Evaluation of collaborative problem-solving skills: students social and cognitive skills on the parabolic motion material

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Abstract. Education is currently demanded to be able to provide 21st century skills to students so that they can be successful in the world of work and life in the future. One of the 21st century skills of particular concern is Collaborative Problem Solving (CPS) which plays an important role for students to be able to solve a problem collaboratively. This study aims to obtain an overview of CPS skills of students in the pursuit of physics. CPS is analyzed through two domains, social skills and cognitive skills. The subjects in this study were students of grade 10 in a public high school in Riau. Data is collected by giving problems of application of parabolic motion in everyday life. Students' answers on answer sheets and recorded conversations of students are then analyzed using a rubric of CPS skills. The results showed that CPS skills of students in social skills and cognitive skills are still dominated in the low and middle categories. This result does not contain all the indicators developed by Hesse et al. several obstacles were also found in the assessment process. For this reason, further research is recommended to assess all indicators and use computer-based assessments.

1. Introduction
Today's education must be able to create a generation that has 21st century skills to succeed in their lives [1]. There are many models proposed to provide a 21st century skills framework that is categorized into four types of skills, namely collaboration, communication, ICT literacy, and social and / or cultural skills; nationality [2, 3, 4]. Collaborative skills are considered important in complex problem-solving processes. Collaboration has an important contribution for each individual, for example being able to be flexible in actively participating and recognizing success as a group effort and each group member. Also, when someone is required to be able to work together with various groups in an increasingly globalized culture and economy [5]. In Education and the world of work, collaborative skills are needed to overcome complex problems. So, there is a shift in the assessment process from solving individual problems to collaborative problem solving [6]. Furthermore in 2015, the Organization for Economic Cooperation and Development (OECD) in the Program for International Student Assessment (PISA) on the skills and knowledge of students chose Collaborative Problem Solving (CPS) as the latest development of 21st century skills for the 2015 international survey [7].

Collaborative Problem Solving (CPS) defined as an ability to be able to work responsively and exchange ideas in a group to take certain steps in finding solutions to a given problem. CPS consists of
social skills and cognitive skills. Social skills as part of the collaborative aspects of problem solving consist of three indicators: participation, perspective development, and social regulation. Whereas cognitive skills as part of the reasoning process in problem solving consists of two indicators: task regulation and knowledge building [8].

Several studies on CPS skills have been carried out to determine how to assess CPS skills as part of 21st century skills assessments [9, 10]. They reveal that practical and adaptive skills are a challenge in the skills assessment of the 21st century. For this reason, a shift in the field of complex construction assessment is required so that a comprehensive assessment caused by knowledge or skills can be carried out. The framework in the CPS process emphasizes communication that aims to collect information, identify information obtained, identify and analyze patterns contained in data, formulate possibilities or rules, generalize rules, and test hypotheses [11]. Other studies have tried to examine the relationship between collective creativity competence (CC) and collaborative problem solving (CPS). The results show that there are statistically different CC competencies between groups of successful and unsuccessful CPS students. In Indonesia, research on CPS has not been done much more focused on the application of CPS as a model or method of learning to improve a knowledge domain [12, 13]. Although collaboration skills have been a topic in many different studies (social, educational and psychological experiments), the construct of CPS skills is seen as a relatively new construct [14].

Based on the description of the CPS skills, it can be seen that this skill is a very important skill in 21st century education and is classified as a new construct. In addition, research in Indonesia related to CPS skills has not been done much especially in physics. For this reason, it is necessary to conduct research as a preliminary study to find out the CPS skills of students on physics material. Based on the identification results needed for 21st century education, there is a strong consistency in the findings of all global organizations and research groups. Most of the competencies identified are in the cognitive and social domains, even though they are identified in different systems and ways [15]. CPS is very useful for solving a complex problem, namely as a complex skill consisting of cognitive and social processes [16]. For this reason, this study aims to conduct an analysis of CPS skills in the domain of social skills and cognitive skills of students in accordance with indicators developed by Hesse et al on the material of parabolic motion. Furthermore, the results of this study are expected to be a basis and reference for more advanced research related to CPS skills.

2. Methods

2.1 Participant

10th grade students of public high school in Riau were chosen as subjects in this study. The determination of the research subject was carried out by purposive sampling by considering that the chosen subjects consisted of active students in the online learning process. They numbered 20 people consisting of 10 male students and 10 female students. The school where they study is a public school with adequate facilities for learning that emphasizes 21st century skills.

2.2 Instrument

The instrument used in this study was a parabolic motion question in the form of a description specifically designed to assess collaborative problem solving (CPS). This problem is the application of parabolic motion material in daily life in the field of sports. The problem was validated by six high school teachers in Bandung and the alpha coefficient (alpha Cronbach) was 0.820 [17]. Students who are divided into small groups are instructed to find the right strategy so that a striker can score before time runs out. The results of students’ answers are analyzed using an assessment rubric by identifying a keyword.

2.3 Research Design

This research is a qualitative research with case study method with embedded, single-case design [18]. 10th grade students were chosen as subjects in this study with a focus on single case studies on Collaborative Problem Solving (CPS) skills from aspects of social skills and cognitive skills. Data
analysis was carried out in four stages namely, data collection, data reduction, data display, and verification. Data collection was carried out through the provision of problems in the form of CPS tests on parabolic motion material to be later solved by the research subjects with group members. Research subject conversations during the problem-solving process are recorded as research data. Data reduction is done by changing the recorded conversations of students in written form (script) as a process of combining and uniforming all data. Data display is done by processing the data into a form of categorization matrix in accordance with certain themes, which ends by providing a code in accordance with the results of data reduction. Student conversation scripts were analyzed to find the keywords of each indicator CPS in each student's conversation. Furthermore, each keyword that arises from the conversation of students is categorized in the low, middle, and high categories. Verification is done by outlining the categories of themes that appear in the categorization and coding table that have been completed to obtain conclusions about students' CPS skills on aspects of social skills and cognitive skills.

3. Result and Discussion
The results of the analysis of student conversations on aspects of social skills in solving problems are shown in Table 1.

| Element | Theme that appears                                      | Low               | Middle           | High          |
|---------|---------------------------------------------------------|-------------------|------------------|---------------|
| Action  | - Answering according to the context of the problem, not trying in a different context | S1.7, S2.7, S1.8, S2.8, S1.9, S2.9 | S1.1, S1.2, S1.2, S2.2, S1.3, S2.3, S1.4, S2.4, S1.5, S2.5, S1.6, S2.6, S1.10, S2.10 | - |
|         | - Involved in a little activity                         |                   |                  |               |
|         | - Have the initiative in starting a conversation to solve a problem | S1.1, S1.3, S1.5, S1.7, S2.7, S1.8, S2.8, S1.9, S2.9 | S1.2, S1.4, S2.4, S1.6, S1.10, S2.10 | S1.1, S2.2, S2.3, S2.5, S2.6 |
| Interaction | - Passive in responding to a question or answer a friend |                   |                  |               |
| Task completion/ perseverance | - Try strategies different for solving problems | S1.2, S2.2, S1.3, S1.6, S1.7, S2.7, S1.8, S2.8 | S1.4, S1.5, S1.10, S2.10 | S2.1, S2.2, S2.3, S2.4, S2.5, S2.6 |
|         | - Induce a way of solving the problem                   |                   |                  |               |
|         | - Not giving instructions as Steps for solving problems | S1.9, S2.9        |                  |               |

These results are based on keyword identification which arises from student conversations during the problem-solving process. For action indicators, the majority of students have worked in accordance with the context of the problem presented. Students start by determining the initial speed of the ball in the x and y directions, then determine the maximum height reached by the ball and calculate its elevation angle. But students in each group have not shown an action to apply the context of the main problem to a different problem context. For example, they don't do tests to find out what happens if the elevation angle is greater or smaller than the elevation angle they get. Students only work using contexts that are familiar with them, and do not try an activity with a new context that is not familiar. Whereas applying a problem context in the context of a new problem is very important as the process of developing problem-solving skills [19, 20, 21]. The following are excerpts of students' conversations in finding solutions to the problems given.
S2.2: Yes already, Means the strategy for scoring goals is by throwing
S1.2: With Direct speed just the speed ...
S2.2: Throwing the ball with
S1.2: Speed of 20.30 m / s with an elevation angle of 52..
S2.2: With a 52-degree tan angle. Already graduated ....

For interaction indicator, some students have done a good interaction between group members. However, some other students tend to be passive in responding to the group members' conversation during the problem-solving process. Some findings show that only one student is active during the problem-solving process in each group, while other members simply listen and respond with short answers. While the collaborative process is very important role by actively participating in the problem-solving process [22, 23]. The following are excerpts of students' passive conversations during the problem-solving process.

S2.5: If I look first look for the x-axis movement review first
S1.5: Hmmm (Students who are passive)

For the task completion/perseverance indicator, A small number of students included in the high category in the process of solving problems or parts of individual tasks. They tend to be more active than their peers by solving each part of the problem. The following are excerpts of students who tend to be active in the process of arranging problem solving.

S2.3: From the y axis, Y is equal to v sin a at times t minus 0.5 times gt the root of two Y here is equal to three. So three is equal to v sin a times t comma two times 3.2 less five times gt root two Three equals v sin a times 3.2 equals 5 times 3.2 root 2. So the result of v sin a is seventeen
S1.3: Where do those five come from?

This active student has more role in explaining the solution in each step of the solution to the group members. However, most students are still indifferent in the process of solving problems or parts of individual assignments. If seen further, these ignorant students are classified as students who are weak in knowledge. In the process of discussion, they tend to ask their colleagues and never provide alternative solutions to problem solving.

The results for CPS skills on cognitive aspects are shown in Table 2. The assessment is carried out only on the task regulation element which consists of 5 indicators. For the Organizers indicator (problem analysis) most students are able to describe problems with their own language according to their understanding owned. They write physical variables that are known in the problem. Then determine what formulation is appropriate for connecting these variables. Following are excerpts of students' conversations in describing the variables.

S1.4: Continue to height = 3 meters, Gravity 10 m/s², Continue time = 3.2 seconds
S1.3: What is asked, consider the initial velocity and angle of ball elevation

Although students in each group have been able to identify the variables needed, but students have not been able to make a sequence of sub-tasks needed in solving problems. They write these variables randomly, depending on which variable they are able to define first. This makes them difficult in solving problems in a structured manner, tends to be confused and guessing.

For indicator sets goals, almost every student does not set clear goals in solving problems. They have a tendency to resolve quickly. Even though problem solving requires a process to construct knowledge [24, 25]. Because it does not set goals in the beginning, the student's problem-solving process eventually becomes less directional. The impact is the process that students do to solve problems become unstructured clearly. For resource management indicators Most students utilize the resources of people, namely members of the group. The point is students in each group complement
each other's knowledge where students who do not understand tend to ask students who already understand. There is an exchange of information and understanding in the process carried out by students during problem solving. In collaboration, exchanging understanding has a positive impact on students to build knowledge of each other [26, 27]. Although it cannot be denied, there are a small number of students who tend to be passive in the process of exchanging understanding. So, the process tends to be one-way from one student to second and not vice versa.

**Table 2. Results of cognitive skills analysis**

| Element                          | Theme that appears                                                                 | Low 0                      | Middle 1                      | High 2 |
|----------------------------------|------------------------------------------------------------------------------------|----------------------------|-------------------------------|--------|
| Organises (problem analysis)     | - Outlines problems with own language that are understood                           | S1.1, S1.7, S2.7           | S2.1, S1.2, S2.2, S1.3, S2.3, S1.4, S2.4, S1.5, S2.5, S1.6, S2.6, S1.8, S2.8, S1.9, S2.9, S1.10, S2.10 |
|                                  | - Unable to describe variables with their own language                              |                            |                               |        |
| Sets goals                       | - Determine goals in general in accordance with the questions in the problem        | S1.1, S2.1, S2.1, S2.2, S1.3, S2.3, S1.5, S2.5, S1.7, S2.7, S1.8, S2.8, S1.9, S2.9, S1.10, S2.10 | S1.4, S2.4, S1.6, S2.6      |        |
|                                  | - Does not specify goals in solving problems                                         |                            |                               |        |
| Resource management              | - Using books and understanding of group members in the problem-solving process    | S1.7, S2.7, S1.8, S2.8, S1.9, S2.9, S1.10, S2.10 | S1.1, S2.1, S2.1, S2.2, S1.3, S2.3, S1.5, S2.5, S1.6, S2.6 |        |
| Collects elements of information | - Identifying and understanding information in the problem                           | S1.1, S2.1, S2.1, S2.2, S1.3, S1.7, S2.7, S2.8 | S1.3, S1.4, S2.4, S1.5, S1.6, S1.8, S1.9, S2.9, S1.10, S2.10 |        |
| Systematicity                    | - Instruct other ways to solve problems                                             | S1.1, S1.2, S2.2, S1.3, S2.3, S1.4, S2.4, S1.5, S2.5, S1.6, S2.6, S1.7, S2.7, S1.8, S2.8, S1.9, S2.9, S1.10, S2.10 | S2.1   |        |
|                                  | - Resolve problems directly with one solution                                        |                            |                               |        |

For indicators collects elements of information Some students have been able to identify the nature of information needed to solve problems. For example, when they determine the initial velocity of a parabolic motion, they understand that a parabolic motion is a two-dimensional motion that must be analyzed in the direction of the x axis and the y axis. Though the information presented in the problem does not include the two axes. But students still have no difficulty in gathering information to then be structured and used in problem solving. This affects the achievement of the Systematicity indicator, i.e. there are no visible steps for systematic problem solving in the process of students. Even students do not do trial and error activities. They immediately provide answers that are not structured based only on information that is known. Not infrequently in conversation students look confused about where to start, what next, what is the solution, to doubt the final result. This result certainly does not have a good impact on students in building their knowledge. Moreover, physics is one part of natural science which is in the process of finding theory, laws and principles is carried out with structured steps [28].
In general, students' CPS skills are based on the results of data analysis, for social skills students are in all categories. However, most students are still in the low and middle categories. For cognitive skills the distribution of students is only in the low and middle categories, and not in the high category. These results indicate that students' CPS skills still need to be improved so that the distribution of student categories can be in the high category. In this study not all elements of CPS skills were assessed. So, the results obtained in this study do not represent the overall CPS skills. This is a limitation in this research related to the difficulty in analyzing research data where each element consists of several indicators and keywords which are then viewed one by one. Furthermore, there are two fundamental findings that become another limitation in this research due to the difficulty of controlling the research subjects. First, there are groups of students who are impressed as they are presenting the results of the discussion. They might work first, then read the results like they were presenting. Second is there are groups of students who have the same answer. There may be groups that work together to solve new problems and then present them separately. It is not in line, where the aim is to identify student collaboration in each group, not a combination of several groups. To be able to understand various variables in the collaborative process, we need a picture of the interaction between students in the process of solving problems together [29]. For this reason, the results of this study are only as a preliminary study to find out the students' CPS skills in two elements of CPS which can then be used as a comparison for further research. In future studies it is recommended to use a computer-based assessment that is able to record all interactions in students in real-time, use all indicators of CPS skills, and can be applied with a greater number of subjects. So that the limitations in this study can be overcome in order to obtain better results.

4. Conclusion
Students' CPS skills on social aspects are spread evenly across all categories, low, middle, and high. However, most of the distribution of students' CPS skills is in the low and middle categories. Students' skills in cognitive aspects are only spread in the low and middle categories. There are no students who are in the high category. These results indicate that most students still have difficulty in applying CPS skills to solve problems. For this reason, further research is needed to address the low levels of student CPS skills. Good research in the assessment process or research to find ways or methods that can improve students' CPS skills. This becomes important as an effort to prepare a generation that is able to survive and succeed in facing life in the 21st century.

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