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Research Article

Exploring the combinatorial reasoning of high school students with reflective and impulsive cognitive style in solving problems

Nurul Aini[1], Dwi Juniati[2], Tatag Yuli Eko Siswono[3]

Department of Mathematics, Universitas Negeri Surabaya, Indonesia

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Abstract

Combinatorial reasoning was a basic competence that every student must have for solving mathematical problems, as it highly related to providing argumentation or strategy in solving mathematical problems. It was the process of creating complex constructs out of a set of given elements that satisfy the conditions explicitly given or inferred from the situation. Considering this issue, this study aimed to explore the combinatorial reasoning of high school students with cognitive-reflective and -impulsive styles in solving problems. More specifically, It correlated combinatorial reasoning with tempo cognitive style, since it applied time-based problem solving in which the speed of responding and the frequency of either correct or wrong answer might affect students' mental action in solving problems. This study was a qualitative research. It used High school students in eleventh grade as the research subject through matching familiar figure test. The researchers distributed a task containing several problems that had similar concept for each and then organized an interview to explore the students' combinatorial reasoning in solving the given problems. Cognitive-reflective subject decided to use two strategies –formula and filling slot- for the sake of her affirmation, while cognitive-impulsive subject decided to only use one strategy –formula. The cognitive-reflective subject tended to be more accurate and careful in solving the problems. Otherwise, the cognitive-impulsive ones tended to be careless and less accurate, given that the subject decided to do spontaneous mental action. The result of this study found some similarities and differences on the combinatorial reasoning of both reflective and impulsive students. The similarities referred to their ways in explaining the notation in the formula they used and generalizing their strategies. The differences referred to the process of investigating various factors, considering any probabilities that might reveal, and evaluation.

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Introduction

Mathematical problem solving in class puts more emphasis on its result rather than the process of reasoning by students (Sumaji et al. 2020). However, reasoning is fundamental as the objective of learning mathematics (Kemendikbud, 2014; NCTM, 2000). Reasoning is the process of combining past experiences to solve problems, and not merely reproducing problem solving. It is also an analysis that gives a careful, systematic reason for each organizational function, further reasoning is treated as logical knowledge (Lahey et al. 1995; Rosdiana et al. 2019; Palengka et al. 2019; Rosida et al. 2018; Syukriani et al. 2017). One kind of reasoning is combinatorial reasoning. Combinatorial reasoning is the process of creating complex constructs out of a set of given elements that satisfy the conditions explicitly given or inferred from the situation (Csapo &Adey, 2012). It is thinking logically in making a list of results or using the principle of multiplication or recursive operation system to identify any possible results and

[1] Doctoral Program Student of Mathematics Education, Universitas Negeri Surabaya, and STKIP PGRI Jombang, Indonesia, E-mail: nurulaini10@mhs.unesa.ac.id. Orcid No: 0000-0003-2515-0788
[2] Department of Mathematics, Universitas Negeri Surabaya - Indonesia, E-mail: dwijuniati@unesa.ac.id. Orcid No. : 0000-0002-5352-3708
[3] Department of Mathematics, Universitas Negeri Surabaya – Indonesia, E-mail: tatagsiswono@unesa.ac.id Orcid No. : 0000-0002-7108-8279

generalize strategies to solve another combinatorial problem (Ersari, 2015). Combinatorial reasoning is a logical thought of connecting formulas, process of counting, and set of results. Formal is a mathematical statement that results in numeric scores commonly called answers for problems of counting. Process of counting is a process to solve problems of counting. Set of results is the list of counted results, and this can be organized in such a way to reflect the process of counting applied (Lockwood, 2018).

Many researchers have suggested that combinatorial reasoning is important for its relation to providing argumentation and strategy to solve mathematical problems; however, it is still poorly researched (Lockwood, 2015; Shin & Steffe, 2009). In addition, combinatorial reasoning is a base of probabilistic thought and the idea of basic mathematics (William, 2012). Hence, it is vital to study this issue, since combinatorial reasoning is a basic competence that every student must have to solve mathematical problems and give them access to easily understand the other mathematics courses, and this corresponds to the objectives of learning mathematics. Piaget put combinatorial reasoning into formal operation phase (i.e., 12 years old up). High school students are in this phase, and thus, they should have had logical and abstract thinking.

This study correlated combinatorial reasoning to tempo cognitive style, since it applies time-based problem solving in which the speed of responding and the frequency of either correct or wrong answer may affect students in solving problems. Some studies found that many students felt difficult in solving combinatorial problems, in particular to enumeration, due to their less accuracy (Lockwood, 2011). Furthermore, cognitive-reflective and -impulsive styles are two cognitive systems that combine the time of making conclusion with performances in solving problems (Rozencwajg & Corroyer, 2005). In the process of solving problems, one competence that every student must have is combinatorial reasoning, for its close relation to making strategy to solve mathematical problems (Shin & Steffe, 2009).

Problem of Study

Combinatorial reasoning, cognitive-reflective and -impulsive styles hold an important role to solve mathematical problems. Cognitive reflective and impulsive styles are cognitive systems that combine the time of making conclusion and performance in the process of solving problems. Through combinatorial reasoning, students enable to define and make an appropriate strategy to solve mathematical problems. An appropriate strategy may help students to solve problems. Problem-solving and reasoning are two crucial aspects of the objectives of learning mathematics. Nevertheless, current learning still put more emphasis on result rather than its process. In addition, cognitive style remains unnoticed yet.

Therefore, this study aimed to explore the process of combinatorial reasoning of high school students with cognitive-reflective and impulsive styles in solving mathematical problems. Based on the information that has been explained, the problem in this study is how is the profile of combinatorial reasoning of high school students with reflective and impulsive cognitive style in solving problems?

Method

Research Design

This study is an exploratory research with qualitative approach (Moleong, 2012; Muhtarom et al. 2019). This study that aims to explore the combinatorial reasoning of high school students with cognitive-reflective and -impulsive styles in solving mathematical problems. This study is the first to link combinatoric reasoning with research subjects who have a reflective cognitive style and an impulsive cognitive style.

Participants

This study took 24 eleventh graders of SMA Misyikat Al-Anwar as the participant subject. It began with providing MFFT (i.e., Matching Familiar Figure Test) to see their cognitive style. The result was then classified based on several categories including cognitive reflective and impulsive.

Table 1.
Structures of Participants

cognitive style	high math skills (test score ≥ 85)	moderate math skills (test score 65≤x <85)	low math skills (test score 0≤x <65)	research subjects
ReflectiveCognitive Style	8	2	4	1
ImpulsiveCognitive Style	4	1	5	1

Table 1 showed that the number of cognitive-reflective students with high math skill (i.e., the test score was ≥ 85) was 8 students, and cognitive-compulsive ones with high math skill (i.e., the test score was ≥ 85) was 4 students. The other cognitive-reflective ones with moderate math skill (i.e., the test score was 65≤x <85) were 2 students, and cognitive-compulsive ones with moderate math skill (i.e., the test score was 65≤x <85) was one student. The other cognitive-reflective ones with low math skill (i.e., the test score was 0 ≤x <65) were 4 students, and those cognitive-compulsive ones with low math skill (i.e., the test score was 0 ≤x <65) were 5 students. The researchers took mathematical competence as the control variable. The subject of this current study referred to one cognitive-reflective student and another cognitive-impulsive student whose test score was ≥ 85, and was considered equivalent and communicative, in which, the SR was a cognitive-reflective subject attaining high score (≥ 85) in competence test, while SI was the subject with cognitive-impulsive style who attained high score (≥ 85) in mathematics competence test.

Instruments

The instrument of this study was divided into five parts. First, it used the researchers self as the primary instrument. Second, it used The Matching Familiar Figures Test to see the students' cognitive reflective and impulsive styles.

The Matching Familiar Figures Test (MFFT)

Test of cognitive style (i.e., MFFT) used is a test made by Jerome Kagan which has been adapted by Warli (2011) and thus, it was not validated again as it had been valid and credible. MFFT test consisted of one main figure and eight optional ones. The students were asked to select one figure among the optional ones that seemed similar to the main one. There were 15 figures consisting of main one and some optional ones, as what was figured out in the following example of MFFT.

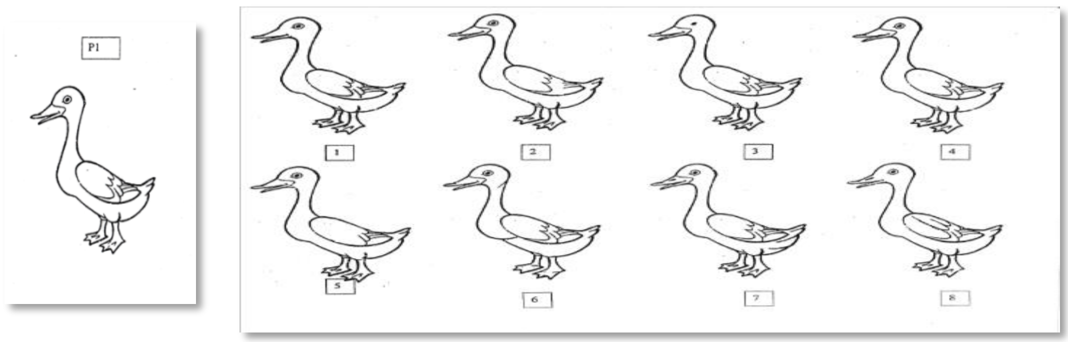

Figure 1.
Example of MFFT

Third, towards the test of math skill, it applied as the control variable. the test of math skill modified from National Final Test, and validated by the expert of mathematics education. Fourth, it used task sheet of permutation problems to see students' combinatorial reasoning. Towards the validation by the expert of mathematical education..Fifth, the researchers organized an interview to help them explore the students' combinatorial reasoning. The following paragraph was the permutation problem that students should solve.

Mr. Dani is a jeweler in Jombang market. He spent IDR 20.000.000,00 to buy a safe-deposit box for his jewelry. The safe-deposit box used a code consisting of four digits. To make him easy to remember the code, Mr. Dani usedthe digits of his marriage year which were 1, 9, 6, and 7. However, it was not allowed to use the same digit for the code. Define how many possible compositions of code digit that Mr. Dani might make! Explain your answer!

Data Analysis

The researchers analyzed the data collected from the students' works along with the result of interview they held in order to see the combinatorial reasoning of students with cognitive reflective and impulsive styles in solving mathematical problems. The phases of data analysis involved data transcription, data reduction, data codification (i.e., *coding*), data verification, data presentation, and conclusion making (Miles &Huberman, 2014; Creswell, 2012; Firdaus, 2019a).

Results

Combinatorial Reasoning by SR in Solving Problem

Process of Investigating Various Factors

SR showed her mental action in identifying some key words by reading the problem twice with careful intonation and highlighting some important parts of the problems. She then expressed the problem by her own words. She, for instance, made a code digit using 1967 indicating that it consisted of 1, 9, 6, and 7, since it was not allowed to use the same digit, and the instruction said to define any possible compositions for code digits.

SR correlated several key words like *not allowed to use the same digit* with the concept of combinatory to define that the problem dealt with permutation. She recalled the formula of permutation by explaining each of the components in the problem. For instance, she defined that *n* in permutation referred to the number of digits, while *r* referred to predetermined code digits. The exclamation mark in the problem referred to factorial for streak-down multiplication. SR connected any information she got to the concept of permutation by organizing examples in order to affirm her understanding. It was seen from SR's works along with interview as follow.

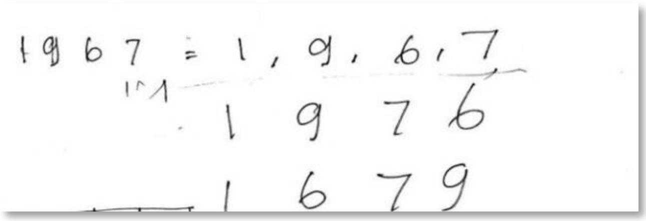

Figure 2.
Example by SR, the Result of Correlating Information with the Concept of Permutation

P : How could you say that these three examples are the compositions of code digits that Mr. Dani would make?

SR : As he uses the digits of his marriage year which is 1967 as the composition of his code digits, and the instruction does not allow him to use the same digit for the code. Indeed, no same digit is found in 1967 and 1976, as well as 1679.

In her first try, SR listed all the digits to be used as passcode. She wrote down four digits; 1, 9, 6, 7. Then, she wrote 1967 as the first passcode, 1976 as the second one, and 1679 as the third one. She explained that those three passcodes had satisfied the instruction as they had no same digit in their composition for each.

The Process of Considering any Probabilities

SR decided to use the simplest strategy for her to identify all possible passcode through filling slot. She argued that this strategy enabled her to seek for all the passcode digits using the principle of multiplication. SR explained that filing slot referred to the principle of multiplication, and thus, all the existing digits should be multiplied.

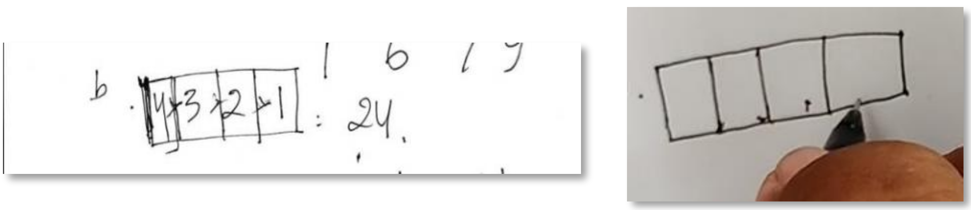

Figure 3.
Student's Work in Operating Filling Slot Strategy

P : How did you operate it?

SR : digit 1 9 6 7 have been mentioned in the problem. These four digits imply that we also need four column for each of them to become a passcode. For instance, if we have 1 9 6 7, we may fill the first column with either of those four digits, and we can fill the second column with either of three remaining digits -since another one has been used for the first column-, and so on until the last column is filled. Then, we should multiply them to become 4 x 3 x 2 x 1 = 24.

P : Could I change all the digits with 4?

SR : No, you can't

P : Why?

SR : Because the instruction said that we are not allowed to use the same digit for the passcode.

Next, SR correlated filling slot strategy with any information she got from the given problem. She drew four column in line as the representation of four digits of code. She then ensured the number of the column by counting them all. She did the process of connection when filling the column by considering any keywords in the problem. She filled the first column with either of four digits from 1 9 6 7. The second column could be filled by either of three remaining digits, since one digit had filled the first column. The third column could be filled by either of two remaining digits, as another different one digit had filled the second column. The fourth column could be filled by the last remaining digit. SR filled those four column based on the given instruction that the passcode should consist of different digit for its composition. She decided that the number of passcodes was 24. She made this decision by multiplying the number of available digits of each column, due to the principle of multiplication.

To affirm her work, SR decided to use the second strategy called formula. She argued that a correct formula for this problem was permutation of different objects, as the instruction said that we were not allowed to use the same digit in the passcode. This was seen in the following piece of interview

P : What kind of formula?

SR : Permutation of different objects.

P : Why ?

SR : Because we are not allowed to use the same digit for the passcode.

SR wrote down the formula of permutation of different objects correctly and it was supported by the result of interview as follow.

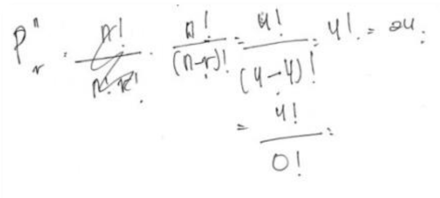

Figure 4.
SR's Work of Operating the Formula of Permutation of Different Objects

P : How was the process?

SR : So, the *n* is 4, since the number of digits is 4

P : Then...

SR : r is also 4, since it needs 4 digits

P : Then....

SR : And then it should be put into the formula $P_{n,r} = \frac{n!}{(n-r)!}$

n= 4, r=4, $P_{4,4} = \frac{4!}{(4-4)!}$, (4-4)!= 0! So, the result is 4! = 24

P : what is the result of 0! ?

SR : 0! is the same with 1, since it is factorial, Ma'am.

Furthermore, SR correlated the formula with the existing information she got from the problem to represent the number of existing digits as *n*, and put the *n* into 4 since the number of digits is 4, and SR represented the passcode as *r*, *r* referred to 4, given the predetermined passcode digits. Then, SR put them all into the formula to become $P_{4,4} = \frac{4!}{(4-4)!}$. SR did the process of counting like (4-4)!= 0!, in which 0! equaled to 1, in accordance to the principle of factorial course. SR defined that the result was 4! And it equaled to 24.

The Process of Evaluation

SR evaluated her work in such a way that was different from the previous one. She listed the passcode one by one. Along with the interview, the result was presented as follow.

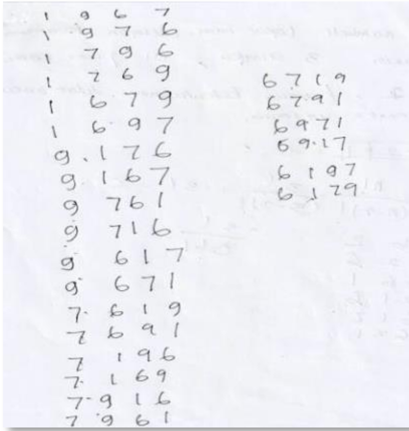

Figure 5.
SR's Work of Evaluation

P : Are you sure with your work?

SR : To make sure my work, I try them all one by one just so to make it clear how many number of passcodes that could be possibly made.

P : Like what?

SR : beginning from digit 1967, 1976, 1796, 1769, 1679, 1697, and then use 9 as the first digit such as 9176, 9167, 9761, 9716, 9617, 9671, now I use 7 as the first digit like 7619, 7691, 7196, 7169, 7961, 7916, and then 6 become the first digit 6719, 6791, 6971, 6917, 6197, 6179 , so the total number of possible passcodes is 24, given the instruction that we are not allowed to repeat any same digit.

P : Are you sure?

SR : (counting 1 up to 24) yes, I am sure it is 24 like I said before.

SR argued that it would be clear if we listed all of the possible passcodes. She began with writing down Mr. Dani's marriage year in 1967. Next, she took digit *1* as the constant variable and listed all the probabilities such as 1976, 1796, 1769, 1679, 1697. Next, she took digit *9* as the constant variable and listed all the probabilities such as 9176, 9167, 9761, 9716, 9617, 9671. Furthermore, SR decided to take digit *7* as the constant variable and listed all the probabilities including 7619, 7691, 7196, 7169, 7961, 7916. SR then took digit *6* as the constant variable and listed all the probabilities such as 6719, 6791, 6971, 6917, 6197, 6179. To be surer on her work, SR checked the result by counting them all one by one, and finally she got 24 possible passcodes. SR recalled her previous answer which was indeed similar to the current one, and she defined that her work was correct.

The Process of Generalizing Strategy

SR first mental action was arranging the problem with the previous one by considering the concept of combinatory which was the same as the prior problem. It was seen in the following result of interview.

SR : I bought a new suitcase that had a passcode consisting of three digits of number in it. Since I was born on 1st June 2001, I decided to use digit 162 for the code. The instruction said that those three digits should be made from different numbers. The same question is just similar to the previous one that asked to seek for the composition of the possible passcodes.

P : Why is it called similar?

SR : Because the previous problem dealt with a safe-deposit box with 4-digit passcode which each of the digits should be different, and the solution also used permutation –as the instruction said that we were not allowed to use the same number- before seeking for the possible compositions.

SR arranged the problem like *I bought a new suitcase equipped by 3-digit passcode, since I was born on 1st June 2001, I used digit 1, 6. and 2 to make the passcode. The instruction said that I could not repeat the same digit for the code. As like the previous problem.*

It also asked to seek for the compositions of passcode. SR explained that this current problem was just similar to the previous one as both of them dealt with permutation, marked by a statement *each of the three digits should be different.*

In addressing the problem, SR decided to use filling slot and permutation of different objects. It showed that SR used the same strategy for the same problem. She evaluated her work by arranging the compositions one by one in systematical and careful way. She did the same treatment for problem number 2.

Combinatorial Reasoning by SI in Solving Problems

The Process of Investigating Various Factors

SI identified some key words by reading the problem at glance, and cut off the problem into pieces without changing the language and expressed it spontaneously. The key words she got involved "in this problem, Mr. Dani spent IDR 20 million to buy a safe-deposit box to keep his jewelry. The deposit box was secured by a 4-digit passcode. To make him easy to remember his passcode, he used the digits of his marriage year, 1967. The year consisted of 4 digits of number and his deposit box passcode consisted of 4 digits as well. This problem asked to define how many possible compositions of passcodes that Mr. Day might make." It was seen in student's work along with the interview.

SI decided to use the concept of permutation for problem number 2, as she thought that it was structured or not random. However, she did not clearly explain what she meant with *not random*. The concept of permutation that SI understood was its formula. She explained each of the notation by correlating them with the given information. It was seen when she explained that notation *n* referred to the number of digits, *r* represented the predetermined passcode digits for the safe-deposit box, and the exclamation mark represented the factorial –backwards multiplication.

Next, SI listed some examples of solution to affirm her understanding about the given problem. When constructing the solution, SI considered the instruction that it should only consisted of 4 digits of different numbers. It was seen from the examples of solution she made: 9617 for the first passcode, 6971 for the second, and 9716 for the third. She argued that those examples were some probabilities that Mr. Dani might make for his box passcode, since it corresponded to the predetermined instruction that it should consisted of four digits with different number for each. It was seen from SI's work as follow.

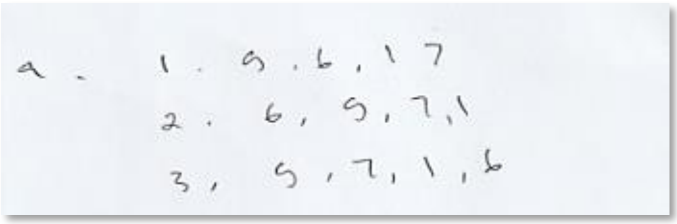

Figure 6.
The Examples that SI Made, as the Result of Correlating the Given Information with Permutation

The Process of Considering any Probabilities that Might Exist

The first mental action that SI did was deciding the strategy to be used, as seen in the following piece of interview.

SI : I use permutation formula

P : Why do you use that?

SI : Because I more understand by using formula

SI argued that using formula was the way she understood to solve the given problem and thus she decided to use permutation formula as the strategy as seen in the following work.

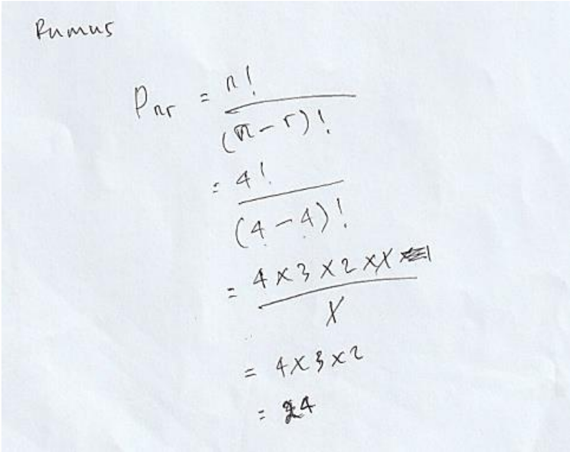

Figure 7.
SI's work in Operating the Formula of Permutation of Different Objects

SI wrote down the formula of permutation correctly. However, she forgot the kind of permutation she chose for the strategy. Next, she correlated the given information with the strategy by representing the number of digits for the passcode as *n,* and the predetermined number of digits as *r*. She then explained that she substituted the *n* with 4 since the number of digits was 4. Additionally, she substituted the *r* with 4 since the predetermined number of digits for the deposit box was 4. She substituted those number into the formula P(n,r) = n!/(n-r)!. Next, she did the process of counting. She described 4! as 4x3x2x1 per (4-4)! = 0!, in which 0! Equaled to 1. What she had explained was actually correct. However, she forgot the name. Next, she omitted the same number like 1 and 1, and multiplied 4 x 3 x 2. She concluded that 24 was the number of possible passcode compositions that Mr. Dani might make.

The Process of Evaluation

SI decided to evaluate her work by using different way. she listed the passcode one by one, as seen in the following figure.

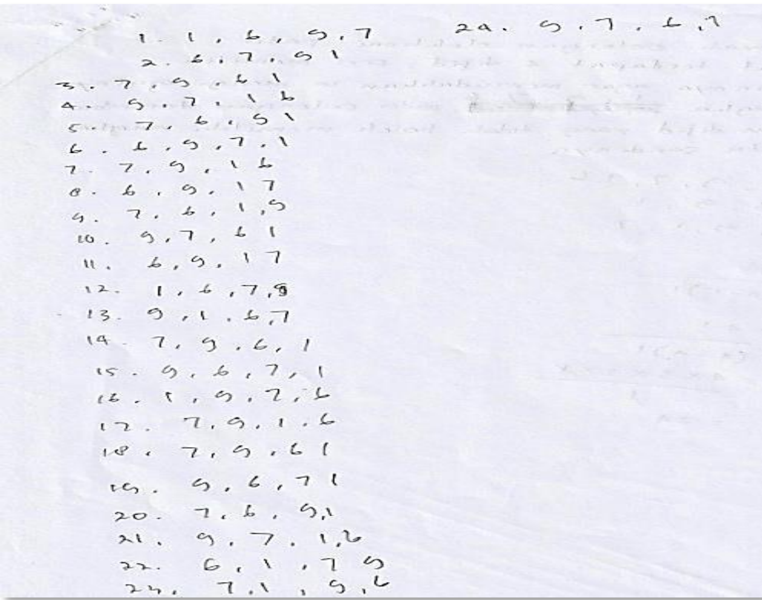

Figure 8.
SI's Work. Listing the Passcode One by One

SI considered listing all the possible passcodes one by one to see how many passcodes that might possibly be made. She decided to use the strategy that differed from the previous one. Before listing the possible passcodes, SI recalled the instruction that it should only consisted of different number for each digit, such as 1-1697, 2-6791, 3-7961, 4-9716, 5-7691, 6-6971, 7-7916, 8-6917, 9-7619, 10-9761,11-6917,12-1679, 13-9167, 14-7961, 15-9671, 16- 1976, 17-7916, 18-7961, 19-9671, 20-7691, 21-9716, 22-6179, 23-7196 and 24-9761. However, she did it spontaneously and did not recheck the listed passcodes she made. As the result, many similar passcodes were found, as what was seen in the fourth and twenty second passcodes, as well as the eighth and the eleventh ones.

The Process of Generalizing Strategy

SI considered that the problem dealt with the concept of combinatory. For instance, Fery chose an electronic piggy bank. As it had a 4-digit passcode, he decided to use his birth year to make him easy to remember the code. It was 1, 9, 7, and 6. There were 4 columns of digit that should be filled by different digit for each. The instruction was just the same as problem number 2. It asked to seek for any possible passcodes to be made. SI explained that the similarity of those two problems relied on the concept they used –*permutation*. This was seen from the instruction mentioned in those problems that the passcode should only consisted of different digits, as follow.

P : Go on to the next problem.
SI : Fery had an electronic piggy bank with 4-digit passcode. He decided to use his birth year to make him easy to remember the code. He used 1, 9, 7, and 6. There were 4 columns of digits for the passcode, and it should only consisted of different numeral digit for each. This was just the same as problem number 2 that asked to seek for any possible number of compositions of passcode.
P : Do you think they are similar?
SI : Yes, they are similar in terms of the context. Both of them use permutation.

Therefore, SI decided to use the same strategy as the previous one. She considered any probabilities that might reveal and evaluated them all. She decided to use permutation as her strategy to solve the problem by seeking for any possible probabilities. Furthermore, SI correlated the given information with the strategy such as representing the number of digit as n and the predetermined digit as r. She did the process of counting respectively. Additionally, SI evaluated her work by listing the result one by one. When she listed the passcode, SI spontaneously did it without having a recheck. As the result, many of the passcodes were repeated. The work was similar to what she had done in problem number 2. Hence, it concluded that SI decided to use the same strategy for similar type of problem.

Discussions and Conclusion

Toward investigating several factors, both subject with cognitive-reflective and -impulsive styles had their own way to identify the keywords in the given problems. The reflective one did a mental action by reading the problem twice with careful intonation and highlighting several spots before expressing them with her own words in order to make it clearer, while the impulsive one only read the problem once at glance and then expressed the keywords by cutting them off into pieces of information without changing either the language use or sentences of the problem. Similarly, they were also different in considering the concept of combinatory that might affect their decision on selecting which kinds of combinatorial concept they would take to address the problem. Subject with cognitive-reflective style clearly explained the information which referred to the instruction mentioned in the problem before immediately correlated it with the concept of combinatory. She then decided to use permutation of different objects related to the given problem. On the other hand, cognitive-impulsive subject did not provide clear explanation, but solely mentioning the given information in either spontaneously random or not random way. Their different cognitive styles brought them into different mental action as well. Subject with cognitive-reflective style seemed to be more careful and accurate in her response, while the cognitive-impulsive one did the otherwise. It was consistent to Rozencwajg & Corroyer (2005) that cognitive-reflective and –impulsive styles were defined as a nature of cognitive system that combined the time of making decision with performance in a problem-solving that contained high uncertainty. Students with slow characteristics in addressing a problem seemed to be more accurate/careful in their answers, and thus their answers were always correct (i.e., reflective student). Otherwise, students with fast characteristics in addressing a problem seemed to be less accurate/careful in their answers, and thus their answers were often wrong (i.e., impulsive student).

Toward explaining the notation that dealt with the formula used, both reflective and impulsive subjects clearly and logically correlated the given information with the notation mentioned in the formula. They also considered the instruction that it should consist of different number for each digit of passcode. This was similar to Lockwood (2018) that, in combinatorial reasoning, students tended to understand the formula to be used as well as the solution they proposed if they decided to use formula.

Toward considering all of the probabilities that might reveal, each of reflective and impulsive subjects had their own way to decide which strategies to be used. Reflective subject decided to use two strategies –formula and filling slot- for the sake of her affirmation, while impulsive subject decided to use one strategy –formula. Reflective subject explained that it was easier to figure out all of the passcodes through filling slot strategy, as it used the principles of multiplication. However, she decided to use the formula of permutation as her second strategy to affirm her work. She argued that permutation of different object was the most appropriate formula, given the instruction of the problem that required different number for each digit of the passcode. Impulsive subject considered that using formula was the best way she could understand in addressing the problem. Hence, she decided to use the formula of permutation as her strategy. It was in line with Shin & Steffe (2009) that combinatorial reasoning was highly related to deciding which strategy to be used for solving mathematical problems. In applying strategy, both reflective and impulsive subjects correlated the given information with the strategy by making a representation of symbol or figure in order to easily interpret the problem. NCTM (2000), Ainswort (2006). Representation was a model that was made to seek for a solution, and it was a way to interpret a problem in order to understand it. Both reflective and impulsive subjects applied filling slot strategy and formula, did operation of counting in reasonable manner, and decided its result. Lockwood (2013) argued that students' combinatory consisted of three interrelated components including formula, process of counting, and result. Ersari (2007) argued that understanding the principle of multiplication made student understand the essence of number, why it should be multiplied, how was the operation system, and they would reasonably think to get any possible results.

Toward the aspect of evaluation, both similarity and difference were found. In terms of its similarity, both subjects decided to use a different strategy by listing the passcode one by one. They thought that it was the best way to see how many possible passcodes to be made. This was consistent to Rezaie & Gooya (2011) that listing member was the most convincing way to count all cases. Furthermore, the difference between reflective and impulsive subjects was found in the process of listing the passcodes. Reflective subject decided one numeral digit as the constant variable and then listed all of the probabilities in careful and accurate manner to avoid any repeated passcodes. To affirm her work, reflective subject would make a re-checking by counting them one by one. As the result, she found 24 probabilities. She matched her current finding with her prior work and found the same result. After all, she confirmed that her work was correct. On the other hand, impulsive subject listed the passcodes spontaneously and she did not do any re-checking on her work. As the result, many of the passcodes were repeated/similar. The technique she used was called *trial-and-error*. Following English (1993), reflective subject used *odometer Complete* technique, while the impulsive one used *trail and eror* technique.This was in line with Rozencwajg & Corroyer (2005) that reflective-impulsive cognitive style was defined as a nature of cognitive system that combined the time of making decision and performance in a condition of solving problems that contained high uncertainty, students with slow characteristics in addressing problems yet being accurate and careful on their answer were always found that their answers were correct (i.e., reflective students), while those with fast characteristics in addressing problems yet being careless/less accurate on their answer often got wrong (i.e., impulsive student).

Toward the aspect of generalizing the strategy, both reflective and impulsive subjects considered the concept they used in the previous problem and decided to use the same strategy as what they did in the previous problem. Reflective subject decided to use filling slot strategy and formula before listing the passcodes one by one. Impulsive subject, however, directly applied the formula of permutation before finally listing the passcodes one by one. It was similar to Aini et al. (2019) that reflective students used three strategies including the principles of multiplication, formula, and member listing, while impulsive ones used two strategies that referred to the application of formula and member listing.

Overall, it concluded that reflective and impulsive students had different combinatorial reasoning in terms of their ways in identifying various factors, deciding which strategy to be used, and the process of evaluation. Issues on combinatorial reasoning that dealt with other cognitive styles would be interesting to be investigated in the future researches.

Recommendations

The result of this current study provided an illustration of combinatorial reasoning by cognitive-reflective and cognitive-compulsive high school students, and it might be useful as a basis for designing a model of learning math in order to develop students' combinatorial reasoning who have the same cognitive style.

Limitations of Study

This study was limited to the course of permutation and research subject who were only cognitive-reflective and –impulsive ones. Therefore, future researchers in education field should do further investigation using distinctive reviewed materials and levels. (Class) education aimed to add the insight of math related to combinatorial reasoning.

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Biodata of the Authors

Nurul Aini, M.Pd. was born in Jombang, Indonesia. She is a postgraduate student in Department of Mathematics Education, Surabaya State University, Indonesia. She is a Lecturer and Researcher in Department of Mathematics Education, Faculty of Education, STKIP PGRI, Jombang, Indonesia. Her research area is Combinatorial Reasoning Profile Of High School Students With Reflective And Impulsive Style In Completing Combinatoric Problems. **Affiliations:** Department of Mathematics Education, Faculty of Mathematics Education, State University of Surabaya, East Java, Indonesia. **E-mail**: nurulaini10@mhs.unesa.ac.id **Orcid ID**: 0000-0003-2515-0788 **Phone**: 082142492269 **SCOPUS ID**: -**WoS Researcher ID**: -

Prof. Dr. Dwi Juniati, M.Si. She graduated her doctoral program from Universite de Provence, Marseille – France in 2002. She is a professor and senior lecturer at mathematics undergraduate and doctoral program of mathematics education at Universitas Negeri Surabaya (State University of Surabaya). Her research interest are mathematics education, cognitive in learning and mathematics (Topology, Fractal and Fuzzy). **Affiliation:** Universitas Negeri Surabaya, Indonesia **Email** dwijuniati@unesa.ac.id **Orcid ID:** 0000-0002-5352-3708 **SCOPUS ID**: 57193704830 **WoS Researcher ID :** AAE-5214-2020

Prof. Dr. Tatag Yuli Eko Siswono, M.Pd. He is a professor and senior lecturer at mathematics undergraduate and doctoral program of mathematics education at Universitas Negeri Surabaya (State University of Surabaya). He research interest are mathematics education.). **Affiliation:** Universitas Negeri Surabaya, Indonesia **Email** tatagsiswono@unesa.ac.id **Orcid ID:** 0000-0002-7108-8279 **SCOPUS ID**: 45561859700 **WoS Researcher ID :** N-8794-2017

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