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Prospective Teachers' Perspectives on Collaborative Problem Solving in Mathematics

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Abstract: This study describes prospective teachers' perspectives on collaborative problem-solving (CPS) in mathematics. The study employed a 20-item questionnaire distributed to 47 prospective mathematics teachers in Indonesia. The questionnaire responses were scored, and two participants with the highest and lowest mean score were interviewed. Despite being quite similar in perspectives on perseverance and interest in collaboration, the prospective teacher with the highest mean score showed more openness to problems and the value of teamwork. Further research can be done by investigating how prospective teachers' perspectives relate to their knowledge of CPS or teaching practices.

Keywords: Collaborative problem solving, mathematics education, teacher education.

INTRODUCTION

Along with the rapid development of research related to the 21st century, attention to the skills students need to have in this century is also proliferating, one of which is collaborative problem solving (CPS). Collaborative problem-solving is a collective problem-solving skill where the individuals involved share the required knowledge and effort (OECD, 2017). The need for an investigation of students' CPS skills had been shown by PISA 2012's focus on interactive problem solving, where students faced problems that required them to interact with tools or media to obtain adequate information (OECD, 2013). The focus was changed to CPS in PISA 2015 (OECD, 2017). PISA 2015 focused its analysis on students' CPS for the first time by developing a student CPS assessment framework.

Several studies have been conducted related to CPS in Mathematics Education. Some of these studies focus on analyzing students' problem-solving processes by comparing individual and

collaborative problem-solving (Barron, 2000; Kapur & Bielaczyc, 2012; Schmitz & Winskel, 2008; Stacey, 1992). Several other studies investigated how to properly assess students' CPS (Chan & Clarke, 2017; Harding et al., 2017). In addition, the analysis of teaching and learning practices in the classroom to improve students' CPS was also the concern of several studies (Chiu, 2008; Hähkiöniemi et al., 2016). Among the studies related to CPS, studies examining prospective Mathematics teachers are still very limited. One of them is the study by Bjuland (2007), which identified the geometrical reasoning of prospective teachers in the collaborative problem-solving process.

In mathematics education, the study of prospective teachers, both their knowledge and perspective on a concept, is critical. In particular, the prospective teacher's perspective on a concept will influence how they teach in the future. Thus, the prospective teacher's perspective on CPS is vital in determining how they facilitate students practicing collaborative problem-solving skills (Xenofontos & Kyriakou, 2017). This study aims to describe the perspective of prospective mathematics teachers on collaborative problem-solving in mathematics. This description of the perspective on CPS will help study how prospective teachers perceive CPS and its potential to facilitate its practice in the future.

THEORETICAL FRAMEWORK

Collaborative Problem Solving (CPS)

CPS, which contains two important 21st-century skills, i.e., problem-solving and collaboration, has been discussed and defined by various entities. The term “collaborative problem solving” was shown to be used formally in works of literature starting in 2015 (Fatmanissa et al., 2022). PISA defined CPS as "an individual's capacity to effectively engage in a process in which two or more agents seek to solve a problem by sharing the understanding and effort required to reach a solution and pooling their knowledge, skills, and efforts to reach that solution" (OECD, 2017). The need to investigate students' CPS has been seen in PISA 2015, which focused on CPS (OECD, 2017).

Another project focusing on CPS is the Assessment and Teaching of 21st Century Skills (ATC21S) project. The project defined CPS as “approaching a problem responsively by working together and exchanging ideas” (Griffin & Care, 2015). Further, it stated that CPS is a joint activity in which a group takes several steps to turn a problem condition into a desired goal. While PISA gave a content-dependent explanation of CPS, ATC21S divided CPS into content-free and content-dependent. The content-dependent CPS involves skills and knowledge of CPS in particular content such as mathematics and science. ATC21S assessed CPS skills by assessing two skills, i.e., problem-solving as a cognitive skill and collaboration as a social skill.

Understanding CPS in Mathematics required understanding problem-solving and collaboration, but they alone were insufficient. Understanding how both constructs relate to each other and how

they could be integrated into the mathematics education context should be there as well (Kapur & Bielaczyc, 2012; Munson, 2019). Therefore, problem solving in mathematics is one thing, but putting it into a collaborative context is another. It led to the need for teachers, and thus prospective teachers, to have knowledge of it and positively consider its integration into practice. For example, van Leeuwen and Janssen (2019) highlighted the importance of teachers in giving more or less control, either socially or cognitively, while identifying an essential moment for students to be engaged in CPS. This control would determine how students' CPS process turned into meaningful learning. Another study by Haataja et al. (2019) investigated teachers' visual attention in scaffolding a successful CPS process. The study showed that the teacher's visual attention was targeted most dominantly to students' papers, to follow students' problem-solving process, and to students' faces to cater for their collaboration, acknowledging the importance of the two constructs in CPS.

Prospective Teachers' Perspectives

Mathematics teacher education is challenged to prepare prospective teachers to teach and constantly reflect their views and beliefs on the issue surrounding it (Columba & Stotz, 2016; Haug & Mork, 2021). Prospective teachers' views or perspectives on teaching and learning significantly impact how they plan, orient, and evaluate their own teaching (Beswick, 2012; Chapman, 2012; Clark et al., 2014; Middleton, 1999). Understanding prospective teachers' perspectives on CPS would benefit the understanding of their future practices surrounding it.

Perspective on CPS is related to how one views CPS. The 2015 PISA conceptual framework (OECD, 2017) divides students' perspectives on CPS into two main dimensions: their perspective on problem-solving and collaboration (Figure 1). The problem-solving dimension includes the perspective on persistence and openness to problems. In contrast, the collaboration dimension is divided into an interest in and value of collaboration.

The "perseverance" sub-dimension refers to how students perceive persistence in completing a task as determining the solution to a problem. It relates to how they view the problem as something that must be solved entirely or not. Openness to problems refers to how students are open to types of problems and the steps for solving them. This sub-dimension relates to how students perceive different problems and various problem-solving strategies. The sub-dimension of interest in collaboration refers to students' interest in collective work and the variety of perspectives that may occur, while the sub-dimension of the value of teamwork refers to how students view teamwork as an important aspect of solving math problems. Although intended for students, this framework is still relevant for being used with prospective teachers as participants. The CPS conceptual framework in PISA 2015 was used to develop a prospective teacher perspective questionnaire on CPS.

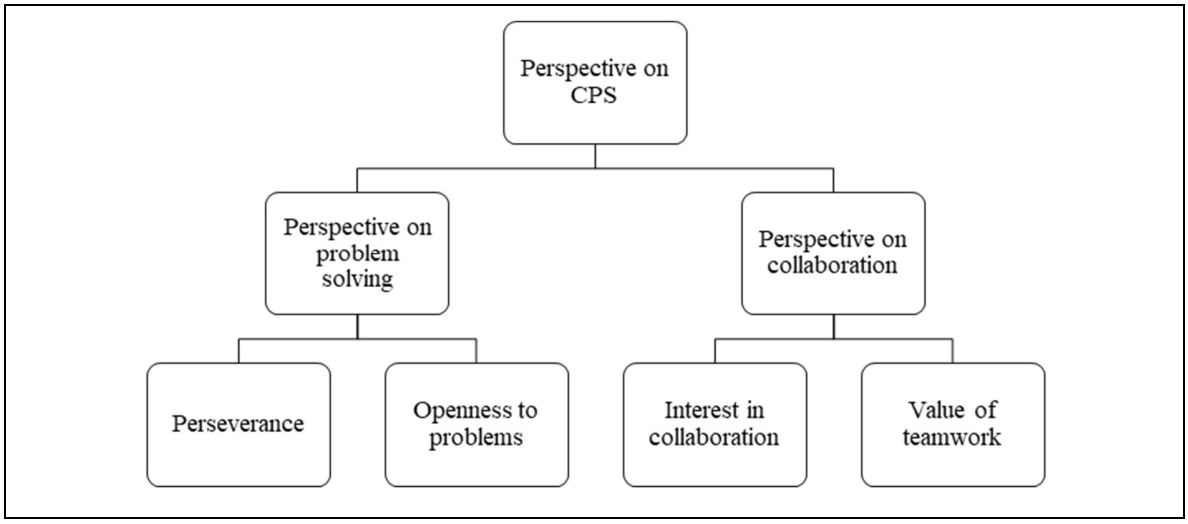

Figure 1: Dimensions of Perspective toward CPS adapted from PISA 2015

METHOD

This study utilized 47 responses from questionnaires and interviews with the selected two participants. Perspectives on CPS were identified using a questionnaire (the complete questionnaire is available upon request to the corresponding author) based on the framework from PISA 2015 (Figure 1). The questionnaire was constructed in Indonesian, and the framework for preparing it is presented in Table 1. Forty-seven prospective teachers were given a questionnaire with Likert scale options: strongly disagree, disagree, agree, and strongly agree.

Dimension	Description	# of Items	
		Positive	Negative
Perseverance	View persistence in completing tasks as determining the solution to a problem	3	3
Openness to problem	Be open to the types of problems and the steps to solve them	3	3
Interest in collaboration	Have an interest in collective work and a variety of perspectives	3	3
Value of teamwork	View teamwork as important in solving math problems	3	3

Table 1: Questionnaire construction

Each sub-dimension was translated into three pairs of positive and negative items. Each positive item contained a statement indicating a positive perspective on the corresponding dimension, while the negative item contained a negative perspective. On positive items, a larger scale indicated a more positive perspective on CPS, while on negative items, a larger scale indicated a more negative perspective on CPS. For example, participants who responded 'agree' on a negative item had a more negative perspective on CPS.

Two mathematics education experts checked the validity of the contents of the questionnaire. After the questionnaires were distributed, 47 participants' responses to the questionnaire were converted into numerical values. For positive items, the answers "strongly disagree", "disagree", "agree", and "strongly agree" were changed to scores of 1, 2, 3, and 4, respectively. For negative items, the responses were changed into a score of 4, 3, 2, and 1. Scores 3 and 4 indicate a tendency to have a positive perspective on CPS. Then, the scores of each participant are added up. An illustration of this process is given in Figure 2.

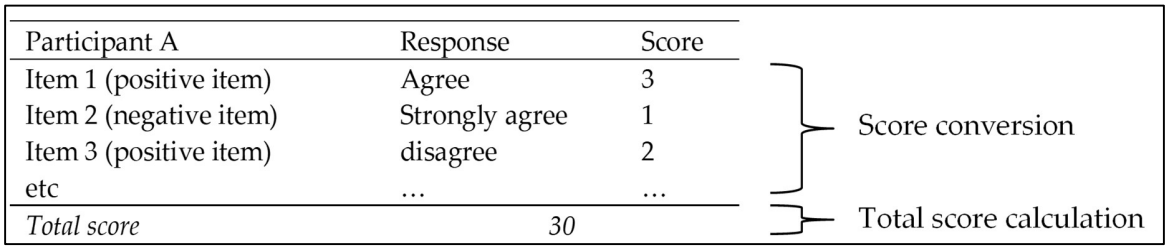

Figure 2: Example of response scoring

The construct validity test was carried out through statistical tests by calculating the correlation between the scores of each item and the total score (Cohen et al., 2007; Creswell, 2012). If the correlation between the two was significant, the item was declared valid. The test used was the non-parametric correlation test, namely the Spearman test. The significance value or p-value in the Spearman test is less than 0.05 (significant) for all items (Table 2 and Table 3) except positive items no. 4, 6, 8, and 12. Thus, these items were discarded in further analysis.

Item No.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Correl. Coeff.	.452**	.337*	.513**	0.154	.616**	0.228	.437**	0.280	.465**	.369*	.594**	0.264

* or ** indicates a significant correlation

Table 2: Spearman Correlation Coefficient of Positive Items

Item No.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Correl. Coeff.	.485**	.549**	.467**	.383**	.534**	.541**	.453**	.659**	.354*	.525**	.655**	.291*

* or ** indicates a significant correlation

Table 3: Spearman Correlation Coefficient of Negative Item

The reliability test was done by checking the inter-rater reliability of the instrument, i.e., by calculating the Cronbach Alpha coefficient of the instrument (Creswell, 2012). The test is considered reliable if the Cronbach Alpha coefficient is high. The value of the Cronbach Alpha coefficient is 0.825 and is considered very reliable (Hendriana & Sumarmo, 2014).

Based on the mean scores on the questionnaire, two prospective mathematics teachers were selected to be interviewed, i.e., one prospective teacher with the highest mean score (initial AA)

and one prospective teacher with the lowest mean score (initial JH). The two prospective teachers were chosen to help us contrast two different kinds of perspectives upon CPS. Both of them were senior-year students majoring in mathematics education at their university. Both prospective teachers had passed a course on problem-solving in teaching and several mathematics courses (e.g., geometry, calculus, discrete mathematics, etc.), expecting them to solve non-routine problems. At the beginning of their senior year, they also underwent a practice teaching program in a real classroom under the guidance of a mentor teacher.

To explore the perspective of prospective teachers more deeply, especially in each sub-dimensional perspective on CPS, semi-structured interviews were conducted with two selected prospective teachers. Each participant was given a separate interview schedule and interviewed individually to minimize the possibility of sharing information. The interview process began with confirming their willingness to be interviewed. The interview focused on extracting participants' opinions about mathematical problem-solving, collaboration, and collaborative problem-solving. The guiding questions included, but were not limited to: (1) what do you consider the most in solving mathematics problems? (2) what do you think about solving mathematical problems in groups? (3) As a prospective teacher, what do you think about implementing collaborative problem-solving activities in the classroom? All interviews were recorded and transcribed for analysis.

In the analysis process, interview transcripts were coded based on the identified sub-dimensions and further analysed to explain each prospective teacher's perspective. Statements expressing opinions on a particular sub-dimension were coded as in Table 1. The coding process referred to the description of each sub-dimension (Table 4) and then written in a memo. For example, opinions that considered the different perspectives of friends were included in the "interest in collaboration" sub-dimension (IC code). Code-based statements were collected and then categorized based on the similarity of perspectives presented in them. Analysis of the interviews was used to enrich the findings obtained from the questionnaire.

Sub-dimension	Code	Sub-dimension	Code
Perseverance	P	Interest in collaboration	IC
Openness to problem	OP	Value of teamwork	VT

Table 4: Coding scheme of interview transcripts

RESULTS

As indicated by the score distribution on each item and the total score, there was a tendency for positive perspectives toward collaborative problem-solving (Table 5). Prospective teachers' responses were broken down into each dimension, and it was shown that openness to problem and

interest in collaboration had the most range of scores. Respondents' total scores ranged from 49 as the lowest to 76 as the highest. An interview was conducted with two prospective teachers to further understand prospective teachers' perspectives, especially on explaining the range of perspectives from the least favouring CPS and the most favoring CPS.

Dimension	Score		
	Average	Maximum	Minimum
Perseverance	3.35	4.00	2.33
Openness to problem	3.15	4.00	2.00
Interest in collaboration	3.25	4.00	2.00
Value of teamwork	3.23	4.00	2.20
Total Score	*65.10*	*76.00*	*49.00*

Table 5: Item Score Distribution

Findings of the interview results revolved around two prospective teachers whose mean score was highest (participant AA) and lowest (participant JH) in the questionnaire. The two participants were chosen to represent two spectrums of perspective, i.e., perspective favoring CPS and perspective less favoring CPS. The description started by elaborating on participants' perspectives on each dimension, i.e., problem-solving and collaboration; then, findings were generated from the perspectives of collaborative problem solving. In general, the interview excerpts revealed apparent differences in some sub-dimensions of the perspectives.

Perspectives on Problem-Solving

On the problem-solving dimension, AA shows strong perseverance. It was revealed through his thorough explanation of how he pursued a solution to a problem he faced. His explanation when being asked about how he put effort into finding a solution was as follows:

> *We can try the solutions that have been done before with my own thoughts, so I'm sure why this method doesn't work. There must be a motivation to find out how we can solve the problem. If we are stuck, we don't know anymore, give us a break first, give our brains a break, for example, like listening to music, after cooling down, we still can't find a solution. So, like that, I usually search again for the material session, maybe on YouTube or the internet, or ask someone more expert.*

His explanation showed many ways to solve a problem, i.e., using a familiar strategy, reflecting on his thinking about why the strategy did not work, cooling his mind down, looking for other sources, or asking experts. His long and detailed procedures revealed his perspectives on how important perseverance is for solving problems. He further added that it bothered him whenever a problem remained unsolved, and he always wanted to find ways to solve it. Other excerpts revealed his openness to types and strategies of problems. Participant AA did not consider the explicit features of the problems, such as length and available picture, as the determining factors of how

he thought about a problem. He also argued that it was important to construct new strategies to solve problems. His openness to new strategies could be inferred from an excerpt below after being asked how if he could not find the solution on the first try:

> *As for how to solve it, it can also be affected, so we can first try solutions that have been done in real life for this problem. From there, if that doesn't work, we'll just try to find a new way.*

Interestingly, AA further emphasized that the new strategies might not have been learned before and might not be usually taught at school. Acknowledging the need to write a solution formally, he nevertheless thought that guess-and-check was a valid strategy whenever the truth of the solution could be proven. AA's openness to solution strategies might be related to his perseverance, considering that various ways to pursue solutions are important.

Similar to AA, JH showed favour to perseverance to some extent. For example, she thought about giving up after several actions, i.e., she could not understand the material related to the problem, looked for other sources, or asked for help. Despite mentioning giving up while being asked about her ways of finding a solution to a problem, JH's description of pursuing a solution could be considered as not different from AA's. However, apparent differences came from her perspectives on the types of problems. JH considered the explicit feature of the problem, such as the length or the availability of supporting pictures. After being asked how she perceived a problem the first time reading it, she stated:

> *If I'm honest, the first time I see it, it's like this. It's going to be difficult when you see such a long question. So sometimes, it's more likely to help if the explanation of the problem is short and clear, accompanied by illustrations*.

Further, JH explained that she considered the mathematics topic related to the problem as an essential feature. She would determine the topic and thus would be able to figure out the solution using the concepts of the topic. Her reason lengthened her emphasis on mathematics topics, that it was difficult for her to solve problems whenever she did not understand the underlying mathematics concept. She usually found it easy when she mastered the topic related to it because the strategy to solve the problem would come from it. Her previous point supported it when she considered giving up when she could not understand the problem's material. It could be inferred that JH saw a problem as the extension of a particular mathematics topic and that the solution heavily relied on it. When she was followed up by a question about how she could describe mathematics, JH's view below could be the reason behind her less-open perspective on the problem:

> *Mathematics is an exact science, so if we look for an answer, it's right or wrong. So surely, we can say it's true or false because there must be a way or procedure to solve it*.

It could be synthesized from both prospective teachers that despite being quite similar in viewing perseverance to pursue a solution, they had different perspectives on problem-solving, especially on how open they were to problem types and strategies. AA did not consider the surface feature of the problem, contrary to JH, who considered the length and picture of the problem. He was more reflective (when he mentioned checking previously done strategies) in choosing strategies and accepted the use of guess-and-check to formulate a new problem-dependent strategy. On the other hand, JH saw a problem as content-dependent and that its solution relied heavily on the underlying topic.

Perspectives on Collaboration

Both prospective teachers revealed a view on collaboration and valuing teamwork to some extent. Both mentioned their preferences for working with peers who could communicate or give opinions well. Interestingly, related to mathematics competence, they have quite different perspectives. AA considered their peers to have "various" competence and that competence was not important in choosing teammates. He was asked about what he did the first time being in a group, and he stated:

> *Of course, within a group, there will be different competencies between us. So, ask first, what is your competence, in what part you are an expert, while where am I more? So, from there, if we don't understand the material, we will explore it again or the problem to be solved. It doesn't matter how competent (you are). But if you are invited to communicate or solve a problem, we can work together*.

In this case, AA perceived collaboration as groups sharing their expertise and effort to reach a solution. He saw it as a process in which 'exploring each competence as possible again. On the contrary, JH mentioned that her peers should "be able to understand the concept of the material". She further explained that understanding the concept and giving an opinion was essential to get a solution in a group. She also mentioned that she preferred collaborating when she did not understand the problem. She explained:

> *When I understand the problem given, I can do it myself, but when I don't understand, I sometimes share it with friends*.

JH might perceive collaboration as a way to learn from others. Her perspective that problem solution relied heavily on the concept brought her emphasis to the needs of someone who mastered it and felt enough when she was that someone. It was understandable for JH to have that opinion, as she mentioned 'feeling burdened' when their teammates relied on her.

Even though both participants preferred collaboration over individual work, they had different reasons behind it. The different perspectives were more exemplified in how they valued teamwork. When asked how to overcome communication problems created by a particular teammate, AA

considered reminding his teammates and finding a solution by communicating the concern to that teammate. He spoke:

> *If during our education to become a teacher we are like this, what will happen when we become teachers. So, we can remind (the person) first if it doesn't work anymore, we can find another way to solve this, what to do so he can be active again. So, he can communicate well in group work. How if, how if next time I get a group with him again.*

He perceived teamwork as something to fight for as part of his exercise on becoming a teacher. He also acknowledged the possibility of being in a group with that person. His action to face the person and work it out together for the team might be better for future interactions. He did admit for the sake of the group that it was possible if the agreed solution was not the correct one, and that was okay as he mentioned, "convey ideas together, choose them together, and we get the results together". He perceived group decision was important, following the process within the group to obtain it. JH had a similar opinion about a group decision, yet she had a different opinion on handling communication problems created by a specific teammate. She thought being in the same group with such a person was difficult enough for her to collaborate with another group. She shared:

> *If you get a friend like that, maybe you can collaborate again with other groups if allowed, because you are looking for a solution. If, for example, it is allowed to collaborate with other groups for sharing, it can help, ma'am, because it's difficult If we are in a group with friends who do not communicate.*

JH perceived collaborating with a more communicative person was important, regardless of which group s/he belonged. It was understandable as she previously considered that she preferred collaboration more when she needed help, and communication problems were probably too difficult to face.

Perspectives on Collaborative Problem Solving

Prospective teachers' perspectives on problem solving and collaboration brought links to those of collaborative problem-solving. Despite being similar in perseverance, AA showed stronger openness to problems by showing a more flexible view of problem types and strategies. In contrast, JH tended to have a more static view of them. AA was more interested in a collective effort and how he valued teamwork, while JH seemed interested in beneficial interaction. When asked about their opinions on implementing CPS activities in their future classroom, both prospective teachers agreed to have the activities under similar conditions.

AA perceived collaborative problem-solving as an important activity to exercise communication and knowledge of students. Further, he thought:

The group is for in the beginning. For the children practice, (...) so it seems like they are more solid, that's how they understand their foundation. So, if you work together, remind each other, so when the material is solid, then they will be able to do it individually again.

Like AA, JH liked having a CPS activity in her teaching, as she believed teachers no longer dominantly provide the information. She stated:

When we teach, it becomes more like a group. Why? Because when we are in a group, we can collaborate with friends and share. Right now, ma'am, the curriculum doesn't require dominant teachers, so they focus more on students. It suits students in groups so that they will look for information first, and then the teacher will correct them.

During the interview sessions, some dialogues with prospective teachers were about assessment. Regarding assessing students' CPS, the two prospective teachers argued slightly differently. AA recommended assessing CPS in a project-like way, in which there was an explicit assessment scheme for communication alongside assessing students' mathematical understanding of the problem. He mentioned the reason that he understood the challenge of assessing individual performance in CPS activities and continued as follows:

It's usually not based on individual assessments for groups, so it's like a project. So, we can also see more about the child's skills. For groups, collaboration is (for example) communication (...). It usually depends on the percentage of the aspects of assessment.

While being asked about the same challenge faced in assessing CPS, JH mentioned that it was possible to have only some of the group members contribute to the problem solution. She responded to this by reflecting on her experience as follows:

I admit too. Sometimes I'm like that too. My friends are like that too. But again, ma'am, from the student's point of view, he could seem to walk together. He could also learn, "Oh, it turned out like this" Even though the answer wasn't correct, at least he understood the concept of that answer, right? We learn that the process is more important than the grade.

JH's opinion was more into the knowledge constructed by students through the process. She argued that the case was expected as she sometimes did it. While being asked further about how she would assess students' performance in this case, she deliberately repeated the same opinions. While listening to JH, it might be inferred that, according to her, assessing other skills outside mathematical concept mastery was not part of assessing students' performance. Thus, while having a CPS activity, she considered having students learn the concept was enough modal to assess their performance. In comparison, AA perceived communication as part of the assessment process, while JH seemed to disregard it for students' assessments. Both prospective teachers recognized CPS to be implemented in the classroom yet had distinct perspectives on assessing students.

DISCUSSION

It had been shown that AA, whose mean score was the highest, and JH, whose mean score was the lowest, demonstrated different perspectives upon most of the sub-dimensions of the perspectives. The noticeable difference was in the sub-dimension of openness to problems, where AA was more flexible in considering problem types and strategies. At the same time, JH was more inflexible by viewing problems based on their surface feature. Both prospective teachers' perspectives on openness to problems might be connected to their beliefs in mathematics. AA's perspectives on creating a new strategy based on the problem and that a problem might not be constituted by its surface feature or structure corresponded to the problem-solving view of mathematics (Ernest, 1989). Especially when he perceived finding a solution to a problem might need new exploration, showing that a solution or discussion result remained upon improvement. In contrast, JH's repeated utterances of a right or wrong solution, understanding of materials, and the exact mathematics corresponded to the instrumentalist view.

On the collaboration dimension, a clear distinction was on the sub-dimension of the value of teamwork. AA perceived teamwork and team members as inevitable, and what came between them should be faced to achieve the solution. On the other hand, JH considered team members as places to lean on, and thus problems that came within them could be the reason for her to look for other 'places' to achieve the solution. Both views became the debates in some literature defining a 'good' CPS skill (Chan et al., 2018). On one side, AA's perspective showed his willingness to handle problems during CPS and gather ideas from within his team, no matter who his teammates were. However, on another side, his perspectives on his team might be biased compared to his view of other teams. What JH argued to have other groups beyond her get help would be what she viewed as a proper collaboration and how she valued teamwork. As the collaboration dimension was more into how prospective teachers viewed social aspects, both perspectives could illustrate the subtle difference between the two.

AA's perspectives on assessing CPS were in line with how PISA assessed CPS, i.e., for problem-solving, the cognitive processes were still included, while assessment of social and collaborative skills, which are associated with noncognitive skills, was added (Greiff, 2013). JH did not consider social aspects, such as communication between the team, as an aspect to be assessed, which showed how she perceived the assessment of CPS or mathematics assessment in general.

Besides contrasting the difference between the two prospective teachers, the reason behind those perspectives was as noteworthy. While CPS is a necessary skill to face the complexity of 21st-century demands, some perspectives less favoring CPS (e.g., not exploring new perspectives, being inflexible in solving problems, etc.) might hinder the practice of improving CPS in the future (Graesser et al., 2018), especially when such perspectives are dynamic and to be developed through teacher education program (Evans, 2011). By understanding the prospective teachers' perspectives

on CPS and why they had them, teacher education and preparation could be more meaningfully conducted (Marble et al., 2000).

CONCLUSION

This study has described several points differentiating two prospective mathematics perspectives toward CPS. Despite being quite similar in perspectives on perseverance and interest in collaboration, the prospective teacher favoring CPS showed more openness to problems and the value of teamwork than another prospective teacher less favoring CPS.

By understanding the characteristics of each perspective, it is hoped that more effort can be made to promote meaningful teacher education in promoting CPS. Each perspective can also contribute to the broader understanding of prospective teachers' perspectives, not only in CPS but also in the teaching practices or the inclusion of social aspects of mathematics in general. It may be too early to conclude that these perspectives might be directly related to what both participants will do in the future as teachers. For example, when the participant considered leaving the group due to uncommunicative peers, s/he might not recommend their students to do so in the future. Yet, the prospective teachers might position students facing the same situation as themselves and have different viewpoints on the uncommunicative person. By this, perspectives have been essential factors in driving teachers' practices.

Due to the small sample and limited duration used in this study, the findings cannot be generalized. Still, it provides valuable descriptions of prospective teachers' perspectives on CPS. Further research can be done by investigating how prospective teachers' perspectives relate to their knowledge of CPS or future teaching practices. A longitudinal study to investigate the changes in perspectives on CPS may be conducted to portray prospective teachers' education influence.

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References

[1] Barron, B. (2000). Problem solving in video-based microworlds: Collaborative and individual outcomes of high-achieving sixth-grade students. Journal of Educational Psychology, 92(2), 391–398.

[2] Beswick, K. (2012). Teachers' beliefs about school mathematics and mathematicians' mathematics and their relationship to practice. Educational Studies in Mathematics, 79(1), 127–147. https://doi.org/10.1007/sl0649-01

[3] Bjuland, R. (2007). Adult Students' Reasoning in Geometry: Teaching Mathematics through Collaborative Problem Solving in Teacher Education. The Mathematics Enthusiast, 4(1), 1–30. https://doi.org/10.54870/1551-3440.1056

[4] Chan, M. C. E., & Clarke, D. (2017). Structured affordances in the use of open-ended tasks to facilitate collaborative problem solving. ZDM - Mathematics Education, 49(6), 951–963. https://doi.org/10.1007/s11858-017-0876-2

[5] Chan, M. C. E., Clarke, D., Cao, Y., & Chao, Y. (2018). The social essentials of learning: an experimental investigation of collaborative problem solving and knowledge construction in mathematics classrooms in Australia and China. Mathematics Education Research Journal, 30(1), 39–50. https://doi.org/10.1007/s13394-017-0209-3

[6] Chapman, O. (2012). Prospective elementary school teachers' ways of making sense of mathematical problem posing . PNA. Revista de Investigación En Didáctica de La Matemática, 6(4), 135–146. https://doi.org/10.30827/pna.v6i4.6137

[7] Chiu, M. M. (2008). Effects of argumentation on group micro-creativity: Statistical discourse analyses of algebra students' collaborative problem solving. Contemporary Educational Psychology, 33(3), 382–402. https://doi.org/10.1016/j.cedpsych.2008.05.001

[8] Clark, L. M., DePiper, J. N., Frank, T. J., Nishio, M., Campbell, P. F., Smith, T. M., Griffin, M. J., Rust, A. H., Conant, D. L., & Choi, Y. (2014). Teacher characteristics associated with mathematics teachers' beliefs and awareness of their students' mathematical dispositions. Journal for Research in Mathematics Education, 45(2), 246–284. https://doi.org/10.5951/jresematheduc.45.2.0246

[9] Cohen, L., Manion, L., & Morrison, K. (2007). Research methods in education. In Professional Development in Education (6th ed., Vol. 38, Issue 3). Taylor- Franchise. https://doi.org/10.1080/19415257.2011.643130

[10] Columba, L., & Stotz, M. (2016). The Power of the Common Core State Standards in Mathematics. Mathematics Teaching Research Journal, 8(3), 6–28. www.hostos.cuny.edu/departments/math/mtrj

[11] Creswell, J. W. (2012). Educational research: Planning, conducting, and evaluating quantitative and qualitative research. In Educational Research (Vol. 4). Pearson. https://doi.org/10.1017/CBO9781107415324.004

[12] Ernest, P. (1989). The Knowledge, Beliefs and Attitudes of the Mathematics Teacher: A Model. Journal of Education for Teaching, 15(1), 13–33.

[13] Evans, B. R. (2011). Elementary Teachers' Mathematical Content Knowledge, Efficacy, Problem Solving Abilities, and Beliefs in Two Alternative Certification Programs. Mathematics Teaching Research Journal, 5(1), 50–70.

[14] Fatmanissa, N., Yuli Eko Siswono, T., Lukito, A., Budi Rahaju, E., & Ismail, I. (2022). Collaborative Problem-Solving in Mathematics: A Systematic Literature Review. Pedagogika, 148(4), 45–65. https://doi.org/10.15823/p.2022.148.3

[15] Graesser, A. C., Fiore, S. M., Greiff, S., Andrews-Todd, J., Foltz, P. W., & Hesse, F. W. (2018). Advancing the Science of Collaborative Problem Solving. Psychological Science in the Public Interest, 19(2), 59–92. https://doi.org/10.1177/1529100618808244

[16] Greiff, S. (2013). Perspectives on problem solving in educational assessment: Analytical, interactive, and collaborative problem solving. Journal of Problem Solving, 5(2), 71–91. https://doi.org/10.7771/1932-6246.1153

[17] Griffin, P., & Care, E. (2015). Assessment and Teaching of 21st Century Skills: Methods and Approach. In Educational Assessment in an Information Age. Springer. https://doi.org/10.1007/978-94-017-9395-7

[18] Haataja, E., Garcia Moreno-Esteva, E., Salonen, V., Laine, A., Toivanen, M., & Hannula, M. S. (2019). Teacher's visual attention when scaffolding collaborative mathematical problem solving. Teaching and Teacher Education, 86, 102877. https://doi.org/https://doi.org/10.1016/j.tate.2019.102877

[19] Hähkiöniemi, M., Fenyvesi, K., Pöysä-tarhonen, J., Tarnanen, M., Kauppinen, M., Martin, A., & Nieminen, P. (2016). Mathematics Learning through Arts and Collaborative Problem-Solving : the Princess and the Diamond-Problem. Bridges Finland Conference Proceedings, 1(August), 97–104.

[20] Harding, S. E., Griffin, P. E., Awwal, N., Alom, B. M., & Scoular, C. (2017). Measuring Collaborative Problem Solving Using Mathematics-Based Tasks. AERA Open, 3(3), 233285841772804. https://doi.org/10.1177/2332858417728046

[21] Haug, B. S., & Mork, S. M. (2021). Taking 21st century skills from vision to classroom: What teachers highlight as supportive professional development in the light of new demands from educational reforms. Teaching and Teacher Education, 100, 103286. https://doi.org/https://doi.org/10.1016/j.tate.2021.103286

[22] Hendriana, H., & Sumarmo, U. (2014). Penilaian Pembelajaran Matematika (Mathematics Teaching Assessment). Refika Aditama.

[23] Kapur, M., & Bielaczyc, K. (2012). Designing for Productive Failure. Journal of the Learning Sciences, 21(1), 45–83. https://doi.org/10.1080/10508406.2011.591717

[24] Marble, S., Finley, S., & Ferguson, C. (2000). Understanding Teachers' Perspectives on Teaching and Learning: A synthesis of Work in Five study sites. Southwest Educational Development Laboratory, 1–42. http://www.sedl.org

[25] Middleton, J. A. (1999). Curricular influences on the motivational beliefs and practice of two middle school mathematics teachers: A follow-up study. Journal for Research in Mathematics Education, 30(3), 356–358. https://doi.org/10.2307/749840

[26] Munson, J. (2019). After eliciting: Variation in elementary mathematics teachers' discursive pathways during collaborative problem solving. Journal of Mathematical Behavior, 56. https://doi.org/10.1016/j.jmathb.2019.100736

[27] OECD. (2013). PISA 2012 Assessment and Analytical Framework: Mathematics, Reading, Science, Problem Solving and Financial Literacy. In OECD Report. https://doi.org/10.1787/9789264190511-en

[28] OECD. (2017). PISA 2015 Assessment and Analytical Framework. OECD Publishing. https://doi.org/10.1787/9789264281820-en

[29] Schmitz, M. J., & Winskel, H. (2008). Towards effective partnerships in a collaborative problem-solving task. British Journal of Educational Psychology, 78(4), 581–596. https://doi.org/10.1348/000709908X281619

[30] Stacey, K. (1992). Mathematical problem solving in groups: are two heads better than one? Journal of Mathematical Behavior, 11, 261–275.

[31] van Leeuwen, A., & Janssen, J. (2019). A systematic review of teacher guidance during collaborative learning in primary and secondary education. Educational Research Review, 27(July 2018), 71–89. https://doi.org/10.1016/j.edurev.2019.02.001

[32] Xenofontos, C., & Kyriakou, A. (2017). Prospective elementary teachers' beliefs about collaborative problem solving and dialogue in mathematics. Mathematics Teacher Education & Development, 19(2), 142–158. http://search.ebscohost.com/login.aspx?direct=true&db=ehh&AN=126728550&site=ehost-live