

# Collaborative Problem-Solving Instrument for Assessing Student's Problem-Solving Ability: Initial Development and Validation

Ikhfan Haris<sup>1,\*</sup>, Arfan Arsyad<sup>2</sup>, Muhammad Sarlin<sup>3</sup>

<sup>1</sup> Faculty of Education, Universitas Negeri Gorontalo, Indonesia

<sup>2</sup> Faculty of Mathematics and Natural Sciences, Universitas Negeri Gorontalo

<sup>3</sup> Faculty of Education, Universitas Negeri Gorontalo, Indonesia

\*Email: [ifanharis@ung.ac.id](mailto:ifanharis@ung.ac.id)

## ABSTRACT

The purpose of the study is to develop an instrument of Collaborative problem solving for assessing the student's problem-solving ability. Collaborative problem solving is a critical competency of the 21st century for student and career readiness. To assess student skill in Collaborative problem solving, teachers must have instruments that can measure these abilities. This instrument was developed based on the adaptation and modification of the PISA 2015 collaborative problem-solving framework. The research method used is the method of research and development of the 4D instructional model (define, design, develop and disseminate) which in this paper will only describe the two first stages (define and design). Aspects of assessing the ability of students in Collaborative problem solving are adapted and modified within student activities in four activities: exploring and understanding, representing and formulating, planning and implementing as well as monitoring and reflecting. Through the stages of defining and design being carried out, an instrument for assessing Collaborative problem-solving abilities for junior high school students for science subjects has been developed based on the adaptation and modification of the PISA 2015 collaborative problem-solving framework. This study has developed some indicators to measure problem-solving abilities of student. The developed instrument consists of fifteen indicators. The result of developed instruments and rubric in this study can support further research in the future regarding collaborative problem-solving abilities.

**Keywords:** Ability, Collaborative, Instrument, Problem Solving, Student.

## 1. INTRODUCTION

The mastery of 21st-century skills called as problem-solving skills, critical thinking, collaboration, and communication skills, is believed to produce quality human resources [1] [2]. One of the 21st-century skills that have received a lot of attention from international institutions like PISA and ATC21S is collaborative solving skills. Collaborative Problem-Solving Skills is an essential and necessary skill in preparing students to become a qualified and successful workforce in a career [3] [4]. In its implementation in learning, collaborative problem-solving skills require interaction between students and each other in solving problems to achieve common goals [5]. The ability to collaborate for problem-solving is crucial to be developed so that students can work together in different groups as a

provision to face the globalization era of the 21st century [6] [7].

In Indonesia, the Ministry of Education has integrated collaborative problem-solving skills in the implemented curriculum in learning activities in responding to the importance of mastery of 21st-century skills. The improvement of the 2013 curriculum has developed several objectives, which are: 1) Strengthening student-centered learning patterns; 2) Strengthening interactive learning patterns (teacher-student-community-natural environment interactive, sources/ other media); 3) Strengthening network learning patterns (students can gain knowledge from anyone and from anywhere contact and obtain via the internet); 4) Strengthening active-seeking learning (active seeking student learning is further strengthened by the scientific learning approach); 5) Strengthening

individual and group learning patterns (collaborating); 6) Strengthening multimedia-based learning; 7) Strengthening mass-classical based learning patterns while still paying attention to the development of the special potential of each student; 8) Strengthening the plural science learning patterns; and 9) Strengthening critical learning patterns [8].

The teacher should teach the students by using the right strategies in learning activities so that students can have the ability to collaborate in problem-solving [9]. The implementation of this strategy has been carrying out practicum activities during the learning process [10]. Students who can collaborate in solving problems should master three components of collaborative abilities. The three components are to: 1) Demonstrate the ability to work effectively and respect team diversity; 2) Show flexibility and willingness to accept other people's opinions in achieving common goals; 3) Carry out joint responsibility in collaborative work because they are required to appreciate the contribution of each team member [11].

The importance of mastering collaborative problem-solving abilities for students made PISA start including it as an indicator in assessing student abilities in 2015. The CPS assessment in the PISA Program 2015 focused on cognitive and social skills related to problem-solving in collaborative scenarios [12]. The indicators were building and maintaining shared understanding, taking appropriate action to solve problems, and building and maintaining group organizations.

The results of the literature reviews show that there is still a lack of instruments that measure students' collaboration skills that are easily accessible and the instruments not focus on specific contexts. Most of the instruments only measure students' readiness or attitude at the time of collaboration rather than focusing on specific skills associated with collaborative behavior in team settings.

## **2. RATIONALE FOR THE STUDY**

An appropriate assessment instrument can measure and identify students' collaborative problem-solving ability. Several researchers have assessed the development of the ability to collaborate with instruments, including questionnaires, self-assessments, and even test questions [13]. The previous studies appear to respond to the recent condition related to students' collaborative problem-solving ability. Many teachers still have difficulty measuring students' collaborative problem-solving ability due to several things, such as the availability of instruments and teachers' ability to use the instruments. Students' understanding of collaboration in problem-solving aspects during the learning process is still low [14] [15].

Collaborative problem-solving skills are collaborative interactions between students to achieve common goals [16] [17]. The survey results in several schools in Gorontalo Province show that the learning process has shown collaboration between students. It can be seen from the interaction between students with one another. The problem arises when we put an observation. The interaction between students is not in terms of discussing lessons to solve problems, but the collaborative interaction is out of the context of the lesson and students' participation in group work is not very good during the process. For example, some students talked to themselves or played and others even slept during the group discussion process. From the survey results, the condition of students cannot work together or collaborate well [18].

Besides, the preliminary studies that we have conducted in four schools in Province Gorontalo, Indonesia show that the availability of standard instruments used by teachers to measure/assess students' abilities in solving collaborative problems is not yet available adequately. It is necessary to develop a standard rubric to assess students' ability to solve problems collaboratively. Therefore, the researcher aimed to develop an instrument in the form of a rubric for assessing students' collaborative problem-solving abilities.

The main objective of developing collaborative problem-solving instruments was to assess and measure students' collaborative problem-solving ability. The instrument is suitable for teachers as a guide in assessing students' abilities in CPS. More concretely, this instrument intended to operationalize the attributes of students' CPS abilities. We assessed CPS indicators according to good guidelines to provide a standardized approach and structure. The results can reflect the assessment of collaborative problem-solving abilities.

The use of cooperative learning instruments can also potentially reduce student misunderstanding of physics concepts [19]. The investigative group learning model can improve student learning outcomes [20]. The investigation group learning model can also foster students' scientific attitudes [21]. One of the students' scientific attitudes is the ability to collaborate.

The instrument developed in this study refers to the Standard Rubric of students' ability to solve collaborative problems from PISA include contributions, time management, problem-solving, working with others, and educational techniques. This rubric will be used in learning activities. We developed the instrument based on student-centered learning activities by the 2013 curriculum principles. One way for learning activities to be student-centered is by carrying out practical activities in groups. Besides, practicum activities in groups can also train students to collaborate in investigating problems given by the

teacher. This practicum group can be called the Investigation Group that is one of cooperative learning by placing students into small groups. Then, the students plan and carry out their investigations in solving problems [22] [23].

### **3. RESULT AND DISCUSSION**

After conducting a study related to the existence of the instrument and standard rubric of students' ability in solving collaborative problems in the sample schools in this study, we determined the development design of the rubric of collaborative problem-solving abilities through the stages of the design process.

#### ***3.1. Define Stage***

The ability to collaborate will be identified using the right instruments. The instrument can measure the circumstances or characteristics of the students. Assessment of students' collaborative problem-solving abilities used a rubric developed concerning the International Reading Association (IRA) and Rochester Institute of Technology (RIT). The adoption of the developed rubric has five aspects of collaborative problem-solving assessment based on the two institutions, namely: contributions, time management, problem-solving, working with others, research techniques, and synthesis [24].

The contribution aspect is an aspect that explains how the characteristics of students' attitudes in providing ideas or ideas so that they can participate in group discussion activities. Time management is an aspect that explains the characteristics of students' attitudes in managing time to complete group assignments on time. The problem-solving aspect is an aspect that explains the characteristics of students in making efforts to solve problems [25]. The aspect of working with others is an aspect explaining the characteristics of students' attitudes in listening to group peer opinions/ ideas and helping to complete group assignments. Research techniques are aspects to describe the characteristics of students' attitudes in finding content sources or theories to answer/ solve problems. Furthermore, the aspect of synthesis is an aspect that explains the characteristics of students' attitudes in compiling complex ideas into structural arrangements. However, in this study, the synthesis aspect was not used because junior high school students were considered not ready to synthesize complex ideas [26]. We only developed the instrument based on four indicators.

#### ***3.2. Design Stage***

At this stage, the researcher explains how to construct or design a collaborative ability rubric. A collaborative problem-solving ability rubric is designed to take into account students' characteristics. The rubric language showed that the instrument was easy to understand so that it can be used for everyone. The instrument design used was based on observations and interviews with teachers from the sample schools.

The findings from field experiment showed that the teachers used several techniques or learning methods in implementing collaborative learning [27]. The results of the analysis and summary of implemented learning techniques found that the collaborative learning techniques used were classified into five categories, namely: (1) discussion, (2) reciprocal teaching by friends, (3) problem solving, (4) managing graphic information, and (5) writing [28].

There were five basic elements so that collaborative learning occurs in a group of learning students. They are: (1) positive interdependence, (2) direct interaction between students, (3) individual responsibility, (4) collaborative skills, and (5) the effectiveness of group processes. In the problem-solving aspect, several stages are carried out in the problem-solving process, namely: (1) identifying the problem, 2) understanding the problem, 3) compile a strategy or plan for completion, 4) solving problems according to the developed plan, and 5) re-checking the answers [29].

For the ability of cooperation so far, the findings of their sample schools used the criteria for cooperation ability including 1) providing information among group members, 2) being able to resolve disputes that occur, 3) creating an atmosphere of close cooperation, 4) exchanging ideas and opinions with group members, 5) support group decisions, 6) respect the input and expertise of other members, 7) participate in carrying out tasks, and 8) appreciate the results of group work [30] [31].

#### ***3.3. Develop Stage***

The researcher developed the design based on the findings in the field about collaborative learning methods carried out. The teachers from sample schools used the instruments to measure students' collaborative problem-solving aspects. A new instrument and rubric were developed which constitute the adoption and modification of various instruments used before the developed instruments [32] [33]. The following instrument designs were used for measuring collaborative problem-solving abilities:

**Table 1.** Scoring Rubric of Problem-Solving Abilities

Indicators of Problem-Solving Abilities	Response	Score
Identify the problem, understand the problem correctly, mention what is known, and ask the problem	- Do not understand the problem at all.	0
	- Do not understand part of the problem by mentioning part of what is known and do not mention what is asked of the problem.	1
	- Do not understand part of the problem by mentioning part of what is known and what is asked of the problem.	2
	- Able to identify problems correctly and precisely.	3
Plan to solve the problem, state, and write down solutions used to solve problems	- Do not plan to solve the problem at all.	0
	- Plan to solve the problem but incorrect and not according to the problem at all.	1
	- Plan a solution that is only a little partially correct.	2
	- Plan a solution that is close to correct.	3
	- Able to plan problem solving correctly and appropriately.	4
Solve problems according to plan, do it properly	- Do not be able to solve the problem at all.	0
	- Solve the problem but do not follow the designed plan.	1
	- Solve part of the problem.	2
	- Solve the problem incorrectly.	3
	- Able to solve problems correctly and precisely.	4
Evaluate, draw conclusions from the answers obtained, and check again that are obtained	- Do not sum up the problem at all.	0
	- Able to conclude the problem but incorrect.	1
	- Able to conclude problems with accuracy.	2
	- Able to conclude problems with accuracy and make conclusions.	3
	- Able to conclude problems appropriately, make conclusions, and double-check the conclusions that have been made.	4

**Table 2.** Score Rubric of Collaboration Abilities

Indicator of Collaboration Abilities	Response	Score
Contribution	- Do not give ideas and do not participate in large or small group discussions.	0
	- Rarely give idea and participate (only once) in large or small group discussions.	1
	- Often give ideas and participate (only 2 times) in large or small group discussions.	2
	- Very often give ideas (more than 2 times) that are used as references in the discussion in large or small group discussions. Able to often lead discussions (more than 2 times) and contribute in participating.	3
Time management	- Do not complete the assignment, causing the group to extend the deadline for doing it.	0
	- Complete the assignment, but it is > 3 minutes late from the specified time, causing the group to extend the deadline for doing it.	1
	- Complete the assignment, but it is ≤ 3 minutes late from the specified time, so it still does not cause the group to extend the deadline for doing it.	2
	- Complete the assignment on time or finishing before the deadline, so that it never causes the group to extend the deadline for processing it.	3
Problem-solving	- Do not try to find and provide answers to problems and assign all tasks (rely on) to others.	0
	- Rarely (only once) make efforts to find answers to problems and use solutions initiated by others.	1
	- Often (only 2 times) make efforts to find answers to problems, but the solutions found are the result of the development of other people's ideas	2
	- Very often (more than 2 times) make a clear effort to find and come up with their own ideas to answer the problem.	3
Team work	- Do not listen to other people's opinions, help others, and participate in group work.	0
	- Rarely (only once) listen to other people's opinions and rarely (only once) help others due to difficulties in group work.	1
	- Often (only 2 times) listen to other people's opinions well and often (only 2 times) help others, but it doesn't make it easy for group work.	2
	- Very often (more than 2 times) listen to other people's opinions well and very often (more than 2 times) help others so that it makes group work easier.	3
Investigation technique	- Do not search for multiple sources (only focuses on one source) and record information.	0
	- Rarely search for multiple sources (only focus on 2 sources) and record information, but not in detail.	1
	- Often search for various sources (only focus on 3 sources) and always records information, but not in detail.	2
	- Very often search for various sources (focused on more than 3 sources) and always record detailed information.	3

#### 4. CONCLUSION

Students need to master problem-solving and collaboration ability due to 21st-century skills. To assess students' problem-solving and collaboration ability, instruments that can measure these abilities are needed.

Standard instruments to measure problem-solving abilities generally include the steps to the problem-solving process, namely: (1) Identifying the problem; 2) Understanding the problem; 3) Compiling a strategy or plan for completion; 4) Solving the problems according to the plan that has been made; and 5) Re-checking the answers. In our research, we added several indicators to this standard instrument, namely aspects to measure students' ability in: (1) Enduring new problems, students; (2) Managing impulsivity when trying given assignments; (3) Flexible thinking when given new data; (4) Thinking deeply (metacognition) when in a learning situation; (5) Striving for accuracy and precision in every work presentation; (6) Asking and answering a problem; (7) Applying past knowledge to new situations; (8) Thinking and communicating with clarity and precision; (9) Collecting data through all senses; (10) Creating, imagining, and innovating; (11) Responding with surprise and attention; (12) Taking risks those who are responsible; (13) Thinking interdependently when given group work; (14) Continuous learning; and (15) Reasoning about the assigned task.

We expected that instruments and rubric developed in this study can support further research in the future regarding collaborative problem-solving abilities.

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