Mathematics critical and creative thinking skill of student to solve Numerical Methods problems based on strength typology

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Abstract. Talent is a special or more dominant potential or ability possessed by someone who can develop through an intensive training or education process. Strength Typology 30 (ST30) views talent as the role of individuals who have eight clusters, namely: Servicing, Thinking, Reasoning, Elementary, Networking, Generating Idea, Technical, and Headman. This research aims to describe how mathematical creative and critical thinking abilities of students who have dominant talent in cluster thinking, reasoning, and generating ideas. The instrument used in this research was a talent assessment (ST-30) through temubakat.com and a mathematical critical and creative thinking skill test on Numerical Method problems. In this research, one research subject was chosen who has dominant talent in the 3 clusters. The dominant talents of subject CLC in the cluster of thinking, reasoning, and generating ideas are Analyst, Strategic, Creator, and Synthesizer. The results showed that CLC subjects had good mathematical critical, and creative thinking skills. He can conduct all aspects of critical thinking skills (focus, reason, inference, situation, clarity, overview) and aspects of creative thinking ability (fluency, flexibility, originality) in solving Numerical Method problems.

1. Introduction
Critical and Creative thinking skills are essential for students [1] and become a learning goal at all levels of discipline [2]. Optimization of higher-order thinking skills is vital because it is a life skill that needs to be developed. Improving the ability to think critically and creatively needs to be done by the teacher because both affect student learning outcomes [3]. However, teachers need to know what factors influence the ability to think critically and creatively.

Critical thinking was affected by the instructional contexts with a new situation, the readiness to enter the ICT community, and the prerequisite, i.e., the mastery of previous lecture materials and students’ learning motivation [4]. Creative thinking is affected by problem identification and definition [5]. Creative people are sensitive to the existence of problems [6]. They believe that without problems, individuals have little chance to show their creative traits [7]. On the other hand, there is an understanding that critical and creativity are viewed from a developmental perspective: they conceptualize critically and creativity within a more broad model of talent development [8][9].

Talent is a special or more dominant potential or ability possessed by someone who can develop through intensive training or education processes [10]. There are two strongholds in looking at talent, namely 1) talent is nurture and 2) talent is nature [11]. In this research, looking at talent as a potential that someone already has in him, God’s gift, and will develop optimally if the potential is awakened.
Research shows that it is a long process to differentiate talent from other personality characteristics down to high-level expertise, creative achievement, or occupational fulfillment [12]. Some of the talents themselves are conspicuous, but some are hidden. Someone who has a striking talent, for example, in mathematics, has a better chance of completing higher education and success in business in the future [13]. Hidden talents include the talent to detect and memorize threats, find creative solutions, understand other people, and deal with changing environments [14].

Many assessments can be used to determine a person’s talent. One of them is Strength Typology-30 (ST-30). ST-30 is a description of competence and interest in roles. ST-30 has 30 human typologies related to productive forces, namely administration, ambassador, analyst, arranger, caretaker, commander, creator, designer, distributor, educator, evaluator, explorer, interpreter, journalist, marketer, mediator, motivator, operator, producer, quality controller, restorer, safe keeper, seller, selector, server, strategist, synthesizer, treasurer, visionary [15]. The thirty typologies are grouped into eight clusters, namely: Servicing, Thinking, Reasoning, Elementary, Networking, Generating Idea, Technical, and Headman. The results can be ST-30 can be used as a personal brand or self-awareness for someone [15].

To see critical and creative mathematical abilities, researchers will focus on only 3 clusters, namely Thinking, Reasoning, and Generating Ideas. In each cluster, only talents related to critical thinking and creative mathematical thinking were taken. The talents referred to are analysts, creators, synthesizers, and strategists. Someone who has an analyst talent is someone who has analysis, likes to play with numbers and data [15]. A person who has the talent of the creator means that person has many ideas and is known to be far ahead [15]. People who have a talent for synthesizers are people who like to read various resources of ideas, strategies, and plans [15]. People who have talent Strategists can choose the best way to achieve a goal, either through analytical skills or intuition [15].

This research aims to describe the mathematical creative and critical thinking abilities of students who have dominant talents in Analysts, Creators, Synthesizers, and Strategists. For the mathematical creative and critical thinking skills it refers to several aspects that will be seen. Aspects of critical thinking skills are Focus, Reason, Inference, Situation, Clarity, and Overview [16]. Aspects of the ability to think creatively are Fluency, Flexibility, and Originality [16]. Originality in mathematics means that other people do not widely use the idea according to their age group.

2. Methods
This research is a descriptive study with a qualitative approach. The subject in this study is one person who has a dominant talent in Analyst, Creator, Synthesizer, and Strategist. Assistive instruments used in this study were talent assessment and mathematical critical and creative thinking skills tests in Numerical Methods Courses. This research uses talent assessment that can be accessed through temubakat.com, which results in the form of Strength Typology-30 (ST-30). From the results of the ST-30, researchers look for students who have a dominant in Analyst, Creator, Synthesizer, and Strategist. Furthermore, students who are determined as subjects get a test of critical mathematical thinking and creative abilities in Numerical Methods Courses. From the test results consisting of 2 questions, then analyzed according to activities in data analysis, namely data reduction, data display, and conclusion drawing/verification. Those activities are carried out interactively and take place continuously until complete so that the data is saturated [17]. Furthermore, to check the validity of the data, time triangulation is used by checking the data to the same source at different times.

3. Results and discussion
The results of the talents assessment (ST-30 through temubakat.com) of forty students who took the Numerical Method Course in the 2019/2020 school year and had talents in Analyst, Creator, Synthesizer, and Strategist are presented in table 1.
Table 1. Students who have potential strengths in the form of Analyst, Creator, Synthesizer, and/or Strategist.

| The many potential forces that arise | Subject code |
|-------------------------------------|--------------|
| 1                                   | APF, AN, DSQ, EEW, GDP, JWW, KT, KC, PDW, RNK, RS, SDF, WH |
| 2                                   | AFA, IW, NPU, NW, RDS, SR, UDN, WW |
| 4                                   | CLC          |

From table 1, it is known that there is one subject whose four potential strengths are Analyst, Creator, Synthesizer, and Strategic, i.e., subject CLC. More detailed ST-30 results from CLC subjects can be seen in the following figure 1.

![Figure 1](image1.png)

**Figure 1.** The result of ST-30 CLC subjects show that analyst, creator, synthesizer, and strategist are the seven strongest potentials.

Furthermore, CLC subjects were given a test of critical and creative thinking skills that can be seen in figure 2 and figure 3, and the response was as follows.

![Figure 2](image2.png)

**Figure 2.** The first question of mathematical critical and creative thinking skill test. The subject was asked whether if Shinta calculated the integral form the available data, by first performing Lagrange’s interpolation, the results would be 4.4531. Furthermore, the subject was asked to use as many other ways as possible in finding the integral result from the available data.
Figure 3. The second question of mathematical critical and creative thinking skill test. In this problem, the subject was asked to check whether Bobby’s approximate function is the best approximation function. If Bobby’s guess is incorrect, the subject was asked to find the best approximation function and include the evidence.

3.1. Critical thinking

In answering the question of figure 2, the subject can identify that the method is Third Order Lagrange Interpolation (Focus). The subject uses information on the use of Third Order Lagrange Interpolation to get the polynomial form. A summary of the student work results is presented in figure 4 below.

**Figure 4.** CLC using third order of Lagrange Interpolation.

Then, the subject can compare the polynomial form that he got with the polynomial form on the questions. He said, “The results of Shinta’s work are correct, but the sign is wrong. So, I think the integral result of Shinta’s Polynomial will also be wrong. But it needs to be checked first to be sure.” The subject found the fact that the results listed in the problem were incorrect. There was an error in writing the sign (Inference). The subject suspects that the integral results generated in the problem also will not be correct because the initial polynomial form is wrong (Reason). The subject proves his statement by working on searching using ordinary integrals (Clarity). However, from the results of the calculation, the subject can realize that the guess is not right because it turns out the integral results are the same as those in the problem. The subject argued that Shinta’s answer to the question was only wrong in writing the answer (situation). At the end of the answer, the subject can convince himself that the correct integral result is 4.4531 because the subject has checked and got the fact that $E_{RMS} = 0$ (Overview). The search results for $E_{RMS} = 0$ can be seen in figure 5 below.
In answering the question of figure 3 the subject can identify that the function provided in the problem is obtained by using The Least Squares Method for The Linear Function (Focus). Subjects use the same method to indicate whether the results obtained are the same or not. Based on the calculation results, the subject concluded that the approximation function in the problem was correct. But, CLC can’t yet say that this approximation function is the best. The CLC subject clue that he must find the $E_{RMS}$ value first, as shown in the answer in figure 6 below.

However, the subject doubted that the approximation function was the best because after searching for $E_{RMS}$ the value was still high at 7.889697 (Inference). He concluded that the approximate function with The Least Squares Method for The Linear Function is not the best, and it is necessary to look for other approximate functions. The findings of the CLC subject can be seen in figure 7 below.

The experimental results of CLC subjects with other methods are presented in table 2. Based on table 2, in the second experiment, the subject CLC using Exponent Function Linearization Method, it can be concluded that the approximation function found by Bobby is not the best function approximation because the $E_{RMS}$ value in The Exponential Function Linearization Method is smaller than The Least Squares Method for The Linear Function (Reason). After using the five methods that can try by the subject, with the step of coherent explanation (Clarity), the subject CLC can make an opinion that the best function is obtained from The Least Squares Method for Quadratic Curves and Second-Order Lagrange Interpolation (Situation). Also, subjects can make comparisons that the
approximation functions obtained from The Quadratic Method for Quadratic Curves and Second-Order Lagrange Interpolation are the same (Overview).

| The number of trial | Method | \( E_{\text{RMS}} \) value and Conclusion of Subject CLC |
|---------------------|--------|----------------------------------------------------------|
| 2                   | Method of Linearization of Exponential Functions | \( E_{\text{RMS}} = 0.032278172 \) is less than \( E_{\text{RMS}} \) value of linear function (\( E_{\text{RMS}} = 7.889697 \)), so exponential function is better function approach. Bobby's have wrong argument that the best function approach is linear function approximation \( f(x) = -0.8711 + 3.132x \). But, I should check other methods to know what the best function approximation is. |
| 3                   | The Power Function Linearization Method | \( E_{\text{RMS}} \) value of power function (\( E_{\text{RMS}} = 1.048727 \)) is not better than \( E_{\text{RMS}} \) value of exponential function (\( E_{\text{RMS}} = 0.032278172 \)). |
| 4                   | The Least Square Method for Quadratic Curve | \( E_{\text{RMS}} \) of the quadratic curve is \( 1.36 \times 10^{-16} \). It is smaller than \( E_{\text{RMS}} \) by other functions before. So, the best method to get an approximation function is the least square method for the quadratic curve. The best approximation function is \( g(x) = 0.58512 + (-1.3872 x) + 1.883 x^2 \). |
| 5                   | Second-Order Lagrange Interpolation | The result is the same as the result of the least square method for the quadratic curve. |

From the questions in figures 2 and 3 it can be concluded that the CLC subject has good mathematical critical thinking skills. All aspects of mathematical critical thinking skills can be raised by CLC subjects in solving problems on Numerical Method. The CLC subject is able to analyze the problems he is facing (Analyst Talent), be observant at seeing the problem-solving clue that is in the problem (Analyst talent), able to implement problem-solving strategies (Strategic Talent), and be able to make a conclusion based on experimental data obtained (Synthesizer Talent) [12].

3.2. Creative thinking

In answering the questions in figure 2, the subject used four methods of solving problems (fluency). The method used to find the integral value can be seen in figure 8-11 below.

**Figure 8.** The first method, subject CLC used Trapezoid. Subject CLC made two regions to get the integral with the boundary are -2 until -1 and -1 until 3.
Figure 9. The second method is ordinary Integral based on 2nd order Lagrange Interpolation result.

\[ \int_{-\infty}^{\infty} e^x \, dx = \lim_{b \to \infty} \left[ e^x + \frac{x e^x}{2} + \frac{xe^x}{2} + \frac{xe^x}{2} \right]_{-\infty}^{b} \]

\[ = \frac{1}{2} \left( 1 + 0 \right) + \frac{1}{2} \left( 0 - 0 \right) + \frac{1}{2} \left( 0 - 0 \right) \]

\[ = \frac{1}{2} \]

Figure 10. The third method is the Simpson 1/3. Subject CLC defines the new point in the available data using Lagrange Polynomial.

Figure 11. In the fourth method, the subject CLC using the new data and fine the integral with Simpson 3/8.

Of the four methods in figure 8-11, there is no same method used by CLC (Flexibility) subjects. Also, in looking for the integral result of this function, the CLC subject uses a different way than the group (Originality), namely looking for a new point using the results of the Lagrange Polynomial as presented in figure 12 below.

\[ \int_{-\infty}^{\infty} e^x \, dx = \lim_{b \to \infty} \left[ e^x + \frac{x e^x}{2} + \frac{xe^x}{2} + \frac{xe^x}{2} \right]_{-\infty}^{b} \]
In solving the problem of figure 3, the CLC subject uses five methods to find the best approximation function (Fluency). The methods used and the results can be seen in Table 3 below.

| Number | Method                                      | Result                                      |
|--------|---------------------------------------------|---------------------------------------------|
| 1      | The least-squares approximation for linear functions | $g(x) = -0.871067 + 3.132x$                |
| 2      | The exponential function linearization      | $g(x) = 0.2900852443e^{1.4260426x}$         |
| 3      | The power function linearization            | $g(x) = 2.05163763x^{1.146811277}$          |
| 4      | The least quadratic method for quadratic curves | $g(x) = 0.58512 + (-1.3872x) + 1.883x^2$   |
| 5      | Lagrange interpolation                      | $g(x) = 1.883x^2 - 1.3872x + 0.58512$      |

From Table 3, CLC subjects used five different methods (Flexibility). The fifth method, Lagrange Interpolation, is original because the answers do not appear to students in the class group (Originality). The steps of the Lagrange interpolation can be seen in Figure 13.

From the questions in figures 2 and 3 it can be concluded that the CLC subject has good mathematical creative thinking skills. Subjects can present 4-5 different solutions for solving numerical method problems. All aspects of mathematical creative thinking skills can be raised in the CLC subject, namely fluency, flexibility, and originality. By having the talents of Creator and Strategist, CLC Subjects are able to find other alternative solutions, even the solutions presented are something the group has not thought of [11]. When performing several methods, the CLC subject is able to synthesize and analyze whether the experiment was done enough, or he must think of another way to solve a problem so that he gets the best result in problem-solving (Strategic talent) [12].

4. Conclusions
The results showed that CLC subjects who have dominant talent in the Analyst, Creator, Synthesizer, and strategist show good abilities in critical thinking and creative mathematical skills. All aspects of critical mathematical thinking (Focus, Reason, Inference, Situation, Clarity, and Overview) and creative mathematical thinking (Fluency, Flexibility, and Originality) can be demonstrated in solving Numerical Method problems. Recommendations from the results of this study are to develop critical
thinking and creative mathematical skills in the Numerical Methods class. It is necessary to look at the talents of each student. Cooperation arrangements in groups with talents who can support each other are needed for maximum results.

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