Mathematical collaborative learning in 21st century based on national science olympiad in junior high school

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Abstract. Learning in 21st century is no longer interpreted as process of transfer of knowledge from teachers to students, but rather emphasizes the efforts of teachers to facilitate students in constructing concepts and solving problems independently. The purpose of this study was to describe mathematical collaborative learning in 21st century. It was qualitative research. The research was conducted at SMP Negeri 1 Colomadu Karanganyar in 2019/2020 academic year. The research instruments included lesson plans, problem solving tasks, and observation sheets. Data validity used time triangulation. Data analyses were done through data collection, data reduction, data presentation, and drawing conclusion. Based on results, 1) The ability of critical thinking: students were skilled in concluding discussion result that had been carried out with logical assumptions and were able to determine the right actions to solve the problems; 2) The ability of creativity: students were skilled at formulating complex problem solving strategies; 3) The ability of collaboration: there was a positive dependence among students so that an academic support system was embodied, in which each group member was committed to achieve mutual success; 4) The ability of communication: there was dynamic interaction between group members and teachers, so that learning occurs effectively.

1. Introduction
The rapid development of science and technology in the 21st century gives boundless limitation of time and space for each individual to seek information and communicate. The rapid development of science and technology also impacts on global challenges and competition faced by each country, especially education in Indonesia. Learning on 21st century requires individuals to have critical thinking skills, creativity skills, collaboration skills, and communication skills to face the challenges of the 21st century globalization [18]. Critical thinking skills are the individual's ability to provide simple explanations, build basic skills, make conclusions, make further explanations, and set strategies. Creativity skills are the individual's ability to generate new ideas. Collaboration skills are the ability of individuals to work together effectively and responsibly in group discussions. Communication skills are the ability of individuals to articulate mathematical ideas using communication skills. These four skills are essential for students to keep up in the 21st century [17].

The 21st century learning is no longer defined as the process of transferring knowledge from teachers to students, but it focuses on teachers’ efforts to facilitate students in constructing concepts and solving problems independently [2]. To realize this, the teacher as the spearhead of learning must be able to plan and implement quality learning so that the planned learning objectives can be achieved. Success in implementing learning in the 21st century is not only seen based on academic achievement but is seen based on skills in solving non-routine problems, such as Olympiad questions. A widely
circulated paradigm in society related to the difficulty in solving the Olympiad questions is presumably still current. This is because the national science olympiad questions’ characteristics include: (1) Unique questions that require creative thinking, logic, and in-depth analysis; (2) It cannot be solved using only formulas; and (3) It takes a longer time to solve these questions than other routine questions [3].

Based on the results of observation conducted by researchers at SMP Negeri 1 Colomadu Karanganyar, they found that many students still had difficulty on understanding and solving Olympiad-type math questions. The results of interview were strengthened by the result of observation with one of the mathematics teachers. He explained that students were less innovative in inferring other learning sources. Thus, they only depend on the information from the teacher.

Olympiad questions require problem-solving skills. Students are expected to be able to select and identify relevant conditions and concepts, formulate plans for completion, and organize prior knowledge to obtain a generalization to have problem-solving skills [16]. The problems discussed have a different meaning from routine assignments or questions. If a problem (question) is given to a student and he immediately knows how to solve it correctly, then the question cannot be said as a problem [5].

When studying Science, there is a fundamental difference between solving routine questions and Olympiad-type questions. In solving routine questions, students are only required to immediately get the correct answer by entering numbers into the formula that has been given previously. Meanwhile, in solving Olympiad questions, students cannot directly find a solution, but they need to reason, guess or predict, even look for simple formulas and then prove them [14]. This is because the Olympiad questions train students to master math/science concepts and terms; identify the essential elements and choose the correct procedure which is focusing on similarities, differences, and analogies; and analyze the results of problem-solving and change strategies if the problem solving is considered incorrect [2].

Through the Ministry of Education and Culture, particularly at the Directorate General of Primary and Secondary Education, the government facilitates Olympiad activities, namely the National Science Olympiad (OSN), as an effort to increase student creativity in the fields of science and technology. OSN on Mathematics in Junior High School (SMP) still need to be socialized to students, parents, teachers, and school supervisors. In fact, the information about the Olympiad which contains the selection of talented students in mathematics has not been implemented optimally.

Educators are expected to be able to create fun and quality learning. These aim to increase student’s enthusiasm for participating in OSN activities related to the talent selection event in mathematics. This learning can be achieved through collaborative learning. The terms of collaborative learning and cooperative learning are often used interchangeably. Collaborative learning and cooperative learning are two different terms. In collaborative learning, students are responsible for their learning and try to find information to answer the questions they are faced with [7]. Here, the teacher acts as a facilitator, providing support without leading the group towards the results that have been prepared in advance. Meanwhile cooperative learning is a broader concept, which includes all types of group work, and discussion activities are guided and directed by the teacher. The teacher assigns tasks, and questions and provides materials and information designed to help students solve the problems.

Collaborative learning is a situation in which two or more people are learning or trying to learn something together [12]. Unlike individual learning, an individual who engages in collaborative learning uses each other's resources and skills (requesting information from one another, evaluating one another’s ideas, monitoring one another’s work). Furthermore, Roselli [12] explains that collaborative learning is based on a model in which knowledge can be created in a population. Its members actively interact by sharing experiences, and each individual depends on and is responsible for one another. To implement the more effective and directed collaborative learning, the teacher must combine it with lesson study activities. This is because a series of lesson study activities emphasize student learning activities.
The implementation of lesson study-based collaborative learning consists of four activity stages, namely planning, implementation, reflection, and follow-up. If we want to observe more deeply, the things raised during the reflection stage in the lesson study activities are authentic data from the results of observations, so that it can be used as a basis for improving the quality of subsequent learning [8]. Lesson study does not prioritize solving problems and difficulties, however dividing problems, interacting, and thinking about solving problems together. Based on the previous description, collaborative learning through lesson study activities is essential to maximize the potential and talents of students in OSN activities.

2. Research Methods
This research used qualitative research. Qualitative research emphasizes on meaning that is closely related to specific values, more emphasis on process rather than measurement, describes, interprets, and gives a meaning that is not sufficient by little explanation because it utilizes multiple methods in research [15]. The research was conducted at SMP Negeri 1 Colomadu Karanganyar in the Odd Semester Academic Year 2019/2020. The research subjects consisted of teachers and students. The first step in implementing this research involved identifying the form of coaching mastery of the concept of Olympiad activities, training interactive learning media, and holding meetings with the coaching team to formulate strategies and work schedules which were then developed in the form of research instruments. The research instruments included a lesson plan, student worksheets, and observation sheets.

The validity of the data was carried out by time triangulation. Time triangulation was done by collecting data at different times. If the data obtained at different time collections give the same results, then the data is said to be valid [13]. Data were obtained through observation and documentation of student work results. Data analysis was conducted through data collection, data reduction, data presentation, and drawing conclusions. Data collection activities up to data analysis in this research are illustrated in Figure 1.

![Figure 1. Data collection activities up to data analysis for this research.](image-url)
3. Results
The implementation of lesson study-based collaborative learning consists of four activity stages, namely planning, implementation, reflection, and follow-up. The details of the activities at each stage are as follows.

3.1. Planning stage
At the planning stage, the research team and the teachers who are members of the lesson study collaboratively compiled a lesson plan of mathematics oriented to the national science olympiad. The first steps in conducting research include identifying forms of coaching for mastery concept, training Microsoft 365 application as an interactive learning medium, drafting research instruments (student worksheets), and compiling learning strategies. The activities carried out at this planning stage were obtained based on the analysis of pre-survey activities carried out by the research team during the learning process, such as: know the teaching steps for delivering the material to students, encounter the learning atmosphere in class, cope with the lack of learning facilities, and collaboratively look for solutions and solve the problems during the learning process conducted by the teacher. Research documentation at the planning stage is shown in Figure 2.

The research team gave intensive coaching on the concept mastery and strategies of Olympiad questions to Mathematics teachers. The teachers enthusiastically welcomed the activity. Several teachers were actively involved in coaching activities. Furthermore, a model teacher named Mr. Sunarto, S.Pd. was chosen to be a model teacher because he is the advisor of Olympiad at the school. In this research, the research team acted as observers who conducted observations during the learning process.

Figure 2. Research documentation at the planning stage.

3.2. The implementation stage
In this stage, activities that have been designed in the planning stage were implemented. Mathematics learning was carried out based on the lesson plan oriented to the national science Olympiad. The details of the learning implementation are explained as follows.

3.2.1. Opening activities
In opening activities, the teacher provided apperceptions and learning objectives by asking and answering questions about the relationship between basic competencies that would be achieved with previous knowledge (the teacher provided illustrations using Microsoft 365 as the interactive media by using projector). Students were enthusiastic in apperception activities. This is because the use of Microsoft 365 as interactive media is new thing for them. The documentation of opening activities in the implementation stage is shown in Figure 3.

Figure 3. The documentation of opening activities.
3.2.2. Main activities

The teacher divided students into heterogeneous groups (1 group consisted of 4 students). Each group was given a student worksheet to complete. The teacher provided the opportunity for each group to present the results of the discussion. This discussion activity encouraged students to collaborate. This was shown by students who were actively competing so that their groups were superior to other groups. Documentation of main activities in the implementation stage is shown in Figure 4.

Figure 4. The documentation of main activities.

3.2.3. Closing activities

The teacher and the students made a summary of the learning material. At the end of the lesson, the teacher gave a problem as a follow-up activity to be solved independently. The documentation of closing activities in the implementation stage is shown in Figure 5. The researchers conducted a post-test at the end of the lesson. The post-test was done independently by each individual. The post-test results showed that 80% of the 36 students were able to answer the questions correctly. The results of students’ work during the post-test are shown in Figure 6.

Figure 5. The documentation of closing activities.

Questions:
Mr Idris has a square apple garden and Mr Halim has a rectangular watermelon garden. Mr Halim’s watermelon garden’s length is 10 m more than the side length of Mr Idris’s apple garden. In contrast, the width is 3 more than the side length of Mr Idris’s apple garden. Supposing it is known that Mr Halim’s garden is 450 m$^2$. What is the area of Mr Idris's apple garden?

Students were able to associate the material with previous knowledge acquired before. Students were able to determine the right action to solve the problem.

Thus, the area of Mr Idris’s apple garden = $15 \times 15 = 225$ m$^2$. It means that students finished the task correctly.

Figure 6. The results of students’ work in post-test.
3.3. The reflection stage
In the reflection activity, the teachers and research team (as observers) held a discussion related to the learning that had just been carried out. The model teacher who carried out lesson plan’s implementation was allowed to state his impressions during the learning process, both for himself and for the students that he taught. The model teacher gave the impression that using Microsoft 365 as interactive learning media made students enthusiastic in learning. The model teacher also explained that giving a challenging student worksheets will challenge them to seek various sources of information to solve the problems they faced. Students actively asked questions during discussion activities, even the creativity of students in solving problems was increasingly diverse. The research team also found that there was still a time gap in learning, so that students used it to converse and annoy other friends.

Researchers as observers conveyed their observational data analysis results, especially those relating to students during learning. The observation results obtained are shown in Table 1.

| Skill           | Observation Description                                                                 | Time  |
|-----------------|------------------------------------------------------------------------------------------|-------|
| Critical thinking | Students provided a simple explanation regarding the relationship between the previous material and the material to be studied. | 2nd minute |
| Communicate     | There was dynamic interaction between group members and teachers.                        | 15th minute |
| Creativity      | Students were creative and innovative in presenting the results of the discussion.        | 45th minute |
| Collaboration   | Each member of the group was committed to achieving mutual success. This was shown by the competitive competition between groups in presenting the results of the discussion. | 60th minute |

3.4. The follow-up stage
The researchers followed-up the results of the reflections which were then used as a guideline for improving the next learning. The research team also found that there was still a time gap in learning so that students used it to converse and annoy other friends. The remedial stage was done to increase the difficulty of student worksheets. Because there was an increase in the difficulty of student worksheets, the discussion activities became more meaningful, and students could also take advantage of the learning discussion time optimally.

4. Discussion
At the planning stage, teachers received intensive training by the research team. The coaching focused on compiling a lesson plan of mathematics oriented to the national science Olympiad, compiling student worksheets, and training the Microsoft 365 applications as the learning media. Meyer [9] explains that coaching is an effort to make learning more meaningful and based on the planning so that the learning progress program that is being implemented is always appropriate with the plan (does not deviate from what has been planned). The existence of coaching can change something into something new and it has better values for future life [10]. Thus, coaching activities to improve the quality of learning must always be carried out.

The implementation of collaborative learning was welcomed enthusiastically by students. During the discussion, there was competitive competition among groups. This discussion activity encourages students to collaborate so that their group is superior to other groups. Students can give a simple explanation regarding the relationship between the previous material and the material to be studied.
This shows that students are proficient in critical thinking. Besides, there is a dynamic interaction between group members and teachers. Students are creative and innovative in presenting the results of the discussion. Each member of the group is committed to achieving mutual success. This is shown by the competitive competition between groups in presenting the results of the discussion. Collaborative learning emphasizes what information is collected, how to interpret the information collected, and how it can be used properly so that a solution is obtained [7]. Hence, collaborative learning influences how effectively students can anticipate change, adapt to new situations, and generate new solutions to the challenges.

Reflection was carried out after the learning practice activities conducted. Reflection is an activity to assess or observe or evaluate what has happened during learning. Teacher and the researcher team as observer were given a chance to express their impression. The model teacher gave impression that the implementation of Microsoft 365 interactive learning media made students enthusiastic in learning. This is because the interactive learning media attract the students’ attention towards the material given and help to provide learning experience that is difficult to obtain in other way [11]. The model teacher also explains that giving a challenging students worksheet trigger students to find various sources to solve the problem they faced. The challenging students worksheet can foster strong character and never give up on students [6]. The researcher team as observer got results that there was still a time gap in learning so that the students used it to converse or annoy other friends. The researcher team are in hand with teacher in lesson study group to do discussion activity to minimize the weaknesses. Discussion activity gave results that it was necessary to increase the difficulty of discussion questions so that the available time could really be maximized by students for group discussion activity. It is expected that the time during the discussion will be used optimally because difficult questions require more time than the routine questions.

Follow-up was a stage that must be taken in order to improve subsequent learning. This follow-up aims to improve the effectiveness and quality of learning [1]. The result of reflection in the previous stage were the basic for implementing follow-up activities. The improvement in the difficulty level of students’ worksheet (the result of reflection stage) made the discussion activities more meaningful. Math problem which has a high difficulties level can form a logical and systematic mindset of students then they will get used to solving the next difficult questions [4]. Students also made optimal use of learning discussion and it had impact on positive dependence among students. The positive dependence among students could embody an academic support system, in which each group member was committed to achieve mutual success. Thus, the collaborative learning oriented to the national science olympiad can be realized.

5. Conclusion
Based on the research result, it was concluded that collaborative learning oriented to the national science olympiad through lesson study activities could provide students to have 21st century skills. These skills include: 1) Critical thinking: students were skilled in concluding discussion result that had been carried out with logical assumptions and were able to determine the right actions to solve the problems; 2) Creativity: students were skilled at formulating complex problem solving strategies; 3) Collaboration: there was a positive dependence among students so that an academic support system was embodied, in which each group member was committed to achieve mutual success; 4) Communication: there was dynamic interaction between group members and teachers, so that learning occurs effectively.

Open problem
Focus this research was describe mathematical collaborative learning in 21st century based on national science olympiad in junior high school. Researchers can examine: how many influence of collaborative learning in the increase of national science olympiad program?
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