



## Competency analysis of computational thinking based on cognitive style

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### Abstract

Computational thinking can be used to enhance students' cognitive abilities. Computational thinking can be utilized across various domains, particularly in addressing intricate and multifaceted issues. The cognitive style is one of the aspects that impacts the student's thinking process. The study seeks to examine students' computational thinking abilities in problem-solving, specifically focusing on cognitive styles. This research falls under the category of descriptive research and adopts a qualitative methodology. The instruments utilized include the GEFT exam, the description test, and the interview guidelines. The data analysis involved examining the responses from two groups of individuals with different cognitive styles, categorized as having high, medium, or poor abilities. Research findings indicate that cognitive styles are associated with variations in computational thinking ability. Students with a cognitive style of field dependence (FD) do poorly in fulfilling all four markers of computational thinking. Out of the three subjects, only one subject comes close to satisfying all four indicators. It can be inferred that students with a field-independent cognitive style outperform students with a field-dependent cognitive style in computational ability.

**Keywords:** Analysis, competency, computational thinking, cognitive style

### Introduction

Learning activities in mathematics education consistently prioritize engagement and emphasis on problem-solving and question-solving. Nevertheless, the proficiency of Indonesian pupils in solving mathematical issues remains insufficient. This phenomenon is evident in the outcomes of the participants in the global comparative study, specifically in the TIMSS (Trends in International Mathematics and Science Study) and PISA (Programme for International Student Assessment) results. According to the 2015 TIMSS findings, Indonesia is placed 45th out of 50 nations, with a score of 397 (IEA, 2015) [7]. According to PISA, Indonesia is ranked 72nd out of 78 nations in maths (OECD, 2019) [11]. According to this data, Indonesian students have the lowest proficiency in mathematics when compared to pupils from other nations. To fully grasp the significance of solving mathematical problems, pupils must possess the capacity for critical thinking. Students with strong cognitive abilities will excel in comprehending and mastering mathematical ideas. Consequently, there is a necessity for education that can enhance pupils' cognitive abilities and foster their aptitude for critical thinking.

The facts can be seen in a field where the learning process is very monotonous and procedural, teachers just explain the material, give examples, give tasks in the form of questions of practice, correct answers, and discuss the solution of questions that are then presented by students how to solve them (Darma Andreas Ngilawajan, 2013) [1]. The most important thing in learning is the student's thinking process. Then it is necessary to create a meaningful and active learning process, through giving a challenge to the student by giving experience to the students' thought process. The challenge and experience can be given problems related to the learning material so that the student can be active in the process of thinking, digging, processing, and solving problems. To find a solution to the given problem, the

student will do the process. Problem Solving in learning will train the student in thinking (La Saudi, Muhammad Sudia, Mustamin Anggo, 2018) [8].

One way to train students' thinking skills is through computational thinking (Computational Thinking). Thinking computing can be applied in all fields and could be used in solving complex and complex problems. According to the NCTM (National Council of Teachers of Mathematics) in 2015, as quoted by Hilda Nurmuslimah (2019) [6], stated that mathematics and computational thinking are skills that should be trained from an early age so they need to be applied to school learning.

Learning by computing thinking, as a basic skill throughout the school curriculum, will enable students to learn to think abstractly, algorithmically, and logically, as well as be ready to solve complex and open problems (Swasti Maharani, 2019) [14]. Besides, when students think, the way students think will be different. Each student has his way of organizing what he sees, remembers, and thinks (Muhammad Basir, 2017) [9]. But the teachers had the same way of thinking that every student would be the same. The difference in how students think is called a cognitive style. Cognitive style is a characteristic of an individual in terms of how to think, remember, process information, and solve problems. By knowing students' cognitive styles, teachers can help guide and group students' ability to solve problems. (La Saudi, Muhammad Sudia., Mustamin Anggo, 2018) [8]. So in this case it appears that there is a relationship between cognitive style and problem solving. Because how one thinks will determine one's success in solving a problem.

The cognitive styles used in this study are the field-dependent (FD) and field-independent (FI) cognitive styles. Both of these have differences where according to Witkin, Oltman, Raskin, and Karp Dona Dinda Pratiwi quoted stating that the Field Dependent cognition style in solving a problem in a way that corresponds to the one that has been

established, whereas the individual with the Field Independent Cognitive style (Fi) in resolving the problem is more to in a non-linear way. (Dona Dinda Pratiwi, 2015) [2]. Of the characteristics of both these cognitive styles are highly related to being applied in research involving the processes of how individuals see a problem and think in solving a problem. The differences in the mindset of these two cognitive styles will affect the process of computational thinking in solving problems.

After conducting observations based on the National Exam (hereinafter UN) average results of one of the first secondary schools in Central Aceh, Takengon State High School 1 became the highest UN average score school in the Central Aceh district in 2019. Looking at this, researchers are interested in making Takengon 1st State High School a research venue to see how students' computational thinking skills in solving problems are reviewed from a cognitive style. The study was carried out on ninth-grade high school students because the students had entered the adolescent age of 14-15 years so the students were able to think abstractly. According to Piaget, each undergoes several levels of intellectual development, namely the first stage sensory-motor (0-2 years), the second stage pre-operative (2-7 years), the third stage concrete operational (7-11 years), and the fourth stage formal operation (>11 years) (Ratna Wills Dahar, 2006) [12]. (Ratna Wills Dahar, 2006) [12]. In addition, students in the ninth grade are considered to have sufficient knowledge to solve mathematical problems.

**Research Methods**

**Research Approach**

Research uses a qualitative approach with a type of descriptive research. Qualitative research is describing in the form of describing the symptoms observed without data analysis by accepting or rejecting hypotheses. Descriptive research is research aimed at describing an event or phenomenon as it is. (Nana Syaodih Sukmadinata, 2010) [10]. This study does not manipulate or alter free variables but

describes a condition as it is. condition depiction can be individual or group.

**Data Sources**

The primary source is the material or documents submitted by the party present at the time of the event (Hardani, 2020) [5]. So in this case the data is directly received from the data source (respondent/sample/informant). Then in this research, the source uses primary data that is data directly obtained from the source by performing measurements, and calculations either in the form of questionnaires, or observations.

The primary data used is the results of the cognitive style test and the written test of computational thinking skills. Cognitive-style tests are used to group a student's cognitive style between field-dependent and field-independent. Then after grouping the students according to their cognitive style, they proceeded to give a written test of computational thinking skills.

**Results and Discussion**

**Cognitive Style Results**

Based on the completion of the Cognitive Style Test (GEFT) at Az-Zahra Takengon, an IT high school student in the ninth grade, 37 students were given a cognitive style test to be grouped into field-dependent and field-independent. It can be concluded that of the 37 students then the cognitive style results show that 49% of students have a field-dependent cognition style consisting of 18 students, and 51% are Independent field-cognition-style students composed of 19 students.

**Competency Result of Computational Thinking**

The student's computational thinking skills test results have an average score of 15.6 with a default deviation (standard deviation) of 6.07. Based on the ability category of each student and his cognitive style.

**Table 1:** Test Result Distribution of Computational Thinking Competency of Students

| Group of Cognitive Style      | Subject Code | Test Score | Competency Category |
|-------------------------------|--------------|------------|---------------------|
| <i>Field Dependent (FD)</i>   | S002         | 7          | Low                 |
|                               | S003         | 9          | Low                 |
|                               | S004         | 13         | Medium              |
|                               | S006         | 12         | Medium              |
|                               | S008         | 12         | Medium              |
|                               | S009         | 9          | Low                 |
|                               | S011         | 12         | Medium              |
|                               | S012         | 23         | High                |
|                               | S015         | 16         | Medium              |
|                               | S016         | 12         | Medium              |
|                               | S020         | 15         | Medium              |
|                               | S023         | 7          | Low                 |
|                               | S025         | 14         | Medium              |
|                               | S029         | 9          | Low                 |
|                               | S033         | 12         | Medium              |
|                               | S034         | 20         | Medium              |
|                               | S036         | 13         | Medium              |
|                               | S037         | 16         | Medium              |
| <i>Field Independent (FI)</i> | S001         | 24         | High                |
|                               | S005         | 15         | Medium              |
|                               | S007         | 15         | Medium              |
|                               | S010         | 20         | Medium              |

|  |      |    |        |
|--|------|----|--------|
|  | S013 | 28 | High   |
|  | S014 | 16 | Medium |
|  | S017 | 12 | Medium |
|  | S018 | 30 | High   |
|  | S019 | 9  | Low    |
|  | S021 | 25 | High   |
|  | S022 | 22 | High   |
|  | S024 | 21 | Medium |
|  | S026 | 24 | High   |
|  | S027 | 6  | Low    |
|  | S028 | 20 | Medium |
|  | S030 | 15 | Medium |
|  | S031 | 14 | Medium |
|  | S032 | 11 | Medium |
|  | S035 | 20 | Medium |

From the table above it can be illustrated that the cognitive-style field-dependent students have test results with a high ability of 1 person, a medium ability of 12 people, and a low ability of 5 people. Whereas in the cognitive-style field-independent students, the test results are 6 high-capability students, 11 medium-capable students, and 2 low-capacity students.

Out of 49% of cognitive-style field-dependent students, they had an average score of 12.8 on the computational thinking test, and out of 51% of field-independent cognitive-style

students, the average score was 18.3. Based on the distribution of the computational thinking test results in the table above, six students were selected to be analysed and interviewed in depth. With three Cognitive Field Dependent (FD) students with one high skill, one medium skill, and one low skill, then three high skilled field independent (FI) students, 1 medium skilled, and 1 low skilled. Here are the details of the selected research subjects in this study that will be analysed in depth.

**Table 2:** Research Subjects That Are Analyzed

| No | Subject Code | Cognitive Style | Score | Competency Category |
|----|--------------|-----------------|-------|---------------------|
| 1. | S012         | FD              | 23    | High                |
| 2. | S034         | FD              | 20    | Medium              |
| 3. | S029         | FD              | 9     | Low                 |
| 4. | S018         | FI              | 30    | High                |
| 5. | S024         | FI              | 21    | Medium              |
| 6. | S019         | FI              | 9     | Low                 |

**Analysis Results of Computational Thinking Competency of Students Field Dependent (FD)**

High Competency Category of Computational Thinking Competency of Students Field Dependent It can be seen that the subject S012 delineates some of the important information contained in the given problem. Where the subject writes the information of a lot of padi seeds on box 1 i.e. 2 padi, box 2 = 4 pedi, box 3 = 8 padi to box 100, and each padi weighs 8 grams. At point b is to determine the order of the number of pedi seeds in box 1, box 2, box 3, box 4, and box 5.

Subject S012 in determining the order of many seeds in each box i.e. write on box 1 which contains 2 seeds has a difference 2 times with box 2 which contains 4 seeds, then on field 2 which contains 4 seeds has a differential 2 times by the box k-3 that contain 8 seeds of padi, look at the pattern then next each box will have the same pattern i. e. each box would have a difference of 2 times. So, in this case then in box 4 will have 2 times the difference with the obtained many seed of padi is 16, and box 5 will obtain the seed it is 16 x 2 is 32.

About determining the number of seeds in box n, Subject S012 makes a table with each section of box 1 to box 5 filled according to the answer to question no. 1 in point b then in field n the student writes n. Then in the form of the pole then obtained field 1 to 5 is once by 2 then in the field n is once 2n. The Determines the weight of the seed in box

100, it is seen that the subject uses the pattern of many seeds in box n where the weight is multiplied by many seeds in the box n. Subject S012 writes 8 grams  $\times$  2n then replaces n with 100, then obtains 8 grams  $\times$  2(100), and then operates and obtains 8 gram  $\times$  200 = 1600 grams.

Medium Level of Computational Thinking Competency of Students Field Dependent In the answer of the subject, the subject writes only some of the important information contained in the problem given. The subject only writes a lot of seeds in box 1 and lots of seeds in box 2. That is, determines the order of the number of peaches in box 1, box 2, box 3, box 4, and box 5. The subject writeth a box 1 = 2, box 2 = 4, box 3 = 8, box 4 = 16 and box 5 = 32. Then the subject creates a way to get a lot of the peanut seeds besides the answers. Which is about determining the number of seeds in box n, the subject only writes  $U_n = 2n$ . The subject does not write the way to obtain the answer. In point d, that is, determines the weight of the seed in box 100. In this point you see the subject S034 write weight =  $2n \times 8$ . Then write  $U_{100} = 2^{100} \times 8$ . then change 8 to a number with a number of elements 2, so obtained 2100 x 23 then perform the operation of multiplication with a result of  $2^{103}$ .

Computational Thinking Competency of Students With Low Competency of Field Dependent The answer of the subject, subject only writes a few sentences that are present in the given problem. It's a piece of a sentence of a mother-in-law telling her pupils to count the number of padi for the snake

stairs. Is to determine the order of the number of seeds in box 1, box 2, box 3, box 4, and box 5. Subject S029 writes box 1 = 2  $\rightarrow 2^1$ , box 2 = 4  $\rightarrow 4^1$ , box 3 = 8  $\rightarrow 8^1$ , box 4 = 10  $\rightarrow 10^1$ .

That is about determining the number of seeds in box n, Subject S029 did not solve the question, there is no answer to the question no answer/empty. That is to determine the weight of the seed in box 100. In this point, the subject S029 writes  $U_n = 2n$ , then each n is replaced with 100 so that  $U_{100} = 2^{100}$  is obtained.

### Analysis Result of Computational Thinking Competency of Students Field Independent (FI)

Computational Thinking Competency of Students Field Independent With High Competency In the answer of the subject, the subject writes the important information contained in the given problem. The subjects write all the information in their language from the contents of the first box to the third box, the weight of the seeds, and the number of the boxes. In point b is to determine the order of the numbers of seeds in box 1, box 2, box 3, box 4, and box 5.

Subject in determines the number of seeds from box 1 to box 5 with the shape of the deposition. Subject divides box 1 with box 5 by  $k_1, k_2, k_3, k_4, k_5$  and then fills in  $k_1 = 2^1 = 2, k_2 = 2^2 = 4, k_3 = 2^3 = 8, k_4 = 2^4 = 16, k_5 = 2^5 = 32$ . Then the subject also makes another way in answering that the subject makes the sequence of the seeds according to the information of the problem presented and then searches for the difference or gap from the order of the box. like the difference between a lot of padi seeds in box 1 with lots of Padi seed in box 2 that is +2. Then the difference is between lots of padi seeds on box 2 with plenty of Padi seed on box 3 yatiu +4. Then it appears that it is +2, +4, then to determine how many different subjects follow the pattern of the previous number of Padi seeds that is 2, 4, 8

Which is to determine the number of seeds in box n, the subject writes a pattern in the form of  $u_n = 2^n$  and creates a table to find the seeds on box n. In that table the subject decomposes box 1 with content 2 with pattern  $2^1$ , box 2 with content 4 with patterns  $2^2$ , and box  $u_n$  with content n and pattern  $2^n$ . That is, determines the weight of the seed in box 100. In this point it is seen that the subject first determines how many seeds are in box 100 by making the symbol  $U_{100} = 2^{100}$ . Then the subject directly writes  $2^3 \times 2^{100}$  and operates the ranked shape into a simple shape  $2^{103}$ .

Computational Thinking Competency of Students With Medium Field Independent Competency Can see the answer of the subject to point in the subject in the deduction of the important information in the given problem first the subject writes all the information that is in the problem, then emphasizes every sentence that is considered important information and then proceeds below it rewrites every information that has been completed. From every important information that the subject has written, it can be seen that the object writes the information in full from the content of the first box to the contents of the third box, the weight of the seeds, and the number of the boxes. Is to determine the order of the numerous seeds in boxes1, boxes2, boxes3, boxes4, and boxes5. The subject creates a symbol to indicate the sequence of boxes, i.e.  $U_1$  which means showing the first box,  $U_2$  which means the second box and so on until the fifth box. Then fill in  $U_1 = 2 = 2^1 U_2 = 4 = 2^2$ ,

$U_3 = 8 = 2^3, U_4 = 16 = 2^4, U_5 = 32 = 2^5$ . Then at point c, which is to determine the number of seeds in box n, the subject makes the table by filling in 3 columns namely column 1 as a sequence, column 2 as a contents box, and column 3 as a pattern formula. Then the subject fills in sequence 1 with the contents of box 2 as the formula of pattern  $2^1$ , sequence 2 with the content of box 4 as the form of pattern  $2^2$ , sequence 3 with the contention of box 8 as a formula of the pattern  $2^3$ , sequence 4 with the containment of box 16 as a form of the Pattern  $2^4$ , sequence  $U_n$  with the Content of the box n as the formula of the model  $2^n$ . Is to determine the weight of the seed on the box 100. Looks like the subject doesn't answer the question.

### Computational Thinking Competency of Students With Field Independent Low

In the answer of the subject, in deducing the important information in the problem given the subject only writes the entire sentence contained in the given problem, without writing and deducing the essential information of the given issue. Which is to determine the order of the number of seeds in boxes1, boxes2, boxes3, boxes4, and boxes5. The subject only writes many seeds on boxes 1, 2, and 3 for 4 and 5 there is no answer at all. That is, to determine how many seeds are in box n, the subject only creates a table by filling box 1 with lots of seeds 2, box 2 with plenty of 4 seeds, and box 3 with lots and 8 seeds. That's to define the weight of the seed on box 100. The subject only reads the weight of the Padi multiplied by 100.

### Computational Thinking Competency of Students that Have Cognitive Style Field Dependent (FD)

In indicator 1, namely, identifying and decomposing large information into small pieces (Decomposition) contained in point a, from the way the subjects S034 and S029 wrote the answer, it appears that the two subjects were less able to decompose the important information of the problem presented. This is in line with the results of research from Restu Lusiana which states that FD subjects are unable to explain what is known and asked of a problem resulting in errors in the work. (Restu Lusiana).

It is in line with the theory stated by Richardson & Turner in Onyekuru quoted by Halida Eka Nurmutia that FD Individuals (2019) [4]. have difficulty breaking information into closed sections. In indicator 2, which is to recognize both the same and different patterns in simplifying the problem to find a solution (Pattern Identification) that exists in point b, the difficulty subject focuses attention on one aspect and analyzes a pattern. This is in line with Wahyuni H. Mailili's research, which states that field-dependent students tend to know the pattern as a whole, it is difficult for the student to concentrate on a single aspect of the situation or to analyze a model into a variety.

On indicator 3 conclude the found pattern (abstraction) presented on the issue of point c, the subject is wrong in concluding and linking from the previously obtained pattern to obtain the shape of the pattern of the multiple peas on the box n. This is in line with the results of a study by Ela Priastuti Mirlanda and Heni Pujiastuti (2018) [3]. which revealed that FD students are better at calculating based on formulas or rules than using patterns and relationships in analyzing mathematical situations. On indicator 4 making the steps used in solving the problem (algorithms) presented

on point d, the subjects S034 and S029 only see the problem in general without analyzing the meaning of what is asked on the subject. This is in line with a study by Dona Dinda Pratiwi (2015) <sup>[2]</sup>, which revealed that FD students stating problem-solving steps are still common based on information studied on the subject without analyzing the actual problem.

### Computational Thinking Competency of Students With Cognitive Style Field Independent (FI)

In indicator 1, namely, identifying and decomposing large information into small pieces (Decomposition) presented at point a, the subject can write information clearly from the problem presented. This is in line with Darma Andreas Ngilawajan (2013) <sup>[1]</sup>, research which argues that in absorbing information FI Subject is better in giving a clearer answer. Indicator 2 is to recognize both the same or different patterns in simplifying the problem to find a solution (Pattern Identification) presented on point b, the subject can recognize the same pattern and different in solving the problem.

This is in line with Wahyuni H. Mailili (2018) <sup>[15]</sup>, who stated that field-independent students tend to know the separate parts of a pattern according to its components. Subjects can present information in the form of images. This is according to a study by Dona Dinda Pratiwi (2015) <sup>[2]</sup>, which says that FI students draw by analyzing the information presented. This is in line with the Witkin and goodenough theory as quoted by Darma Andreas Ngilawajan (2013) <sup>[1]</sup>, characteristic of the FI cognitive style that is capable of processing information organizing unorganized objects, and reorganizing already organized objects.

On indicator 3 conclude the found pattern (abstraction) presented on point c, the subject can conclude and link from the previously acquired pattern to obtain the shape of the pattern of many seeds of peaches on box n. This is in line with the results of research by Ela Priastuti Mirlanda and Heni Pujiastuti (2018) <sup>[3]</sup>, which revealed that FI students when solving problems are skilled in using patterns and analyzing mathematical situations. On indicator 4 making the steps used in solving the problem (algorithms) presented on point d, the subject can understand what is asked of the issue and can describe the appropriate steps for solving it. This is in line with research by Dona Dinda Pratiwi (2015) <sup>[2]</sup>, that states that FI students can describe problem-solving steps well present problem-solving steps accurately, and respond orally clearly. This is in line with the theory of Witkin and goodenough as quoted by Darma Andreas Ngilawajan (2013) <sup>[1]</sup>, characteristic of the FI cognitive style that can organize unorganized problems as well as reorganize already organized problems so that FI students can respond orally with clear arguments.

### Conclusions

#### Computational Thinking Competency of Students With Cognitive Style Field Dependent

Subjects are less able to decipher important information from the problem presented, and less can present information in the form of images. Subject difficulties in concluding and linking from previously obtained patterns to obtain the form formula pattern  $U_n$ , the subject is wrong in

processing information, and see the problem in general without analyzing the meaning of what is asked on the subject.

### Computational Thinking Competency of Students with Cognitive Style Field Independent

In delineating important information, the subject can write information from the problem presented, can recognize both different patterns in solving problems, can present information in the form of images, can conclude and link from previously acquired patterns to obtain the form formula pattern  $U_n$ , can understand what is asked of the matter and can explain the steps of settlement accurately. It can then be concluded that in computational thinking students who are cognitive-style field-independent are better compared to students who are cognitively-styled field-dependent.

Cognitive FI students should practice more frequently in more complex subjects to improve FI students' skills, whereas FD students should work more often in problem-based subjections to be trained in analyzing information and processing information. Furthermore, teachers are required to be aware that each student has a different cognitive style, therefore it is expected that teachers give more guidance and guidance to students who are FD-style cognitive in solving mathematical problems. In addition, it is advised to teachers to apply to students learning that can develop computational thinking skills in resolving problems

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