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Students' Critical Thinking in Solving Statistical Problems Collaboratively

Latifah Nuryah Rachma Mufidah[1], Siti Khoiriyah[2]

[1,2] Universitas Negeri Surabaya, Kampus Ketintang Surabaya 60231, Indonesia
Email: latifah.19006@mhs.unesa.ac.id, siti.19048@mhs.unesa.ac.id

Abstract

Critical thinking and collaborative is an ability that is needed by students in 21st century education. The purpose of this research is to describe students' critical thinking skills in solving statistical problems collaboratively. The type of research used in this study is descriptive research with a qualitative approach. The subjects of this study were 4 grade 11 students of SMA Negeri in Mojokerto where students would work in pairs or collaborate with 2 people to solve statistical problem-solving questions. The research methods used are critical thinking skills tests in collaborative statistical problem solving and interviews. The results obtained from this study showed that students' critical thinking skills in solving statistical problems collaboratively were divided into two categories, namely high and low. Subjects who have a high critical thinking ability category are able to fulfill the indicators of interpretation, analysis, and inference. Collaboration ability in solving problems goes well. Collaboration exchanges information and gives advice to each other in solving the given problem. Subjects who have low critical thinking ability category are less able to interpret the problem, and fulfill the indicators of analvsis and inference. Collaboration ability in solving problems is less.
Keywords: critical thinking, collaborative problem solving, statistics

Abstrak

Berpikir kritis dan kolaboratif menjadi kemampuan yang sangat diperlukan siswa pada pendidikan abad 21. Tujuan penelitian ini mendeskripsikan kemampuan berpikir kritis siswa dalam memecahkan masalah statistika dengan kolaboratif. Jenis penelitian yang digunakan pada penelitian ini adalah penelitian deskriptif dengan pendekatan kualitatif. Subjek penelitian ini adalah 4 siswa kelas 11 SMA Negeri di Mojokerto dimana siswa akan berpasangan atau berkolaborasi 2 orang untuk menyelesaikan soal pemecahan masalah statistika. Metode penelitian yang digunakan adalah tes keterampilan berpikir kritis dalam pemecahan masalah statistika secara kolaboratif dan wawancara. Hasil yang diperoleh dari penelitian ini kemampuan berpikir kritis siswa dalam memecahkan masalah statistika dengan kolaboratif terbagi menjadi dua yakni tinggi dan rendah. Subjek yang memiliki kategori kemampuan berpikir kritis tinggi mampu memenuhi indikator interpretasi, analisis, dan inferensi. Kemampuan kolaborasi dalam memecahkan masalah berjalan baik. Kolaborasi pertukaran informasi dan saling memberi saran dalam memecahkan masalah yang diberikan. Subjek yang memiliki kategori kemampuan berpikir kritis rendah kurang mampu dalam menginterpretasi masalah, dan memenuhi indikator analisis dan inferensi. Kemampuan kolaborasi dalam memecahkan masalah tergolong kurang.
Kata kunci: berpikir kritis, pemecahan masalah kolaboratif, statistika

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Introduction

In 21st-century education, critical and collaborative thinking skills are needed for students (Saputra et al, 2019). Since 1942, critical thinking has been a key goal in education (Ennis, 2015). In Permendikbud No. 20 of 2016, the government has determined that the standards of competence for graduating mathematics subiects in elementary to secondary school students are to think and act creatively, productively, critically, independently, collaboratively, and communicatively. Two standards in the Permendikbud can answer the challenges of 21st-century education, namely the ability to think critically and collaboratively. Critical thinking is an ability that a person has in thinking that is always curious about existing information to achieve a deep understanding. Critical thinking skills are

needed in the educational process to get high grades and are used to deal with daily activities and careers (Moon, 2007; Asyari et al, 2016). For this reason, critical thinking skills need to be developed at every level of education.

The need for facilities so that students' critical thinking skills can be further developed is supported by the results of the PISA study, which says that the critical thinking skills of students in Indonesia are still relatively low. Indonesian students are ranked 72 out of 79 participating countries. The test results showed that the average student score was 371 in reading, 379 in math, and 396 in science. These scores are below the average of 79 PISA participating countries, 487 for reading skills and 489 for math and science skills (OECD, 2019). These results are similar to the results of Trend in International Mathematics and Science Study (TIMSS), published by the Ministry of Education and Culture, showing that student scores in Indonesia are still below average, ranking 38 out of 42 countries.

PISA and TIMSS show that the score of critical thinking skills of students in Indonesia is low and still below average. Not achieving the indicators can influence the low level of critical thinking skills. Siswono (2018) states that indicators in critical thinking include the following: studying material, marking, and providing brief explanations, building basic skills, concluding, providing further explanations, strategizing, and tactics. These ability indicators allow students to think critically in solving problems. This shows that critical thinking is one of the things related to problem-solving.

Problem-solving is a process that individuals go through when facing or solving obstacles when the answer or answer method found is not yet clear (Siswono, 2018). Problem-solving requires a more complex thinking process and a high level of thinking ability. Meanwhile, Wardhani (2008) states that mathematical problem-solving activities include students' ability to understand the problems presented, model problems into mathematical models, solve models, and interpret the models obtained.

Based on this description, problem-solving requires critical thinking skills. Winarti et al. (2019) stated that for the problem-solving process to be more effective, it should be done in teamwork, making children better understand the lesson and each other. Rinadin (2020) stated that collaborative problem-solving with critical thinking skills has a significant effect. The results show that when students solve problems collaboratively, the level of students' critical thinking skills tends to increase. One that can build critical thinking skills is a collaboration (Laal et al., 2013). This opinion is the basis that collaborative problem-solving is needed. Students can contribute fairly to the problem-solving process.

This study aims to describe students' critical thinking skills in solving statistical problems collaboratively. It is expected to be a reference and reflection material for teachers in the development of students' critical thinking in the future.

Literature Review

Critical Thinking Ability

Sander & Moulenbelt (2011) defines *critical thinking* as reasonable thinking and reflective thinking toward deciding something. People can have critical thinking skills if they can deduce what is

known from the problems given, know the steps to use the information to solve a problem, and find sources of information suitable for solving the problems presented (Rahma, 2017). Tuzlukova & Usha-Prabhukanth (2018) state that critical thinking is an active and capable intellectual process of conceptualizing, applying, analyzing, synthesizing, and evaluating information obtained through observation, reflection, experience, or communication to guide beliefs or actions. Critical thinking ability can be influenced by not achieving indicators. Siswono (2018) states that indicators in critical thinking include the following: studying material, marking, and providing brief explanations, building basic skills, concluding, providing further explanations, strategizing, and tacties.

According to Facione & Facione (2013), the indicators of critical thinking skills are as follows.

1. Interpretation is the ability to understand and express the meaning of a situation, data, assessment, rules, or criteria that vary
2. Analysis is the ability to clear conclusions based on the relationship of information owned and concepts with what is asked from the problems presented.
3. Evaluation is the ability to assess the credibility of statements or other representations of one's opinion or assess a conclusion based on the relationship of the information and the concept with what is asked from the problem presented.
4. Inference is a person's ability to identify the elements needed to make relevant conclusions from a problem and its consequences according to the available data.
5. Explanation is the ability to reason by providing reasonable reasons from evidence, concepts, methodologies, and logical criteria obtained based on existing data.
6. Self-regulation is the ability to re-examine the cognitive activities of the self, the elements used, and the results obtained. By using analysis and evaluation to correct, validate and confirm the results of the reasoning that has been done.

According to Karim & Normaya (2015), the following indicators will be used by researchers.

1. Interpretation, which is the ability to understand the problems presented. This can be shown through knowing exactly what is known and what is asked in the problem presented.
2. Analysis is the ability to identify the relationship between the information or data obtained with the concepts and questions given in the problem. It is shown by making mathematical models appropriately and providing logical explanations.
3. Evaluation is the ability to accurately use strategies in solving problems completely and correctly in calculations.
4. Inference, which is the drawing of appropriate conclusions from the results obtained

This research refers to the critical thinking indicators, according to Facione, which have been adapted by Normaya, namely Interpretation, Analysis, Evaluation, and Inference.

Table 1. Indicators of Critical Thinking and CPS Normaya Adaption

Common Indicators	Sub Indicators
Interpretation	a. Able to gather meaningful information on the problem presented. b. Able to categorize meanings so as to clearly state the statements in the problem.
Analysis	a. Investigating the data obtained to be deciphered and processed into a problem-solving strategy. b. Identify the interconnectedness of information, concepts, statements, and questions in order to find the right problem-solving strategies
Evaluation	a. Assess the truth of the statements presented by using appropite problem-solving strategies
Inference	a. Provide more than one correct answer or solution to the problem b. Provide logicl reasons for the answers given through the completion stage in drawing conclusions.

Collaborative Problem Solving (CPS)

The importance of critical thinking skills in solving problems that students must have in 21st-century demands requires an approach that can develop or train critical thinking skills. Knowing how a good and wise teacher can use learning methods to solve problems is necessary. Problem-based instruction will be more effective if students work together with each other. Students will find and understand difficult concepts more easily if they discuss them with each other, and students routinely work in groups to help each other solve complex problems. Cooperative learning is a group of learning strategies involving students working together to achieve a common goal (Garside, 1996). Thus, a more comprehensive approach is needed by adapting and integrating the best strategies from both approaches into a collaborative problem-solving approach.

The term Collaborative Problem Solving has various definitions depending on the context. Some studies define Collaborative Problem Solving as an approach to learning, and others define it as an ability that exists in students. For example, PISA defines Collaborative Problem Solving as the capacity of individuals to solve problems together by pooling the knowledge, skills, and efforts of each individual involved to find a solution to a given problem (Stadler et al, 2020). While other researchers define Collaborative Problem Solving as a learning activity in which students work in small groups while learning mathematics to achieve a common goal (Albert & Kim, 2013). According to Dillenbourg (1999), Collaborative Problem Solving is a collaboration carried out by two or more people with the same goal, namely to solve a particular problem. Collaborative Problem Solving is supported by student problem-solving activities where students can make agreements based on their respective natural collaborative processes. Collaborative Problem Solving is an important and necessary skill in education and the workforce (OECD, 2015). Greene (1999) said through the book "The Explosive Child", states that Collaborative Problem Solving refers to two main principles, namely challenges in children's social interactions, emotions, and behavior which are understood as a by-product of cognitive development. Second, collaborative problem solving can be used as a focus of attention in dealing with a problem or challenge.

In this research, Collaborative problem-solving is considered a learning approach. Collaborative problem-solving strongly supports a strong problem-solving activity where learners engage in problems based on their scientific collaboration. Mathematical problems requiring some form of problem-solving are more applicable to collaborative learning than those requiring applying skills. Collaborative problem-solving is one of the essential approaches teachers can use to balance the development of practical skills independently and top-level problem-solving collaboratively (Albert & Kim, 2013).

From the above opinion, it can be concluded that Collaborative Problem Solving is a problem-solving activity where students effectively contribute to a problem-solving project which, in its stages, is solved together and share their knowledge to achieve the solution to the problem.

Table 2 Matrix of collaborative problem solving skills for PISA 2015

	(1)Establishing and maintaining shared understanding	(2) Taking appropriate action to solve the problem	(3) Establishing and maintaining team organisation
(A) Exploring and understanding	(A1) Discovering perspectives and abilities of team members	(A2) Discovering the type of collaborative interaction to solve the problem, along with goals	(A3) Understanding roles to solve the problem
(B) Representing and formulating	(B1) Building a shared representation and negotiating the meaning of the problem (common ground)	(B2) Identifying and describing tasks to be completed	(B3) Describing roles and team organisation (communication protocol/rules of engagement)
(C) Planning and executing	(C1) Communicating with team members about the actions to be/ being performed	(C2) Enacting plans	(C3) Following rules of engagement (e.g., prompting other team members to perform their tasks.)
(D) Monitoring and reflecting	(D1) Monitoring and repairing the shared understanding	(D2) Monitoring results of actions and evaluating success in solving the problem	(D3) Monitoring, providing feedback and adapting the team organisation and roles

By the Matrix of collaborative problem-solving skills for PISA 2015, there are three main components in collaborative problem-solving, namely:

1. Building and maintaining shared understanding, in this aspect, individuals or students in one group are required to have the ability to build an understanding of the problems presented together, identify the point of view, ideas, and understanding of each student in one group, and build understanding regarding the activities and goals that have been set in order to achieve problem-solving solutions (C Graesser et al, 2018). Students must also be able to build, monitor and maintain shared understanding throughout the problem-solving task by responding to requests for information, transmitting important information about the task being solved, constructing or negotiating shared meaning, verifying what each other knows, and taking action to correct deficits in shared knowledge. This skill involves students' self-awareness of proficiency in performing the task, recognizing their own strengths and weaknesses in relation to the task (metamemory), and recognizing the strengths and weaknesses of other partners (transactive memory).
2. It is taking the right action to solve the problem. This aspect requires students to be able to identify actions to be taken to achieve the desired solution. This includes understanding the constraints of the problem at hand, creating team goals to achieve the solution, taking action on the task, and monitoring the results concerning the group goals and the problem. These actions may include means of communication,

such as explaining, justifying, negotiating, arguing, and debating, in order for complex information and perspectives to be transferred and for more creative or optimal solutions to be reached.

It is building and maintaining organizational cohesiveness. This aspect means that students must be able to organize in groups, for example, when they are leaders or members. This also includes understanding each task that has been distributed according to the abilities of each member, the responsibility of each member in doing their respective tasks, following the group agreement rules that have previously been set, and monitoring, evaluating, and providing feedback on the results obtained.

Method

This research seeks to explain or describe a situation systematically so that the research subject becomes clearer. Researchers use a qualitative approach in this study so that all facts obtained, both oral and written, from various data sources from participants will be described clearly, so that they can answer the problems in this study. This research aims to explain or describe students' critical thinking skills in solving statistical problems collaboratively. So the type of research used in this research is descriptive research. Descriptive research is research that aims to describe existing phenomena, both natural and man-made phenomena. The phenomena can be in the form of activities, relationships of change, characteristics, differences, and similarities between one phenomenon and another (Sukmadinata, 2006). The steps in this research consist of 4 stages: preparation implementation, data analysis, and report preparation (Siswono, 2018).

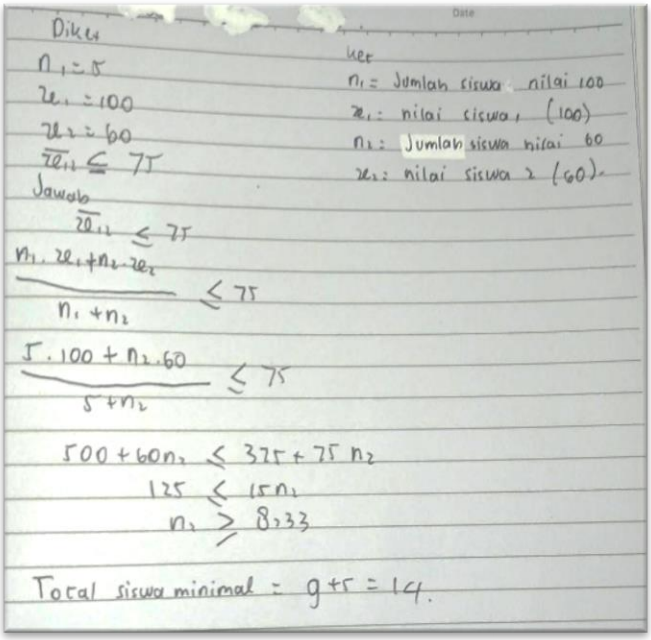
The preparation stage includes making research instruments and determining research subjects. The subjects in this study were students of SMA Negeri 1 Puri Mojokerto in grade 11, in which later students will pair up or collaborate with two people to solve problem-solving problems of statistics material. And then, the research subjects were selected in two categories, namely collaborative pairs of high and low mathematical abilities and high and moderate mathematical abilities, based on the results of mathematics scores on students' report cards. The research instruments used are critical thinking ability test questions in solving statistical problems collaboratively with indicators of interpretation, analysis, evaluation inference, and interview guidelines.

Furthermore, the implementation stage includes taking or collecting data from research subjects on collaborative problem-solving related to statistics and interviews conducted online through WhatsApp groups or video calls. The data analysis stage is carried out after the data has been collected. The data obtained was analyzed based on indicators of students' critical thinking skills in collaborative problem-solving—namely interpretation, analysis, evaluation, and inference (Munawaroh, 2020). At the interpretation stage, students are expected to be able to know what is known and ask from the problems presented. Existing information is understood and collected by students. The second stage is analysis; students can compile information from the problems given into a form of mathematical modeling. The next stage is evaluation; students can use the right strategy to solve the problem presented: inference stage, accuracy in concluding solving problems.

Furthermore, compile a research report on students' critical thinking skills in solving statistical problems collaboratively. The question of this instrument mainly is a school in city C held a math competition. The students of class XI A took the math test, with the following results. Five students scored 100, the other students scored 60. The terms of the competition indicate that if the average score of the class is at least 75, it will get extra points. Class XI A gets the extra point. What is the least number of students in the class?

Results and Discussion

In this research, the subjects were two groups, each containing two students. This study's subject refers to the mathematical ability level of students measured based on their mathematics grades on the school report card. The research subjects were selected in two categories: collaborative pairs of high and low mathematical ability and high and moderate mathematical ability based on students' math report card scores. Furthermore, the subjects solved problems in the form of problems collaboratively. Subjects were given a statistics problem followed by an interview about critical thinking in problem-solving through a WhatsApp group. The results of the discussion of activity sheets and interviews will then be analyzed based on indicators of students' critical thinking in collaborative problem-solving.



Known Information:
$n_1 = 5$ n_1 = the number of student, the value 100
$\mu_1 = 100$ μ_1 = the value of student, (100)
$\mu_2 = 60$ n_2 = the number of student, the value 60
$\bar{\mu}_{12} \leq 75$ μ_2 = the value of student 2, (60)

Answer:
$\bar{\mu}_{12} \leq 75$

$\frac{n_1.\mu_1+n_2.\mu_2}{n_1+n_2} \leq 75$

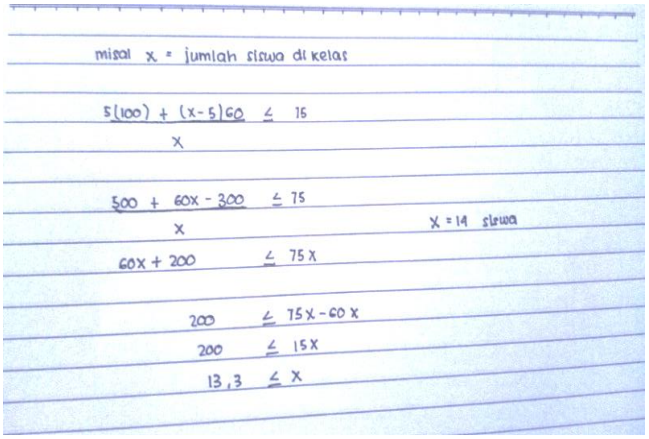
$\frac{5.100+n_2.60}{5+n_2} \leq 75$
$500 + 60.n_2 \leq 375 + 75.n_2$
$125 \leq 15\ n_2$
$n2 \geq 8.33$
Minimum number of students

Figure 1. Students' answer 1

Based on the indicators of students' critical thinking in collaborative problem solving, the critical thinking process of subject one consisting of high and low mathematical ability students shows that: 1) in the interpretation step, the subject mentions what is known correctly, but for what is asked in the problem that has been given has not been mentioned. The subject also has yet to mention that the average information is 75. 2) In the analysis step, the subject has correctly modeled the given problem in mathematical modeling 3) In the evaluation step, the subject uses the right way to solve the problem.

However, one step needs to be corrected in the calculation, namely in rounding the decimal value for the number of students. The subject is directly rounded without giving information. The subject should explain why the rounding is needed 4) At the inference step, the subject can conclude correctly.

The interview results showed that the interaction between each other went well. Rinadin (2020) states that there is a significant effect of collaborative problem-solving with critical thinking skills. The existence of communication of division of labor and precise information evidences them. The collaboration in solving the statistics problem shows that subject 1 has high critical thinking.



Suppose x = the number of students in the class

$\frac{5(100)+(x-5)60}{x} \leq 75$ $\quad x \leq 13{,}3$

$\frac{500+60x-300}{x} \leq 75$ $\quad x = 14$ students

$60x + 200 \leq 75x$

$200 \leq 75x - 60x$

$200 \leq 15x$

Figure 2. Students' answer 2

Based on the indicators of students' critical thinking in collaborative problem solving, the critical thinking process of subject two consisting of students with high and medium mathematical abilities shows that: 1) in the interpretation step, subject two did not mention what was known in the problem presented. Furthermore, I should have mentioned what was asked in the problem. However, when the interview was conducted, the subject could correctly mention what known from the problem was presented 2) At the analysis step, the subject could correctly model the problem into a form of mathematical modeling. However, the subject did not mention in advance the formula used in the calculation.

The subject directly substitutes numbers variables without being given a description. Supported by Pambudi et al (2020) research which states that in analyzing the facts/data in the problem, students have many difficulties in linking with relevant mathematical concepts, confusing modeling into mathematical form 3) In the evaluation step, the subject ean find the right way of solving problems and calculations. 4) the subject needs to draw conclusions more precisely at the inference step. The subject directly mentions the number of students is 14. The subject should have given the conclusion that the number of students is at least 14. The interview results showed that the discussion on subject two could have gone better, indicated by the unclear division of group tasks. The subject needed help determining the solution method, so decision-making was not carried out collaboratively. Subject 2's collaboration in solving statistical problems has low critical thinking ability. From the collaborative problem-solving process, subject 1 worked well in the group, exchanging information/ideas. This study also found that

subject 2 experienced a less clear division of tasks and a need for more communication in subject 2. This shows that subject 2 is not optimal in collaborative problem-solving activities. Communication is the main means of building shared understanding, as modeled in Common Ground Theory (Clark, 1996; Clark & Brennan, 1991).

Conclusion

Based on the results and discussion of students' critical thinking skills in solving statistical problems collaboratively, it can be divided into two categories: high and low. Subjects with a high critical thinking ability category can fulfill the indicators of interpretation, analysis, and inference. Collaborative ability in solving problems goes well. Collaboration exchanges information and advises each other in solving the given problem. Subjects with low critical thinking ability are less able to interpret the problem and fulfill the indicators of analysis and inference. Collaboration ability in solving problems is less. The results obtained are expected to be used as a reference in conducting similar research. They can be used as a basis for thesis/consideration and evaluation tools to determine students' problem-solving skills.

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