelve, twelve then plus one become thirteen. Twelve means one hundred and thirty two. |

Other students with spatial imagery and two students with object imagery used different strategy that categorized as the grouping by hundreds, tens, ones, etc. This strategy was used by separating the numbers into part-whole relationships such as hundreds, tens, ones, or decimals/factions. The computation was done by adding or subtracting the relevant part-whole relationships from left to right or from right to left, and then joining the parts again at the end of the process. For example, to solve 33 + 99 was done by thinking 30 + 90 = 120, 3 + 9 = 12, 132. This strategy also performed when students solve addition item in decimal. The same student used grouping by hundreds, tens, ones, etc to solve this item, though student with object imagery have incorrect answer. Students with verbal ability and two students with object imagery used mental image of paper and pencil strategy. The transcripts presented in Extract 2 illustrates the grouping by hundreds, tens, ones, etc strategy of student with spatial imagery.

Extract 2

| | | |
|---|---|---|
| Researcher | : | Can you tell me the answer for two point five plus three point seven? |
| Rivan | : | Six point two. |
| Researcher | : | Are you sure it is correct? |
| Rivan | : | Yes, six point two. |
| Researcher | : | Can you tell me what you did? |
| Rivan | : | Yes, five plus seven is one point three, then added to two and three |

which is six point two.

### 4.2. Strategies on Multiplication and Division

To the multiplication and division items which were asked in the interview, there were found three strategies and categorized as mental image of paper-and-pencil, double or half, and multiple compatible factors. Students with verbal ability used mental image of paper and pencil to solve these items whereas 1 student with object imagery used double or half strategy and 2 students with object imagery used multiple compatible factors strategy. The process of calculation of double or half strategy was done by doubling one factor and halving the other to provide a "nice" number. For example, $16 \times 35 = 8 \times 70 = 560$. The students who used multiple compatible factors strategy to solve the problem by factoring and then regrouping to develop numbers that are easier to work with. The transcripts presented in Extract 3 illustrates the multiple compatible factors strategy of student with object imagery.

Extract 3

| | | |
|---|---|---|
| Researcher | : | Can you tell me the answer for eight times fifty? |
| Naufal | : | Four hundred. |
| Researcher | : | Are you sure it is correct? |
| Naufal | : | Yes. |
| Researcher | : | Can you tell me what you did? |
| Naufal | : | Yes, two times fifty is a hundred, then a hundred times four is four hundred. |

Students with spatial imagery tend to use multiple compatible factors strategy for this problem, though they realize this item could solve by using other strategies. They thought that this strategy more efficient than others.

## 5. DISCUSSION

The first aim of this study was to describe elementary students strategies in mental computation. First, the findings of this study showed that students with spatial ability used different strategies almost on each items. They would choose the effective strategies to get an exact answer. This result is in accord with previous research studies Anderson, et al (2008) and Kozhevnikov, et al (2002) which found that the spatial cognitive style is beneficial for mathematics. Secondly, it was found that students with object imagery also used non-standard algorithm for few items and used mental image of paper and pencil for the rest. Thirdly, students with verbal ability had a greater tendency to use mental image of paper and pencil. When researcher was trying to explore more about other strategies, they were stucked with paper and pencil algorithm. Furthermore, students strategies in performing the task reflects their understanding and familiarity with number and its operations. The students with spatial imagery showed that they can explore more their knowledge of number properties and numerical operations.

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