International Journal of Evaluation and Research in Education (IJERE)
Vol. 15, No. 3, June 2026, pp. 2326~2337
ISSN: 2252-8822, DOI: 10.11591/ijere.v15i3.38475

Students' perceptions of mathematics collaborative problem-solving session (MCPSS) at the foundation level

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Article Info

Article history:

Received Jan 1, 2026
Revised Mar 17, 2026
Accepted May 14, 2026

Keywords:

Collaborative
Collaborative problem-solving
Mathematic assessment
Mathematics education
Problem-solving

ABSTRACT

Collaborative problem-solving (CPS) skills are a vital component for students, especially in preparing them for future endeavors. It combines elements of collaborative and problem-solving skills into a single skill, emphasizing students' ability to work together efficiently to solve everyday problems. While many studies have emphasized the importance of CPS, there remains a lack of research on students' perceptions of its implementation in teaching and learning. The objective of the study is to determine students' perceptions towards the mathematics collaborative problem-solving session (MCPSS) at a foundation center in Malaysia. The study utilized the mixed-method approach, using both a questionnaire and an interview to collect the data. The study sample consisted of 140 students randomly selected for a foundation center. Data from the study were analyzed using descriptive and thematic analysis. The study's findings showed that most students held positive perceptions of the implementation of MCPSS in the mathematics course, with the majority of responses being between agreeing and strongly agreeing with the items related to meaningful learning, reflective learning, teamwork, and communication skills in MCPSS (SD=0.74–1.20). The outcome of the survey highlighted the overall acceptance of the students in the implementation of MCPSS in the mathematics foundation course.

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1. INTRODUCTION

Collaborative and problem-solving skills are arguably among the two most significant components for students' learning in the 21st century. As teaching and learning have slowly shifted from teacher-centered to student-centered learning [1], both collaborative and problem-solving skills are important for equipping learners to face complex real-world challenges, especially in the workplace. Collaborative skill can be defined as the ability to actively participate with others to achieve a common goal while demonstrating high productivity, responsibility, and respect for others [2]. On the other hand, problem-solving skills can be referred to an individual ability to take part in cognitive activities when addressing and comprehending problems in which the solution is not easily obtained [3]. In the teaching and learning of mathematics, both collaborative and problem-solving skills are essential, as they provide the students with the fundamental tool needed for successfully mastery. This was highlighted by Harding *et al*. [4], who noted that students' mathematical ability in the classroom can be further enhanced by focusing on collaborative and problem-solving activities and processes. The introduction of the collaborative problem-solving (CPS) framework

offers educators more flexibility in focusing teaching and learning towards both collaborative and problem-solving skills. It merges the elements of collaborative and problem-solving into a single component, allowing educators to adapt their teaching and learning in a more practical and accessible way. CPS is beneficial to educators, as it facilitates the organization of students' understanding and actions in learning by enabling the adaptation of new and existing knowledge when solving complex problems [5]. In addition, CPS approaches encourage students to engage with critical thinking questions and scenarios, which can foster their higher order thinking skills (HOTS) in the classroom [6].

While many studies have highlighted the positive impact on CPS in mathematics learning [5]–[9], there is still a lack of studies which focus on students' perceptions towards the implementation of CPS in the classroom. Understanding the students' perceptions in the implementation of a teaching and learning approach is vital. According to André *et al*. [10], students' perceptions are significant assets for educators to measure the effectiveness of teaching practices in the classroom. It allows the educators to evaluate the students' acceptance of the new approach, which can help with further adapt and improve teaching and learning in the school. In addition, students' perceptions allow the educators to determine the efficiency of the teaching approach in encompassing the different learning style among students, which can be an important factor towards their overall achievement in learning [11]. This study focused on the students' perceptions towards the implementation of the mathematics collaborative problem-solving session (MCPSS) at the foundation level in Malaysia. MCPSS was developed with the intention of adapting CPS elements in the foundation mathematics group assessment. This study centered on understanding how students perceived the importance and the overall implementation of MCPSS in the foundation mathematics course.

According to Scoular *et al*. [12], CPS is an ability when a group of students work together by sharing their knowledge, experiences, and techniques to achieve a shared objective. In addition, Maxim [13] stated that CPS is the capability of an individual to efficiently participate in group work which involves assembling knowledge, skills, and contribution to the completion of a common task. It is an essential skill in the 21st century, as academics and the workplace demand the application of problem-solving, communication, and teamwork skills [14]–[17]. CPS can be differentiated with collaborative learning, in which CPS not only supports the students' knowledge of a subject but also requires students to complete a given problem where all team members have verbally and consensually agreed with the solution of the task [18], [19]. Xu *et al*. [20] summarized that CPS is a natural combination of both collaborative learning and problem-based learning, and it is mainly student-centered, requires them to solve ill-structured problems related to daily life to trigger their learning development.

According to Ying and Tiemann [21], the CPS framework consists of two main dimensions. The first dimension of CPS is the cognitive dimension, where it focuses on the students' problem-solving and thinking ability. It consists of three main elements, which includes: i) the identification of problems; ii) the construction of approaches; and iii) the implementation of solutions. Graesser *et al*. [22] stated that cognitive dimension of CPS demands that individuals not only have mental capability but also the ability to incorporate different views before deciding a proper solution for a problem. The second dimension of CPS is the students' social skills. In this dimension, CPS measures the overall efficiency of the group's chemistry, communication, and responsiveness as they work together to solve a common problem [21]. Monitoring both dimensions of CPS is crucial for educators as it will influence the overall success of the CPS activities in the classroom.

Several studies have highlighted the potential of CPS in mathematics learning. In Sasanti *et al.* [23] study on the effect of CPS on students' mathematics critical thinking abilities in the classrooms, students who participated in the mathematics CPS activity demonstrated significantly higher performance in their mathematics test than students who participated in a conventional mathematics teaching approach. The findings of the study suggested that CPS have a positive effect on students' critical thinking, which is essential for students' comprehension and mastery in mathematics. Similarly, Xu *et al*. [20] also showed that CPS can cultivate the students' critical thinking skills in mathematics, which can positively impact their confidence and attitudinal tendencies in solving problems that are challenging. CPS can also foster the students' cognitive, collaborative, problem-solving, and metacognitive abilities, while positively impacting the relationship among other students through effective teamwork [24]. Moreover, the study by Ferguson-Patrick [25] stated that CPS encourages students' participation and engagement in mathematics, requiring them to apply their leadership, communication, social and problem-solving skills to achieve a common goal.

The main objective of the study is to examine the students' perceptions towards the implementation of the MCPSS at the foundation level. In addition, the study will focus on students' feedback on the strengths and areas of improvement of MCPSS's implementation at the foundation level. The research questions are as:

- What are the students' perceptions towards the implementation of the MCPSS in the foundation level?
- What are the strengths and areas of improvement for the implementation of the MCPSS at the foundation level?

2. METHOD

2.1. Research design and samples

The study employed a mixed-method research design, where both quantitative and qualitative data were collected throughout the study. For qualitative data, the students' perceptions towards the MCPSS were collected via a questionnaire. As for the qualitative data, students' feedback (strengths and areas for improvement) was collected via students' interviews and written feedback in the questionnaire.

The study samples consisted of 140 students (questionnaire) and 10 students (interviews) from a foundation center in Malaysia. These students were randomly selected via convenience sampling from the total of 900 students who enrolled at a foundation center in Malaysia. The students who enrolled in the foundation center were aged between 17 to 18 years old and had the passed their Malaysian Certificate of Education (also known as Sijil Pelajaran Malaysia (SPM)), with a minimum grade C in all subjects. The study sample size was determined using the Raosoft sample size calculator with a 95% confidence level.

2.2. Mathematics collaborative problem-solving session

The MCPSS was developed as an alternative approach for mathematics group assignments for the mathematics course at the foundation center. It adapts the CPS components to the mathematics group assessment. Compared to other CPS adaptations, MCPSS was developed specifically with the goal of assessing the students' mathematical learning outcome based on collaborative and problem-solving skills at the foundation level. Before the introduction of MCPSS, the mathematics course at the foundation center heavily relied on graded assignments, in the form of individual and group exercises, to assess students' comprehension of the mathematical content. While implementing graded assignments can be time-efficient, it raises several concerns among the mathematics educators at the foundation center. It was difficult for mathematics educators to detect plagiarism in students' assignments submissions because the nature of mathematics questions and solutions varies little from one another. This leaves room for students to potentially complete their assignment by copying solution from others or using artificial intelligence (AI) and auto-calculator applications such as ChatGPT^{tm}, and Photomaths^{tm}. In group assignments, issues such as the "free rider" problem are also common, in which several team members do not participate or contribute the completion of the group assignments. These issues provide sufficient reasons for the changes in the assessment approach and the development of MCPSS for the mathematics course.

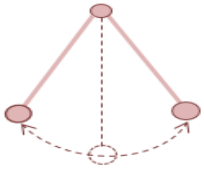
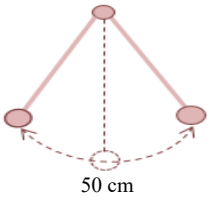
MCPSS is a group-based assessment, in which students work together to complete a set of questions within a time constraint. The main objective of MCPSS is to evaluate foundation students in mathematics rigors, teamwork and communication skills. It differs from conventional standard problem-solving and collaborative learning strategies, as it is mainly a mathematics assessment to evaluate the students' capability in adapting to diverse perspectives and skills in a group in order to produce a joint or collective mathematics solution. MCPSS adapted CPS elements as its core, where it encourages students to share their mathematics ideas, reasoning, and strategies with other students in order to complete the mathematical tasks. MCPSS allows educators to assess students' team-works and communication skills in mathematics while at the same time assessing their mathematical knowledge in solving mathematics problems. The MCPSS process starts with developing mathematics questions for the assessment. The mathematics questions consisted of the triggers, questions, and potential solutions. Each question will be vetted by the panel of mathematics educators based on an established standard at the beginning of the semester. Table 1 shows an example of a trigger and question for the MCPSS.

It is noted that several different sets of questions will be developed to ensure that no group have identical questions, which can reduce potential issues related to plagiarism. In addition, the rubric for the MCPSS will be developed during the vetting process to provide grading guidelines for the facilitators during the session. Once the vetting process has been completed, students will be assigned randomly into a group, and each group comprises of four to five team members. Next, the questions' trigger will be released two weeks before the MCPSS assessments begin. The triggers are ill-structured questions that provide general information on the potential questions that will be tested in the MCPSS. The goal of the triggers is to help students prepare for the upcoming MCPSS by conducting initial research and predictions on the potential questions that are related to the MCPSS questions.

On the day of the MCPSS, students will be given a set of MCPSS materials consisting of a random selection of questions, a piece of A1 paper, markers, and several sheets of A4 paper. Throughout the session, students are not allowed to use any mobile devices, such as mobile phones, tablets, and laptops to prevent them from using AI and auto-calculator applications. Students are required to complete the MCPSS question within 20 minutes and will be assessed by the facilitators on their teamwork and communication skills using the rubric. Once the 20 minutes are completed, each group will elect one student from their group to present their written solution (on the A1 paper) to the facilitators, where their solution will represent the overall group's mathematical rigors. Students will also need to complete the peer-assessment form, which allows

them to determine each group member's contribution throughout the MCPSS. This will reduce the issues that are related to students being "free riders" during the assessment. Figure 1 shows the summary of the steps involved in conducting a MCPSS.

Table 1. Example of a trigger and question for the MCPSS

Trigger	Question
The figure below shows an experiment of a swinging pendulum. A pendulum swings through an arc of x cm initially. For the second swing, the length of the arc is the length of the previous swing.	The figure below shows an experiment of a swinging pendulum. A pendulum swings through an arc of 50 cm initially. For the second swing, the length of the arc is 0.85, the length of the previous swing.
	
Keyword: Arithmetic and geometric series	(a) Determine the type of series that can describe the length of the swing arc. Explain your answer. (b) On which swing will the length of the arc be less than 20 cm? Explain your answer.

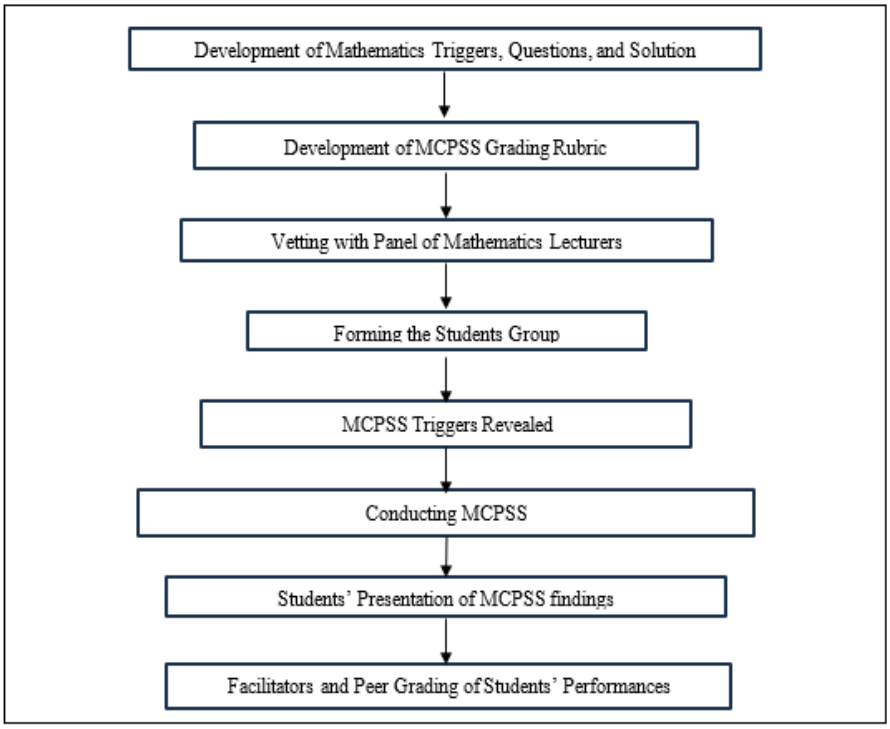


Figure 1. Summary of the steps involved in conducting MCPSS

2.3. Data instruments

The data of the study were collected using a questionnaire and students' interview. The questionnaire consists of two main sections. The first section focused on the students' overall perceptions towards the implementation of the MCPSS at foundation level. In this section, students were required to provide their responses based on a 5-Likert scale, with 1–strongly disagree, 2–disagree, 3–not sure, 4–agree, and 5–strongly agree. It consisted of 12 items, in which items 1 to 4 related to students' perceptions on meaningful learning in MCPSS, items 5 to 8 related to students' perceptions on reflective learning in MCPSS, and items 9 to 12 related to students' perceptions on teamwork and communication skills in MCPSS. In the questionnaire, meaningful learning refers to the students' ability to build new knowledge

while utilizing previous knowledge to gain understanding [26]. On the other hand, reflective learning refers to students' ability to recall personal experiences and to gain new knowledge and skills, which will be used to improve future performance [27]. The second section of the questionnaire consisted of an open-ended question, gathering students' overall feedback on the implementation of MCPSS at the foundation level.

For the students' interviews, the study employed a semi-structured interview approach. An interview protocol consisting of 4 open-ended questions was developed for this study. The goal of the students' interview was to gather their feedback on the implementation of MCPSS at the foundation level, especially on its strength and area for improvement.

2.4. Reliability and validity of the instruments

To evaluate the reliability and validity of the instruments of the study, a pilot study was carried out to 30 students who had completed their studies at the foundation center the year before. Before conducting the pilot study, content validity was carried out in order to validate the items of the questionnaire. A team of experts panels, consisting of six senior mathematics lecturers, was given the task of checking and reviewing the questionnaire items based on clarity, representation, and applicability of the study through the 4-Likert-scale (1-not relevant to 4-very relevance). The item content validity index (ICV-I) was calculated based on the feedback. The findings showed that the ICV-I values were between 0.82 to 0.97, showing that the items of the questionnaire were highly relevance to the study. As for the pilot study, the reliability and validity of the questionnaire were evaluated using Cronbach's alpha and bivariable correlate analyses respectively. The results showed that the items on the questionnaire were both highly reliable (Cronbach's alpha=0.914) and valid (bivariable correlate, $p<0.05$).

For the students' interview protocol, the content validity of the students' interview questions was examined and verified by the expert panels before the pilot test. This was to ensure that the questions were able to cover the intended aspects of the study as well as producing meaningful and relevant data needed for the study. Several students were interviewed using the interview protocol to ensure the questions are clear, easily understood, and the intended results could be achieved. Refinements were made based on feedback from the pilot study to enhance the interview protocol's reliability and validity.

2.5. Procedure and analysis

Prior to the MCPSS starting, the students were briefed by the facilitators regarding the objectives, procedures and rubrics for the assessment. Students were then seated in their assigned group and started the MCPSS assessment. Once the session was completed, each student was instructed to fill in the peer-assessment form (assess each of their team members) and questionnaire via Google Form, where it was required to be completed and submitted before leaving the classroom. In addition, 10 students were randomly selected for interviews to gather their feedback and experiences with MCPSS assessments. Quantitative data obtained from the questionnaire was analyzed using descriptive analysis (mode, percentages, and standard deviation). As for the qualitative data obtained from the students' interview and questionnaire, the data were analyzed using thematic analysis.

The procedure of the thematic analysis was based on Braun and Clarke's thematic analysis framework [28]. This framework consisted of six phases, which includes understanding the data, generating of initial codes, identification of potential themes, reassessing of themes, defining and naming of the themes, and reporting in writing [29]. For this study, all information obtained from the students' interviews was transcribed and reviewed using NVivo software. This is important as it allows the researchers to get familiar with the overall data collected. Next, the initial codes were generated through the process of labelling the important parts of the students' interviews. These codes were then examined and grouped by the researchers into several initial themes, by identifying the similarities and differences within the students' responses. The potential themes were then reviewed and refined to make sure each of the themes was clear, consistent and can be distinguished from one another. The process of reviewing or reassessing the themes was conducted thoroughly among the researchers to ensure that the overall validity of the themes can be achieved. The process was followed by the defining and naming of each of the themes. This was done by ensuring each theme was named by its underlying meaning, scope, significant and contribution to the research questions. Finally, the findings were then interpreted and reported based on the thematic framework, and it includes the students' interview excerpts to ensure that the overall transparency and clarity to be achieved.

3. RESULTS AND DISCUSSION

3.1. What are the students' perceptions towards the implementation of MCPSS at the foundation level?

The findings were analyzed based on items 1 to 12 of the questionnaire. It was noted that items 1 to 4 are related to the student's perceptions on meaningful learning in MCPSS, items 5 to 8 are related to the

students' perceptions on reflective learning in MCPSS, and items 9 to 12 are related to students' perceptions on teamwork and communication skills in MCPSS. Table 2 shows the findings on the students' perceptions on meaningful learning in MCPSS at foundation level. It was found that for item 1, "My group able to solve the entire problem during the MCPSS assessment", the majority of the students have selected "agree" (N=63, 45%), followed by "strongly agree" (N=48, 34.29%), "not sure" (N=23, 16.43%), "disagree" (N=5, 3.57%) and "strongly disagree" (N=1, 0.71%), with SD=0.84. For item 2, "I use the reference material that I brought to the MCPSS assessment", it was found that the majority of the students have selected "strongly agree" (N=55, 39.29%), followed by "agree" (N=52, 37.14%), "not sure" (N=27, 19.29%), "disagree" (N=5, 3.57%) and "strongly disagree" (N=1, 0.71%), with SD=0.89. Similarly for item 3, "My friends give good commitment (in terms of attendance, punctuality, cooperation) during the group discussion of the MCPSS assessment", most of the students have selected "strongly agree" (N=76, 54.29%), followed by "agree" (N=36, 25.71%), "not sure" (N=23, 16.43%), and "disagree" (N=5, 3.57%), with SD=0.82. Lastly, for item 4, "presentation of the output during MCPSS is being explained clearly", most of the students have selected "strongly agree" (N=62, 44.29%), followed by "agree" (N=56, 40.00%), "not sure" (N=21, 15.00%), and "disagree" (N=1, 0.71%), with SD=0.74. Overall, it can be summarized that the majority of the students had selected between "agree" and "strongly agree" for the items 1 to 4, with SD between 0.74 and 0.89. Based on the findings in items 1 to 4, it indicated that the majority of the students have positive perceptions towards the implementation of MCPSS on meaningful learning in the foundation mathematics course.

Table 3 shows the findings on the students' perceptions on reflective learning in MCPSS at foundation level. It was found that for item 5, "I can deeply understand the problem during the MCPSS assessment", most of the students have chosen "agree" (N=62, 44.29%), followed by "strongly agree" (N=41, 29.29%), "not sure" (N=33, 23.57%), "disagree" (N=3, 2.14%) and "strongly disagree" (N=1, 0.71%), with SD=0.83. For item 6, "I can solve the entire problem with my existing knowledge", the majority of the students have selected "agree" (N=58, 41.43%), followed by "strongly agree" (N=39, 27.86%), "not sure" (N=34, 24.29%), "disagree" (N=8, 5.71%), and "strongly disagree" (N=1, 0.71%), with SD=0.89. As for item 7, "I acquired a new idea in solving a problem during the MCPSS assessment", it was found that most of the students have selected "agree" (N=49, 35.00%), followed by "strongly agree" (N=48, 34.29%), "not sure" (N=36, 25.71%), "disagree" (N=6, 4.29%), and "strongly disagree" (N=1, 0.71%), with SD=0.92. For the last item, "My group spent a long time understanding the problem before starting to answer questions during the MCPSS assessment", it was found that majority of the students have selected "not sure" (N=52, 37.14%), "disagree" (N=33, 23.57%), "strongly agree" (N=22, 15.71%), "agree" (N=18, 12.86%), and "strongly disagree" (N=15, 10.71%), with SD=1.20. In general, it was shown that majority of the students selected between "agree" and "strongly agree" for item 5, 6, and 7, with SD between 0.83 and 0.92. Only for item 8 that it showed difference responses among students, where majority of the students have selected between "not sure" and "disagree" with the item. Nevertheless, it can still be concluded that students have a positive perception towards the implementation of MCPSS on reflective learning in the foundation mathematics course.

Table 2. Students' perceptions of meaningful learning in the MCPSS at the foundation level

No. Item	Item description	Scale	N	Percentage (%)	SD
1.	My group able to solve the entire problem during the MCPSS assessment.	1	1	0.71	0.84
		2	5	3.57	
		3	23	16.43	
		4	63	45.00	
		5	48	34.29	
2.	I use the reference material that I brought to the MCPSS assessment.	1	1	0.71	0.89
		2	5	3.57	
		3	27	19.29	
		4	52	37.14	
		5	55	39.29	
3.	My friends give good commitment (in terms of attendance, punctuality, cooperation) during the group discussion of the MCPSS assessment.	1	0	0.00	0.82
		2	5	3.57	
		3	23	16.43	
		4	36	25.71	
		5	76	54.29	
4.	Presentation of the output during MCPSS is being explained clearly.	1	0	0.00	0.74
		2	1	0.71	
		3	21	15.00	
		4	56	40.00	
		5	62	44.29	

Scale: 1=strongly disagree, 2=disagree, 3=not sure, 4=agree, and 5=strongly agree.

Table 3. Students' perceptions of reflective learning in the MCPSS at the foundation level

No. Item	Item description	Scale	N	Percentage (%)	SD
5.	I can deeply understand the problem during the MCPSS assessment.	1	1	0.71	0.83
		2	3	2.14	
		3	33	23.57	
		4	62	44.29	
		5	41	29.29	
6.	I can solve the entire problem with my existing knowledge.	1	1	0.71	0.89
		2	8	5.71	
		3	34	24.29	
		4	58	41.43	
		5	39	27.86	
7.	I acquired a new idea in solving a problem during the MCPSS assessment.	1	1	0.71	0.92
		2	6	4.29	
		3	36	25.71	
		4	49	35.00	
		5	48	34.29	
8.	My group spent a long time understanding the problem before starting to answer questions during the MCPSS assessment.	1	15	10.71	1.20
		2	33	23.57	
		3	52	37.14	
		4	18	12.86	
		5	22	15.71	

Scale: 1=strongly disagree, 2=disagree, 3=not sure, 4=agree, and 5=strongly agree.

Table 4 shows the findings of the students' perceptions on teamwork and communication skills in MCPSS at foundation level. It was found that for item 9, "I am comfortable working in my group before and during the MCPSS assessment", majority of the students chosen "strongly agree" (N=82, 58.57%), followed by "agree" (N=34, 24.29%), "not sure" (N=20, 14.29%), "disagree" (N=3, 2.14%), and "strongly agree" (N=1, 0.71%), with SD=0.86. For item 10, "all my group members contribute ideas to solving a problem during the MCPSS assessment", most of the students selected "strongly agree" (N=79, 56.43%), followed by "agree" (N=42. 30.00%), "not sure" (N=13, 9.29%), and "disagree" (N=6, 4.29%), with the SD=0.83. Similarly for item 11, "all my group members are actively involved in the discussion during the MCPSS assessment", the majority of the students selected "strongly agree" (N=80, 57.14%), followed by "agree" (N=41, 29.29%), "not sure" (N=15, 10.71%), and "disagree" (N=4, 2.86%), with SD=0.79. For the final item, "all my group members show an initiative in helping to solve problems during the MCPSS assessment", it was found that most of the students selected "strongly agree" (N=80, 57.14%), followed by "agree" (N=43, 30.71%), "not sure" (N=12, 8.57%), and "disagree" (N=5, 3.57%), with SD=0.80. Overall, it can be summarized that majority of the students had selected between "agree" and "strongly agree" for the item 9 to item 12, with SD between 0.79 and 0.86. This indicated that majority of the students have positive perceptions towards the implementation of MCPSS on teamwork and communication skills in the foundation mathematics course.

Table 4. Students' perceptions of teamwork and communication skills in the MCPSS at the foundation level

No. Item	Item description	Scale	N	Percentage (%)	SD
9.	I am comfortable working in my group before and during the MCPSS assessment.	1	1	0.71	0.86
		2	3	2.14	
		3	20	14.29	
		4	34	24.29	
		5	82	58.57	
10.	All my group members contribute ideas to solving a problem during the MCPSS assessment.	1	0	0.00	0.83
		2	6	4.29	
		3	13	9.29	
		4	42	30.00	
		5	79	56.43	
11.	All my group members are actively involved in the discussion during the MCPSS assessment.	1	0	0.00	0.79
		2	4	2.86	
		3	15	10.71	
		4	41	29.29	
		5	80	57.14	
12.	All my group members show an initiative in helping to solve problems during the MCPSS assessment.	1	0	0.00	0.80
		2	5	3.57	
		3	12	8.57	
		4	43	30.71	
		5	80	57.14	

Scale: 1=strongly disagree, 2=disagree, 3=not sure, 4=agree, and 5=strongly agree.

3.2. What are the strengths and areas of improvement for the implementation of MCPSS in the foundation level?

The findings were collected using the second section of the questionnaire (open-ended question) and the students' interview on their experiences in MCPSS. Thematic analysis was used to analyze the data, where four themes were generated from the thematic coding: i) teamwork; ii) social and communication skills; iii) application of mathematics skills; and iv) challenges.

3.2.1. Teamwork

This theme describes the students' ability to work together to complete the given task in MCPSS. Many students believed that the MCPSS assessment encourages teamwork towards shared objectives. This is shown by feedback obtained from the students' comments and interviews.

> "*MCPSS helps in building up teamwork among group members*." (Student A)
> "*MCPSS is an interesting assessment because it encourages students to develop their mindset, cooperative skills and greater responsibility toward one another.*" (Student B)
> "*During the MCPSS, we were able to work together as a team and shared ideas from one another*." (Student C)

While most of the feedback on teamwork in MCPSS is positive, there are some comments that raised concern about the students' contribution to their group.

> "*Some group members just watch the calculations without giving any idea, and they got marks without trying to solve the question.*" (Student D)
> "*All the group members should present the answer together or the other members of the group should help to explain the answer more clearly to the lecturers after the picked person presents the answer.*" (Student E)

Overall, it can be summarized that majority of the students felt that MCPSS helps them in developing teamwork and trust among other students, which can benefit them in the long run. This can be an advantage for them as they can work together if they face difficulties in solving future mathematics problems or even preparing for any upcoming examination in the future. While problem such as "free rider" still present in MCPSS, it is noted that students can evaluate their team members contribution performances through the peer-assessment form, which can affect the student's overall scores in the assessment.

3.2.2. Social and communication skills

For this theme, it describes as the students' ability to interact effectively with each other to convey information in order to solve problems related to mathematics tasks. Based on the feedback obtained from students, it was found that students were generally positive with the MCPSS in encouraging them to communicate with one another while completing the assessment.

> "*MCPSS helped me to be confident in my presentation skills where I was able to share my findings and new information with other students.*" (Student F)
> "*MCPSS influences my abilities in social and communication. Before this, I was a shy and introverted person, and I rarely talked with others. Through MCPSS, I was able to be more open for discussion with other group members in order to solve mathematical problems.*" (Student G)

In general, the majority of the students agreed that MCPSS encourages students to step out of their comfort zone, where they need to present, communicate and work together to solve mathematics problems that are too difficult to solve alone.

3.2.3. Application of mathematics skills

This theme describes students' abilities in applying and adopting new mathematics knowledge in solving the MCPSS tasks. In general, students' feedback was positive, praising MCPSS for helping them gain new mathematical knowledge and skills and preparing them for the mathematics examination.

> "*This assessment encourages me to think outside the box while solving mathematics problems with my team. Besides that, the assessment requires us to be creative and alerting mathematical problems.*" (Student H)

> "*I believe the MCPSS assessment helps me to prepare for the mathematics examination. Questions prepared in MCPSS are challenging and significant effort to solve. It is also beneficial as it helps me to understand the application of mathematics in real-life situations.*" (Student I)

It can be generally stated that MCPSS encourages students to deepen their understanding in mathematics learning. Questions prepared in MCPSS encourage students to do more research in mathematics and to be more alert with more content, applications, and different approaches in mathematics.

3.2.4. Challenges

This theme describes the challenges that students encountered during the MCPSS assessment. For this study, students have identified several issues related to the MCPSS assessments. Firstly, students feel that the duration for the MCPSS assessment should be longer, as they need more time to complete the task.

> "*It was fun and interactive sessions. My only issue might be the time limit. I would like to suggest adding 5 to 10 minutes of extra time to allow us to complete writing the solution on paper.*" (Students J)
>
> "*The time for us to solve the question were a little bit short, I suggest it to be at least 30 minutes because this is not an individual work where discussion among group members are more likely to take more time, if it were an individual task, usually 10-15 minutes are standard for a person to solve a math problem (if they do know what they are learning in class).*" (Student K)

In addition, some of the students also felt that the MCPSS questions were too difficult to comprehend and could not be completed within the limited time.

> "*It is good, but some of the questions in the MCPSS are very challenging. We think that some of the questions need further elaboration or information to make it easier for us to understand and solve.*" (Student L)

While MCPSS can provide positive benefits to students, it is not perfect, as indicated by the students' feedback. It is noted that the MCPSS is developed to assess large groups of students, and issues such as time and content difficulties might be a problem for some of the minority of the students. Nevertheless, these issues will be taken into account for future improvements of the MCPSS assessment.

3.3. Discussion

The findings of the study show that the students' perceptions of the implementation of the MCPSS at the foundation level were positive across all aspects of meaningful learning, reflective learning, teamwork, and communication skills. In addition, students generally agreed that MCPSS can benefit for their mathematics learning through exposure of new contents, applications, and approaches to learning. Students also felt that MCPSS can encourage them to communicate and work together with others while solving mathematics problems. These findings corroborate the studies that promote CPS in learning. Anisah and Suryati [30] study on undergraduate students' perception of group-work activities highlighted that students preferred working in groups, as it promotes CPS abilities among their peers. The findings showed that group-work activities that enable students to share knowledge and feedback through discussions help them write and publish high-quality research articles, which are essential to their overall learning in university. In addition, Abbas *et al*. [5] study also showed that students gave a positive perception of CPS activities. In their research, most students agreed that CPS encourages them to engage with learning materials, gain new knowledge and share ideas with other students. This practice will be beneficial in the long run as it supports students in developing problem-solving and team-work abilities [5].

While the majority of the students perceived the MCPSS as a positive experience, several issues need to be improved in the MCPSS assessment. The findings of this study showed that students were concerned with their team members participating in the assessment, stating that the lack of commitment among team members contributed towards the overall group work. Although the peer-assessment form was included in the MCPSS assessment, further improvement is needed to address this issue. One of the significant factors contributing to this issue is differences in the students' mathematical abilities. Students with higher mathematics abilities might contribute more to ideas, planning, and the overall task than students with lower mathematics abilities. This is supported by Zhang [31] study, which found that students with high mathematics achievement contributed more in terms of communication, discussion, and solution than students with low mathematics achievement. High mathematics achievement students tend to be more confident and control in the group, in terms of guiding them in the planning and discussion stages. On the

other hand, low-achieving students in mathematics feel embarrassed and lack confidence in their ability to contribute to the group, which will gradually make them uninterested and silent during the group task [31]. Therefore, students grouping by mathematics ability should be taken into account before conducting the MCPSS assessment. Educators must ensure that students in each group must consist of a balance of high and low mathematics achievement students, with the condition that the student's mathematics gap is close with one another. This will reduce the dominance of the high-achieving students in mathematics and provide more opportunities for low-achieving students to participate in the MCPSS assessment.

Lastly, the findings highlighted issues related to the MCPSS assessment's overall completion time. It was found that some students voiced their concerns about the MCPSS assessment's overall completion time, suggesting more time given to complete the MCPSS task. Hence, it is recommended that the MCPSS assessment's overall completion time be adjusted appropriately based on the current students' mathematics abilities and the MCPSS task's overall difficulty. Understanding the adequate completion time is vital for any assessment. An assessment with sufficient completion time can provide ample opportunity for students to complete tasks, allowing for a more accurate measurement of their understanding of the learning content. This is supported by Kane [32], which found that students' competence level in a subject can be misjudged if they are not given sufficient time to complete the task. This gives the students a significant disadvantage when compared to classmates who can finish the task quickly. Hence, educators need to provide sufficient completion time for the assessment to allow all students an equal opportunity to complete the task.

4. CONCLUSION

This study investigates the students' perceptions towards the implementation of the MCPSS at the foundation level. The findings of the study showed that the majority of students provided positive feedback across all aspects of their meaningful learning, reflective learning, teamwork, and communication skills. Besides that, students also felt that MCPSS can encourage them to communicate and work together with others while exposing them to new mathematics content and applications. However, issues related to the MCPSS time limit and group contributions need to be addressed to improve its overall effectiveness. It is hoped that this study can encourage other educators to apply and adapt CPS activities into their teaching and learning. In addition, it is hoped that the study on MCPSS will provide the framework for educators in investigating the effectiveness of CPS activities in teaching and learning. Future recommendations for the study include the adapting MCPSS to different science subjects at the foundation level. It is also recommended that the number of samples be increased for both quantitative and qualitative data to widen the overall feedback on MCPSS. The duration of the study should also be increased to provide more time for students and educators to adapt to the MCPSS approach.

FUNDING INFORMATION

Authors declare no funding involved.

AUTHOR CONTRIBUTIONS STATEMENT

This journal uses the Contributor Roles Taxonomy (CRediT) to recognize individual author contributions, reduce authorship disputes, and facilitate collaboration.

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C : **C**onceptualization
M : **M**ethodology
So : **So**ftware
Va : **Va**lidation
Fo : **Fo**rmal analysis
I : **I**nvestigation
R : **R**esources
D : **D**ata Curation
O : Writing - **O**riginal Draft
E : Writing - Review & **E**diting
Vi : **Vi**sualization
Su : **Su**pervision
P : **P**roject administration
Fu : **Fu**nding acquisition

CONFLICT OF INTEREST STATEMENT

Authors declare no conflict of interest.

INFORMED CONSENT

An official letter was submitted to the foundation center to obtain permission for this study. All students who contributed to the study were fully informed about its purpose. All information collected for this study will be kept confidential.

DATA AVAILABILITY

The data that supports the findings of this study are available on request from the corresponding author [GTGS]. The data, which contains information that could compromise the privacy of research participants, is not publicly available due to certain restrictions.

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