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THE IMPLEMENTATION OF SCIENTIFIC APPROACH WITH GROUP SETTING TO IMPROVE THE 11TH GRADE SCIENCE 6 STUDENTS' MATHEMATICAL CRITICAL THINKING SKILLS AT SMAN 22 BANDUNG IN THE LEARNING OF DERIVATIVES AND ITS APPLICATIONS

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Abstract

Students with conventional learning still have difficulty in answering problems related to mathematical critical thinking skills. For this reason, a research with a different approach is needed to improve students' mathematical critical thinking skills. This study was conducted under the action research method. It aims to analyse the role of scientific approach to Mathematical Critical Thinking (MCT) skills of high school students. This study was conducted in SMAN 22 Bandung and involved 31 students from grade XI Science 6 as participants and three essays of MCT test as the instruments. This study was conducted in three cycles. One cycle in research activities is a stage that starts from the planning, observation and reflection stages. The researcher found that there was an improvement on the students' MCT skills from cycle I to cycle III. The ability to think critically mathematically students have increased from cycle to cycle, but the results have not been satisfactory because almost half (45.16%) of students who have just completed the MCT test well.
Keywords: Mathematical Critical Thinking skills

Abstrak

Siswa dengan pembelajaran konvensional masih mengalami kesulitan dalam menjawab masalah yang berkaitan dengan kemampuan berpikir kritis matematis. Untuk itu perlu dilakukan suatu penelitian dengan pendekatan yang berbeda untuk meningkatkan kemampuan berpikir kritis matematis siswa. Penelitian ini adalah suatu penelitian tindakan kelas yang bertujuan menganalisis peranan pendekatan saintifik terhadap kemampuan berpikir kritis matematis (KBKM) siswa. Penelitian ini dilaksanakan di SMAN 22 Bandung dengan melibatkan 31 siswa kelas XI MIPA 6 dan tiga tes uraian KBKM,. Penelitian dilaksanakan dalam tiga siklus. satu siklus pada kegiatan Penelitian (PTK) adalah tahapan yang dimulai dari tahap perencanaan, pengamatan, dan refleksi. Dan peneliti menemukan terdapat peningkatan KBKM siswa dari siklus I sampai siklus III. Kemampuan berpikir kritis matematis siswa mengalami peningkatan dari siklus ke siklus, namun hasilnya belum memuaskan karena hampir setengahnya (45,16%) siswa yang baru bisa menyelesaikan tes KBKM dengan baik
Kata Kunci: kemampuan berpikir kritis matematis

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INTRODUCTION

In the past few years, Indonesia education assessment system has been developing Higher Order Thinking Skills (HOTS)-based assessment system with regards to the amendments of 2013 curriculum in assessment standards, particularly in Mathematics. It is designed to build students' Critical Thinking skills in solving proposed problems. In addition, the learning process is expected to allow students developing their critical thinking skills as parts of requisite competences in the future (Prihartini, Lestari, & Saputri, 2015).

Many experts have conducted researches related to Mathematical Critical Thinking (MCT) skills. The findings showed that students still encountered difficulties in answering critical thinking questions. Sariningsih dkk found similar results to their research which showed that the participants encountered difficulties in solving mathematical problems related to identifying relevant and irrelevant data in a given case (Sariningsih, Sumarmo, Zukarnaen, Hamidah, & Hidayat, 2015). In line with the findings, Mulyana, Sumarmo, & Kurniawan (2018) also discovered similar findings which related to students' ability in examining and proving the validity of counting process.

Therefore, this research aims to analyse the improvement of high school students' critical thinking skills - in the topic of derivative and its application, students' performance, and students' difficulties when completing MCT test.

Mathematical Critical Thinking is the foundation of thinking skills which is used to analyse arguments and to generate ideas towards each meaning in order to develop logical mind set. Some experts define the term 'critical thinking' with different expressions, however, the core meaning remains the same. Ennis (Sariningsih et al., 2015) states that critical thinking is a reflective thinking which is full of considerations and decision makings about what is believed and what is done.

Similar idea is proposed by Noer (Jumaisyaroh, Napitupulu, & Hasratuddin, 2016) who states that mathematical critical thinking is a process of thinking which leads to conclusion drawing about what we should believe and what future action we should take; whereas, Susanto (Jumaisyaroh et al., 2016) proposes that mathematical critical thinking is a thinking activity about ideas or notions which relates to concepts or given problems.

Furthermore, Gokhale (Hendriana, Rohaeti, & Sumarmo, 2017) defines the term 'critical thinking' as a process of thinking which involves analysing, synthesising, and evaluating concepts. Critical thinking also involves manipulating data or information in order to make them more meaningful.

Referring to the abovementioned definitions of critical thinking by those experts, it can be concluded that mathematical critical thinking is basically an ability that requires students to verify the validity of concepts before accepting them. Therefore, based on the indicators of mathematical critical thinking proposed by the experts, this research used the following indicators: 1) verifying the validity of a statement, 2) identifying relevant and irrelevant data, 3) identifying the validity of the process, and 4) composing answers along with reasons.

METHOD

The method used in this research was classroom action research which refers to a reflective analysis compiled by the researcher in order to deepen the understanding throughout the learning process. The subject of this research was 31 grade XI Science students of SMA Negeri 22 Bandung in academic year 2018/2019. The instruments of this research were three essays of MCT test in each cycle and interview guidelines for some participants.

In cycle I, the MCT test consists of 3 questions with indicators (1) checking the truth of the steps in the completion process, (2) checking the validity of a statement; and (3) identifying relevant and irrelevant data.

Soal Tes Kemampuan Berpikir Kritis Matematis (Siklus I)

Petunjuk:

1. Baca soal-soal di bawah ini dengan teliti, kemudian selesaikan disertai dengan rumus, konsep, atau prinsip yang digunakan.
2. Kerjakan soal yang menurut anda lebih mudah terlebih dahulu
3. Setelah selesai, periksa kembali pekerjaan sebelum dikumpulkan
4. Selamat bekerja dan semoga sukses

Soal

1. Seorang siswa menjawab soal turunan di bawah ini.

   Tentukan turunan pertama dari $f(x) = (3x^2 - 2x)^4$

   Jawab:

   $f(x) = (3x^2 - 2x)^4$

   Misal $u(x) = 3x^2 - 2x$

   Maka $u'(x) = 6x - 2$

   Sehingga

   (1) $f'(x) = [u(x)]^4$
   (2) $f'(x) = [u(x)]^4 u'(x)$
   (3) $f'(x) = 4(3x^2 - 2x)^3(6x - 2)$
   (4) $f'(x) = (12x^2 - 8x)^3(6x - 2)$

   Analisislah tiap langkah penyelesaian di atas. Benarkah penyelesaian di atas, berikan penjelasan. Jika terjadi kesalahan, tuliskan pada langkah mana kesalahannya dan tuliskan perbaikannya.

2. Periksa kebenaran pernyataan berikut

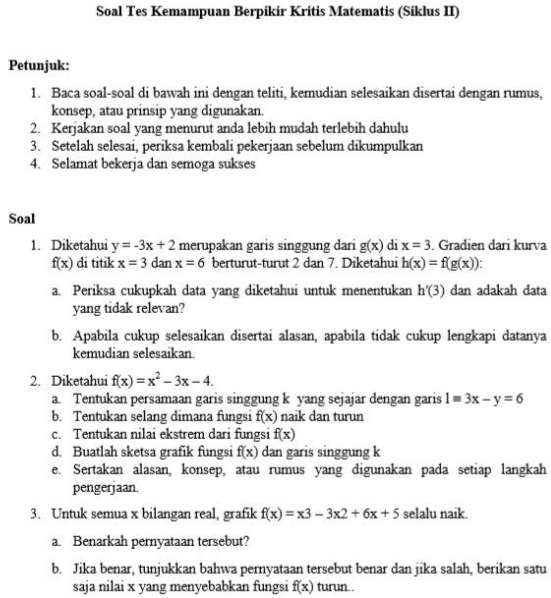
   Turunan pertama dari $f(x) = \frac{ax+b}{cx+d}, x \neq -\frac{d}{c}$ adalah $f'(x) = \frac{ad-bc}{(cx+d)^2}, x \neq -\frac{d}{c}$.

   Berikan ilustrasi untuk penjelasannya.

3. Suatu polinom $f(x) = x^3 + ax^2 + bx + c$ dirumuskan dengan data-data nilai $f(-1)$, $f'(-1)$, dan $f''(-1)$ berturut-turut 8, -8, dan 0. f' adalah turunan pertama fungsi f dan f'' adalah turunan kedua fungsi f. Cukupkah data tersebut untuk menentukan rumus $f(x)$? Adalah data yang tidak relevan? Jika data belum cukup, lengkapi data tersebur dan beri penjelasan setiap langkah pengerjaannya.

Figure 1
MCT Test Question Cycle I

Just like in cycle I, the MCT test questions in cycle II also consisted of 3 questions with indicators (1) identifying relevant and irrelevant data; (2) solving problems with reasons; and (3) Checking the truth of a statement;



Soal Tes Kemampuan Berpikir Kritis Matematis (Siklus II)

Petunjuk:

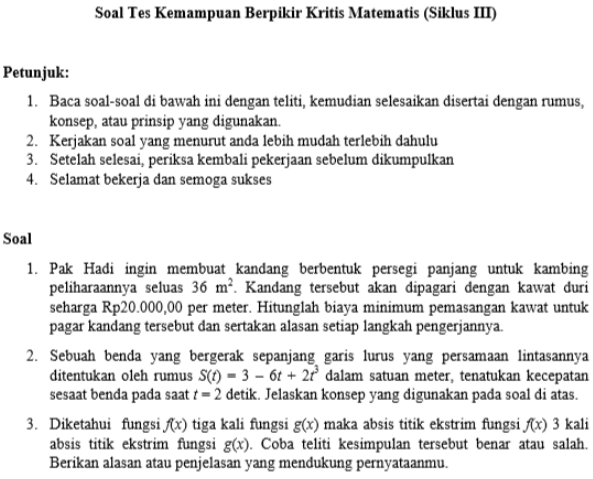
1. Baca soal-soal di bawah ini dengan teliti, kemudian selesaikan disertai dengan rumus, konsep, atau prinsip yang digunakan.
2. Kerjakan soal yang menurut anda lebih mudah terlebih dahulu
3. Setelah selesai, periksa kembali pekerjaan sebelum dikumpulkan
4. Selamat bekerja dan semoga sukses

Soal

1. Diketahui y = -3x + 2 merupakan garis singgung dari g(x) di x = 3. Gradien dari kurva f(x) di titik x = 3 dan x = 6 berturut-turut 2 dan 7. Diketahui h(x) = f(g(x)):
   a. Periksa cukupkah data yang diketahui untuk menentukan h'(3) dan adakah data yang tidak relevan?
   b. Apabila cukup selesaikan disertai alasan, apabila tidak cukup lengkapi datanya kemudian selesaikan.
2. Diketahui $f(x) = x^2 - 3x - 4$.
   a. Tentukan persamaan garis singgung k yang sejajar dengan garis l ≡ 3x – y = 6
   b. Tentukan selang dimana fungsi f(x) naik dan turun
   c. Tentukan nilai ekstrem dari fungsi f(x)
   d. Buatlah sketsa grafik fungsi f(x) dan garis singgung k
   e. Sertakan alasan, konsep, atau rumus yang digunakan pada setiap langkah pengerjaan.
3. Untuk semua x bilangan real, grafik f(x) = x3 – 3x2 + 6x + 5 selalu naik.
   a. Benarkah pernyataan tersebut?
   b. Jika benar, tunjukkan bahwa pernyataan tersebut benar dan jika salah, berikan satu saja nilai x yang menyebabkan fungsi f(x) turun..

Figure 2
MCT Test Question Cycle II

In cycle III students are given 3 KB questions as many questions with indicator (1) solving problems with reasons; (2) solving problems with reasons; and (3) check the truth of a statement;



Soal Tes Kemampuan Berpikir Kritis Matematis (Siklus III)

Petunjuk:

1. Baca soal-soal di bawah ini dengan teliti, kemudian selesaikan disertai dengan rumus, konsep, atau prinsip yang digunakan.
2. Kerjakan soal yang menurut anda lebih mudah terlebih dahulu
3. Setelah selesai, periksa kembali pekerjaan sebelum dikumpulkan
4. Selamat bekerja dan semoga sukses

Soal

1. Pak Hadi ingin membuat kandang berbentuk persegi panjang untuk kambing peliharaannya seluas 36 m^2. Kandang tersebut akan dipagari dengan kawat duri seharga Rp20.000,00 per meter. Hitunglah biaya minimum pemasangan kawat untuk pagar kandang tersebut dan sertakan alasan setiap langkah pengerjannya.
2. Sebuah benda yang bergerak sepanjang garis lurus yang persamaan lintasannya ditentukan oleh rumus $S(t) = 3 - 6t + 2t^3$ dalam satuan meter, tenatukan kecepatan sesaat benda pada saat $t = 2$ detik. Jelaskan konsep yang digunakan pada soal di atas.
3. Diketahui fungsi $f(x)$ tiga kali fungsi $g(x)$ maka absis titik ekstrim fungsi $f(x)$ 3 kali absis titik ekstrim fungsi $g(x)$. Coba teliti kesimpulan tersebut benar atau salah. Berikan alasan atau penjelasan yang mendukung pernyataanmu.

Figure 3
MCT Test Question Cycle III

FINDINGS AND DISCUSSION

Findings

This study was conducted in three cycles. Each cycle was done in one meeting of 3 hour-lesson. In the first cycle, the learning process incorporated discussion method; however, the discussion was done in pairs (Figure 1). The MCT test result in Cycle I is shown in the following table:

Table 1 Result of Mathematical Critical Thinking Test in Cycle I

Variables	Q 1	Q 2	Q 3	Total
Maximum Score	6	4	8	18
Average	4,97	3,03	1,87	9.88
%	82,80	75,81	23,39	55,91
Number of Ss who passed	27	20	4	5
Studying Mastery Percentage	87.10	64.52	12.90	16.13

Notes:
Indicator Question 1 : identifying the validity of the process
Indicator Question 2 : verifying the validity of a statement
Indicator Question 3 : identifying relevant and irrelevant data

From the above shown table, it can be seen that most of the students (87, 10% for Question 1 and 64, 52% for Question 2) were able to complete the questions. Nevertheless, there was only small number of students (12, 90%) who were able to complete the question. Overall, there were 16, 13% of students who are able to pass or to obtain higher or equal score to the Minimum Mastery Criteria in Mathematics.

Figure 1
Learning Process in Cycle I

From the observation, the researchers carried on reflections to improve the learning process. The learning process in Cycle 2 was then designed. Discussion method was still used, however students were to choose their own groups which is different from the group in cycle 2. The group formed by students consists of 4-5 people, it is hoped that students in groups already

understand the character and abilities of their groupmates. The shift was expected to improve students' participation in the learning process as well as students' MCT skills. Data from Cycle 2 are shown in the following table:

Table 2 Result of Mathematical Critical Thinking Test in Cycle 2

Variables	Q 1	Q 2	Q 3	Total
Maximum Score	6	15	6	27
Average	1.13	9.87	3.71	14.71
%	14.11	65.81	61.83	54.48
Number of Ss who passed	0	16	10	7
Studying Mastery Percentage	0.00	51.61	32.26	22,58

Notes:
Indicator Question 1 : identifying relevant and irrelevant data
Indicator Question 2 : solving mathematical problems along with explanations
Indicator Question 3 : verifying the validity of a statement

According to Table 2, none of the students were able to complete Question 1 correctly. Most of them (51,61%) were able to complete Question 2 and a small number of students (32,26%) were able to complete Question 3 with 75% result score higher than the minimum score. The result of MCT test in Cycle 2 showed that there was an increase in the percentage of students who were able to exceed the Minimum Mastery Criteria, even though the increase was not significant.

Figure 2
Learning Process in Cycle II

From the result of the observation and the test in Cycle 2, the researcher planned to make some amendments for the next cycle. In order to make the students understand the lesson more, the researcher decided to arrange the learning process in the form of group discussion; however, the groups were formed by distributing the students who had reached the Minimum Mastery Criteria in each group equally. The students were expected to help the other students who had not yet reached the criteria.

The result of the MCT test in Cycle III showed that there was an improvement in the number of students who were able to reach the Minimum Mastery Criteria. Nonetheless, the result was not yet satisfactory as the number of the students who had passed was not yet significant. The result of MCT test in Cycle III is shown in the following table:

Table 3 Result of Mathematical Critical Thinking Test in Cycle 3

Variables	Q 1	Q 2	Q 3	Total
Maximum Score	10	6	8	24
Average	6.13	3.00	7.16	16.29
%	61.29	50.00	89.52	56.17
Number of Ss who passed	13	9	28	14
Studying Mastery Percentage	41.94	29.03	90.32	45,16

Notes:
Indicator Question 1 : solving mathematical problems along with explanations
Indicator Question 2 : solving mathematical problems along with explanations
Indicator Question 3 : verifying the validity of a statement

The above shown table suggests that more than half of the number of the students (41,94%) were able to answer Question 1 completely; small number of the students (29,03%) were able to answer Question 2 adequately; and most of the students (90,32%) were able to answer Question 3 correctly.

Figure 3
Learning Process in Cycle III

Discussion

According to MCT test given in Cycle I to Cycle III, there was some improvement in students' MCT skills; even though, there were only 14 out of 31 students who were able to obtain score more than the Minimum Mastery Criteria. The results of MCT test from Cycle I to Cycle III are shown in the following table:

Table 4 Result of Mathematical Critical Thinking Test from Cycle 1 to Cycle 3

Variables	Cycle 1	Cycle 2	Cycle 3
Maximum Score	18	27	24
Average	9.88	14.71	16.29
%	55,91	54.48	56.17
Number of Ss who passed	5	7	14
Studying Mastery Percentage	16.13	22,58	45,16

In cycle 1, there were only small number of students who were able to answer the MCT test. The reason was because the students were not used to completing higher order thinking tests. However, most of the students were able to identify the validity of process; some of them were able to verify the validity of the questions; and only small number of students were able to identify relevant and irrelevant data – some of them did not complete the questions. The result of Cycle II showed that there was some improvement even though it was not significant. On the other hand, the test result in Cycle III showed that the students' mathematical critical thinking skills were generally improved. It is in line with the previous study conducted by Syukur (Abdullah, 2013) and (Prihartini et al., 2015) who found that high school students; critical thinking skills can be developed through Open Ended approach.

Based on the students' answer of the MCT test in Cycle I and II, it can be seen that the students found identifying relevant and irrelevant data question difficult to answer. Most of them were not able to identify relevant and irrelevant data. It is in line with the results of the previous study conducted by (Sariningsih et al., 2015). The study found that the participants encountered difficulties in completing questions on identifying relevant and irrelevant data. Nonetheless, most of the students were able to complete questions about verifying the steps of completion process and solving mathematical problems along with the reasons. This finding, on the other hand, was the complete opposite of the previous research conducted by (Mulyana et al., 2018) which stated that the participants encountered difficulties in completing questions of verifying the counting process.

Based on the observation throughout the learning process in each cycle, students' performance was shown increasing regardless a small number of students who were still reluctant to participate. Students' participation increased during the group discussions since they were comfortable asking to their peers instead of to the teacher. Group setting also played an important role in improving students' critical thinking skills. It is in line with the study conducted by Filsaime (Haryani, 2012) which states that in order to improve students critical thinking skills through discussion method, the teacher should create comfortable atmosphere for students to interact with one another. In conclusion, the learning process from cycle to cycle influenced students' ability in developing their critical thinking as stated by de Bono dan Syaban (Haryani, 2012) that Mathematics learning can develop students' critical thinking.

CONCLUSION

The students' mathematical critical thinking skills have improved from cycle to cycle; however the result shown was less satisfactory as there were only half of the number of participants who were able to complete the MCT test successfully. Generally, the result showed that there was improvement in students' enthusiasm in learning in each cycle, particularly during group discussion. Students were more willing to express their thoughts in front of the class which resulted in better understanding of the lesson.

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