Measuring collaborative problem-solving skills (CPSS) of vocational high school students using web-based assessment

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Abstract. This study describes an online method for measuring students’ collaborative problem-solving skills individually using two interactive web-based assessment on the webcps program, with students working in pairs. The method used in this research is a qualitative method of case studies of vocational high school students on dynamic electric material. Process flow data was taken from 30 students (17 of them male students and 13 female students) who completed the assignment at one of the vocational high schools in Riau province. Data is transformed into indicators of collaborative problem-solving skills and is categorized based on four levels namely beginner (level 1), emerging (level 2), intermediate (level 3), and advanced (level 4). The results show that students are at various levels with different characteristics in both the social domain and cognitive domain in CPS skills. The assessment used in this study can be used as a measurement tools electrical circuit and as an instrument of measurement for collaborative problem-solving skills.

1. Introduction

Collaborative Problem Solving (CPS) has received increasing international attention because a lot of complex work in the modern world is done by teams [1]. Collaborative Problem Solving (CPS) has called important skills for students to be built [2]. CPS is becoming increasingly important for academic and career success in the 21st century [3,4]. There are many challenges faced by educators when considering not only how to define 21st-century skills and teaching but also the ability to measure and monitor these skills.

Collaborative problem solving is a combined skill that involves social and cognitive skills [5]. This CPS skill was rationalized by the ATC 21st project team as a joint skill that developed from the relationship between critical thinking, problem-solving, decision making and collaboration the term “collaborative problem solving” was adapted [6]. CPS skills are divided into five indicators: participation, perspective-taking, social regulation, task regulation, and knowledge development [5]. This CPS skills indicator is used as a framework for developing and testing scenario-based task that are designed to obtain CPS Skills. CPS is a set of skills we need to rely on when the capacity or resources of just one person are not enough to solve the problem. So that, we need to learn how to combine different resources and skills when facing complex problems. The OECD has also adopted these approaches, with slightly different interpretations and conceptual frameworks and will assess CPS in the 2015 PISA study.

In assessing CPS skills it can be done through a different approach. There are two approaches that have been applied in developing CPS assessment: the Human-Human (H-H) and Human-Agent (H-A)
approaches [7]. In the H-H approach, students collaborate with each other. Previous studies conducted collaborative activities to test student group collaboration and problem solving processes; in this study, students interact with group members in CPS situations, such as math questions, logic problem, and environmental science assignment [8,9]. These studies make observations during activities and assess CPS skills by analyzing observational data manually based on student interactions and the processes involved in problem solving. Overall, the findings from previous studies show that the H-H approach has several advantages, such as providing authentic H-H interactions for students, bringing the approach closer to the real CPS situation [8,9]. Therefore, the Collaborative Problem Solving Skill assessment in this study uses a web-based Human-Human (H-H) approach, which uses an agent (computer) as a CPS assessment medium through the webcps.site page [10].

Based on previous research, CPS research has been carried out in various fields including technology, organization, education, and psychology [11,12]. In the field of Education, in the Mathematical T-Shirt Task, for the social dimension, building mutual understanding, and negotiation had a high frequency, for the cognitive dimension, execution has a high frequency [13]. Then the H-A assessment developed is feasible to measure the skills of CPS students [14,15]. Development of web-based CPS instruments through tasks and "Keywords" the social domain and cognitive domain [10]. Based on research recommendation, it needs to improve the development of "keywords" that complement many regions in Indonesia, therefore, researchers use the WEB-based CPS Accessing instrument to test the ability of CPS students in one school in the Riau region.

This research was conducted with the aim of obtaining an overview of: (1) Level of Collaborative Problem-Solving Skills (CPSS) Vocational high school students on dynamic electric material using WEB-based assessment. (2) Characteristics of students' social domains and cognitive domains in Collaborative Problem-Solving Skill (CPSS) on dynamic electricity material using WEB-based assessment.

2. Methods

2.1 Research design

The method used in this study is a qualitative research method with a case study model [16]. Case studies are research strategies in which researchers carefully investigate a program, event, activity, process, or group of individuals. The research process in this study is given in Figure 1.

![Figure 1. Qualitative research procedure case study](image-url)

- **Phase**: Qualitative data
  - **Procedure**: Through the webcps.site page, a CPS assessment consisting of 2 assignments is given to students after learning dynamic electricity
  - **Results**: Log files student activities during the CPS assessment, CPSS level

- **Analysis of qualitative data**
  - **Procedure**: Classification of log file based on keyword social domain and cognitive domain
  - **Results**: Characteristic s of the CPSS social domain and cognitive domain

- **Qualitative data**
  - **Procedure**: Nvivo 12 plus software
  - **Results**: Interpretation and explanation of qualitative results

- **Results**
  - **Procedure**: Discussion, Implications, Future research

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From the CPS assessment data through the webcps.site, CPS skills of students are categorized based on four levels [10], namely: beginner (level 1), emerging (level 2), intermediate (level 3), and advanced (level 4) that have been developed in the social domain and cognitive domain. Then the results of the student activity log file during the CPS skills assessment were analysed based on the CPSS domain keywords that had been developed by [10]. Furthermore, researchers interpret and explain the data obtained.

### 2.2 Participant

Participant in this study were class X students in one school in Riau Province, one of the island adjacent to Malaysia and Singapore. The number of participants in this study was 30 students of class X TKJ 1, age around 16 years (17 of whom were male and 13 were female). The sampling technique in this study is convenience sampling [17]. Samples were taken randomly, based on the consideration of physics teachers in the school, that there was no difference in quality, so the physics teacher suggested that the research be conducted in class X TKJ 1 who had studied dynamic electric material.

### 2.3 Instrument

The CPS Skills Assessment used is the problem solving task contained in the webcps.site that has been developed from collaboration between UPI lecturers and IPB [10]. The task given is in the form of a physics problem solving task related to dynamic electricity that has been poured / simulated through a computer. The CPS task consists of two tasks consisting of; (1) Task 1: Design a series of light bulbs provided, (2) Task 2: Design a simple electrical circuit at home. This CPS assessment has been validated by 5 validators with the results of the valid assessment being in high criteria. The results of the reliability analysis showed that the alpha coefficient (Cronbach's alpha) for the CPS question was 0.820. The Cronbach alpha results show that the descriptors have relatively high internal consistency, especially for the developed CPS task.

### 2.4 Data analysis

After students work on physics problem solving tasks through the webcps.site, the results of student activity log files are classified into five aspects of CPS, namely: (1) participation skills, (2) perspective-taking skills, (3) social regulation, (4) task regulation, and (5) knowledge building, based on keywords developed by [10] which appear in the chat history as in Table 1.

| CPS Skill | Social Domain Keywords | Cognitive Domain Keywords |
|-----------|------------------------|--------------------------|
| **Level 1: Beginner** | Communication only occurs 3 times; hi, hello, how are you, my name is ..., nice to meet you. | In the book .... page .... or include a link ... (only one keyword appears); It's very difficult, whatever, how about you ...., I'll just follow you, you just do it ....); Try, replace, exchange, check, test, test, ....; Let's try it |
| **Level 2: Emerging** | Communication occurs more than 5 times; The conversation was not immediately replied, It take a long time to answer conversations with partners | I am confused; I don't understand; How, this; Why yes ...; We look for information in books only; Work respectively; I try; You try; Here's the answer; Based on references in the book .... |
| **Level 3: Intermediate** | There is no time lag in responding to the conversation What do you think, Do you have other sources of information, Maybe this can be a reference, you mean like this ...., I tried, but it hasn't worked | Apparently, we are different ways but the results will be obtained the same; How/what if we equate our understanding; Your effort is good; Our idea can be accepted; Has it been resolved yet; Wow, your idea is brilliant!; Good, let's apply your degree degrees; Let's look for other sources/ information; We look for other sources regarding electrical circuits; Based on the discussion in the book .... |
| **Level 4: Advance** | What if, another, another way, alternative, means ..., is that right; how about doing it this way; Let's do it in stages; Your idea is good, but it would be better if ....; We use your idea, if it doesn't work; We combine the ideas | Your idea is good, but it would be better if ....; We use your idea, if it doesn't work, my idea; We combine the ideas; First, we look for information about electrical circuits; After that ....; Next ....; We must succeed and we have responsibilities; Based on information on the web. |
3. Result and Discussion

3.1. Student CPS skill level based on web-based assessment

The level of CPS skills of students in each task based on a web-based assessment on the webcps program provided can be seen in Table 2.

| Social Domain CPS Level | Cognitive Domain CPS Level |
|-------------------------|----------------------------|
| Beginner                | Beginner                   |
| Emerging                | Emerging                   |
| Intermediate            | Intermediate               |
| Advance                 | Advance                    |

| Task 1 | N | % | N | % | N | % | N | % | N | % |
|--------|---|---|---|---|---|---|---|---|---|---|
| Beginner | 9 | 30 | 12 | 40 | 9 | 30 | 0 | 0 | 12 | 40 |
| Emerging | 12 | 40 | 0 | 0 | 0 | 0 | 16 | 53 | 8 | 27 |
| Intermediate | 6 | 20 | 0 | 0 | 6 | 20 | 0 | 0 | 0 | 0 |

Based on Table 2, it shows that in the social domain of CPS skills, the most occupied level by students in Task 1 is the Emerging level of 12 students or around 40%. Students participate when given assistance / direction. Communication with a partner only occurs at times when something important happens, so students are not too responsive to the couple. Furthermore, at the beginner and intermediate level they have the same number of students, which is 9 participants or around 30%. Unlike the case with Task 2, the same number of students is the beginner and emerging level, which is 12 students or around 40%. While the intermediate level in task 2 is as many as 6 students or about 20%. At the beginner level students do not participate in identifying the series of problems to be made, and do not specify steps, and do not share assignments to complete the ranks. At the Intermediate level, students actively respond to partners to solve problems or sequences that will be created. Finally, at the advanced level the two tasks were not found by students occupying that level. That is, there are no students who repeatedly participate in active discussions with partners to complete assignments and use various strategies before giving answers.

The cognitive domain achieved by students can be seen in Table 2, the beginner level, and the level that appears in Task 1 is occupied by students with the same number of 12 students or around 40%. Furthermore, at the intermediate level reached by 6 participants or around 20%. Unlike the case with Task 2, the number of students who are still large at the beginner level is 16 students or around 53%. While the emerging and intermediate levels in assignment 2 are 8 students and 6 students or around 27% and 20%. At the beginner level, students when faced with obstacles in solving problems, students tend not to want to try/be lazy. At an emerging level, students limit themselves to finding sources of reference when solving problems. Finally, the advanced level (score = 4) of the CPS cognitive domain was not found by students at that level in both task 1 and task 2. Students have not been able to identify cause and effect relationships based on information obtained and students have not been able to modify and apply hypotheses in ideas solution to a problem.

In Collaborative Problem-Solving skills, the social domain is the "collaborative" part of "collaborative problem solving". While the cognitive domain is part of the "problem solving" of "collaborative problem solving [5]. Based on the findings of the two assignments given, CPS skills in students' social domains appear more often about cognitive domain skills. This is also found in research previously that, students scored higher on indicators assigned to social dimensions on indicators assigned to cognitive dimensions [2,18]. Likewise with the compilation of students has been successful and collaborates well to solve problems, but students with compilations that perform poorly try to solve the right problems to solve problems [14].

Furthermore, in this study it was found, students who obtained high scores on CPS domain skills were more likely to get high scores on cognitive domain skills. Looking at previous research that the correlation between social and cognitive domains is 0.77, shows that students who score high in the cognitive dimension are more likely to get high scores on the social dimension and vice versa [19].
3.2 Characteristics of students' social domains, and cognitive domains in collaborative problem-solving skill on web-based assessment

To measure each aspect of the social and cognitive domains, the WEB-based CPS assessment process data captured in the form of log files are then analysed. The log file lists each activity that is marked by the time carried out by participants can be seen in Figure 2 and Figure 3.

| Students (St) | Chat History                  | Time_stamp | Analysis of CPS Social Domain Skills |
|--------------|-------------------------------|------------|-------------------------------------|
| St 15        | "hi..."                       | 03:56:27   | This conversation demonstrates the CPS skills of participation. |
| St 16        | "who is this?"..."            | 03:57:00   | Students do not participate in identifying problems, determining steps, and sharing assignments to make a simple set of available tools. |
| St 15        | "very difficult"...           | 04:06:10   | Students do not know what to do so do not communicate with partners to determine their respective tasks in solving problems. |
| St 16        | "mine is also like that"...   | 04:11:21   | |
| St 15        | "how to do this?"...          | 04:11:35   | |
| St 16        | "not finished yet"...         | 04:14:33   | |
| St 16        | "I’m not even one yet"...     | 04:12:30   | |
| St 15        | "the lights aren’t on"...     | 04:12:40   | |
| St 16        | "me too"...                   | 04:13:54   | |
| St 15        | "how is this?"...             | 04:14:03   | |
| St 16        | "how?"...                     | 04:21:23   | |
| St 16        | "I will make it"...           | 04:21:27   | |

Number of chats 14 chats

Figure 2. Analysis of participant log files of participants 15 and 16 (social domain aspects).

| Students (St) | Chat History                  | Time_stamp | Analysis of CPS Cognitive Domain Skills |
|--------------|-------------------------------|------------|-----------------------------------------|
| St 22        | "hmm"                         | 06:55:37   | St 21 Provides a hypothesis in solving a series of problem to be created. |
|             | "series or parallel arrangement huh?..." | 06:55:52 | |
| St 21        | "let’s try to make a circuit of series’ first" | 06:56:26 | St 22 searching for information both from books and the internet. |
| St 22        | "may also"                     | 06:56:36   | |
|             | I searched for information from books or the internet first ye Man..." | 06:57:04 | |
| St 21        | "ok, I try to make the circuit" | 06:57:16   | St 21 sensitive to need more information. |
| St 22        | "zip"...                       | 06:57:25   | |
| St 21        | " Fad...what kind of series arrangement!?" | 06:57:52 | |
|             | "I am confused."              | 06:57:56   | |
|             | "forget"...                    | 06:58:10   | |
| St 22        | "wait"...                      | 06:58:31   | St 22 link information obtained from books to partner. |
|             | I seen from the assignment book that the teacher gave, "..." | 06:59:07 | |
|             | the series is usually arranged in a row or..." | 06:59:26 | |
| St 21        | "ok.. I will try"...           | 06:59:38   | |

Figure 3. Analysis of participant log files from participants 21 and 22 (cognitive domain aspects)

Figure 2 shows the interaction of students when working on task 1, it can be seen that the communication that occurs between students 15 and 16 in the task time for 30 minutes, the amount of communication that occurs is less than 14 chats. This shows that the lack of interaction between the two students. They focus on trying to navigate the task space that they do not understand and read instructions to find out how to solve the problem rather than communicating with a partner to determine their respective tasks in solving problems (chat St 15: "very difficult ..." how is this?" ; chat St 16: "mine is also like that" ; Chat St 15: "how to do this?... not finished later ... I’m not even one yet... the lights aren’t on "; Chat St 16: "me too...how is this?... how? ..I will make it .. "). Information communicated to
each other is unclear, and students are more concerned with exploring the assignment space rather than participating in each other. It shows participation skills, perspective taking skills, and social regulation of students at level 1.

Perspective-taking on social domain skills is often seen as a core communicative competence [5]. Perspective-taking refers to the ability to adapt one's own speech to the needs and intellectual abilities of peer students. Looking at previous research, sometimes participants lack the ability or willingness to adapt and contribute to their communication partners in collaboration [20]. It was also found in this study that the findings of pairs of students 15 and 16 in Task 1 (see Figure 2), participants were not able to adjust their contributions to enhance partner understanding in collaborating.

Unlike the case with the interaction of pairs 21 and 22 as in Figure 3, the two students participate in each other and determine the steps to solve the problem. Students 22 gather information by looking at references from books and from the internet on communication (chat St 22: "I searched for information from books or the internet first ye Man"; chat St 21: "ok... I try to make the circuit..."). Then student 21 (chat St 21: "Fad...what kind of series arrangement?"). Shows that students 21 are sensitive to the need for more information. This shows that students are at level 3 aspects of task regulation skills in cognitive domain.

The task regulation in the CPS cognitive domain, the ability to gather information such as sharing information that refers to information relevant to the content use for more information. This means that students are at level 3 aspects of task regulation skills in cognitive domain.

4. Conclusion

The approach and results of this study can have important implications for the measurement of CPS skills. By using webcps.site pages, researchers analyse how the characteristics of the social domain and cognitive domain of students at both the low and medium level reached by students. CPS skills and behaviours that show evidence of each skill can be used in a broader context. The assessment used in this study can be used as a teaching tool to understand the concept of simple electrical circuits and as an instrument of measurement for collaborative problem-solving skills.

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