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Struggling Students' Psychological Safety and Cognition in Group Discussion

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The study was designed to explore how better-achievers raised struggling students' psychological safety and cognition in collaborative group discussion engaging in conjecturing-based teaching. Four target students in a heterogeneous group were selected from six groups of four in a sixth-grade classroom studying the derived formula of circle area. The data from part of the study collected verbatim transcripts, nonverbal gestures of video classroom observation, as well as individual and group worksheets. The micro-level analysis was proceeded by identifying the episodes of group discussion and the ways of interaction. The results of the study indicate that direct contribution, indirect contribution, and questioning were three ways of verbal interaction of the struggling students in group discussion. The main interaction of two struggling students was nonverbal. Asking various questions with different purposes and indirect contributions were two ways used by the better-achievers that raised the struggling students' psychological safety and cognition. Questions asked by the better-achievers were for helping the struggling students to know that a mathematical expression can represent two meanings.

Keywords: struggling student, group discussion, psychological safety, questioning, impersonal skill

The skill of teamwork collaboration is one of the competencies of the twenty-first century. As such, group learning has been stressed in the reforms of mathematics instruction across countries. Group learning in general classrooms involves dividing the class into small groups of students who sit together face-to-face. Without appropriate guidance from the teacher, the group's dynamics result in a student becoming the leader and a star of the group. This group structure creates challenges for all students to actively participate in the group and their learning. With it, group learning becomes an issue for some students due to inappropriate level of psychological safety and cognitive learning. While the research literature provides guidelines on group learning (Jolliffe, 2007; Slavin, 2011, 2015; Thousand et al., 1994) there is still a need for research to understanding how to create groups to support meaningful collaboration and learning among students in the mathematics classroom. This paper reports on a study that contributes to this understanding regarding collaboration of students of different abilities in mathematics. The study explored how better-achievers raised struggling students' psychological safety and cognition in collaborative group discussion in the context of conjecturing-based teaching.

Background and Related Literature

This section provides the background for situating the study in group learning. It draws on the research literature to highlight the nature of psychological safety, collaborative group learning, and student talk in small groups and the relationships among them.

Importance of Psychological Safety

There is agreement that in the workplace the provision of a psychological safety work environment is one way to improve individual and team learning (Edmondson, 1999). Edmondson defined team psychological safety as "a shared belief held by members of a team that the team is safe for interpersonal risk taking" (p. 350). A high degree of psychological safety of individuals results in more interpersonal communication and leads to more voice behaviors among employees at the workplace (Bienefeld & Grote, 2014; Leroy et al., 2012; Newman et al., 2017). The employees with psychological safety are more likely to raise disagreement, give candid feedback, and point out errors to their supervisor (Tynan, 2005). In addition, psychological safety in small groups in the workplace has been found to influence performance indirectly through facilitating cognitive learning at both individual level and team level (Hirak et al., 2012; Li & Tan, 2012). This perspective of psychological safety suggests that it is a moderator of increasing knowledge sharing, engagement, and cognitive learning. Thus, it has relevance and importance to group learning in the mathematics classroom and should receive more attention in research to understand and improve students' participation in group work.

Collaborative Group Learning

For group learning to be collaborative functionally, the following elements are needed (In'am & Sutrisno, 2021; Krummheuer, 2015):

1. Mutual support. One's success depends on the success of the entire group. If the group fails, one will also fail. Therefore, each member of the group should work together to accomplish the given task.
2. Interpersonal interaction. Students in a group can contribute to each other's success in learning. Interpersonal interaction has an impact on individual learning.
3. Individual accountability. Collaborative learning emphasizes the performance

at individual and group levels. Individual efforts are at stake in the group's fate. Therefore, collaborative learning is "learning together, acting alone".
4. Skills of collaboration. The skills include academic-related task-work and interpersonal skills of teamwork. If one has the skills of collaboration, then they would have high-quality and efficient learning.

Collaborative group learning brings about interaction that could make disputes inevitable. Thus, teachers should teach students mutual trust and mutual support to help them to develop psychological safety (Tatsis et al., 2018).

Collaborative group learning in mathematics education has been conceptualized in terms of the perspective of social cognition theory (In‘am & Sutrisno, 2021; Rogoff, 1999). Based on this perspective, for instance, collaborative group learning provides students who are better-achievers in mathematics with the opportunity to assist struggling students in cognition. It also provides the opportunity for the better-achievers to develop leadership and interpersonal skills (Martins et. al., 2013). In general, collaborative group learning allows students to achieve common goals in the process of interacting with group members.

As previously discussed, the literature suggested that when team psychological safety was higher, cognitive diversity was more positively related to team performance. This relationship indicates that more effective group performance could be achieved by raising psychological safety and reducing conflict within a heterogeneous group with cognitive diversity. Thus, raising psychological safety is expected to provide the appropriate atmosphere of group learning. However, the issue is how to raise the psychological safety. Given its importance, this issue needs more attention in research in mathematics education. This study offers one approach to address this issue of how better-achievers in mathematics raise struggling students’ psychological safety while engaging in group discussion of conjecturing-based teaching.

Student Talk in Group Discussion

Student talk is a vehicle of group discussion (Franke et al., 2009). Student talk via describing, explaining, and justifying can examine if students have misunderstanding and lack of understanding (Krummheuer, 2015). Furthermore, student talk makes it possible for students to know each other’s thinking and provides them with mutual support to gain more complete mathematical understanding. Finally, talk can help students to develop advanced understanding and provide them with the opportunity to internalize new knowledge (Kartono & Shora, 2020).

Student talk, as explanation, should be precise and explicit beyond giving an answer (Jung & Schütte, 2018; Nathan & Knuth, 2003) to positively support achievement outcomes. Questioning is good way of triggering student talk, but little research focuses on student’s questioning in group discussions (Hiebert, 2003). Questioning by students is more challenging than by teachers since students could encounter the following obstacles:

1. Limited knowledge. Students with little knowledge may not know what question to ask since, for example, they may have difficulty in judging where the contradiction lies and in identifying the missing information needed to solve a problem.
2. Social disorder. If students ask a bad question, they may lose position in the group/class or feel humiliated, which makes them afraid to ask further questions.
3. Lack of questioning skill. Students may not have the skill to ask questions in the group unless a teacher intentionally emphasizes and support the importance of student's questioning.

In general, student talk is important to raise the psychological safety and cognitive learning of the students. However, this role of student talk has received little attention in mathematics education research. This study considers it in relation to groups with students of diverse levels of achievements in mathematics.

Theoretical Perspectives

As discussed in the preceding section, psychological safety, collaborative learning, and group talk are important to this study. In this section the theoretical perspectives underlying collaborative group learning and the conjecturing-based teaching model are presented as the bases of framing the work.

Collaborative Group Learning

In this study, collaborative group learning is based on social theory, social imitation theory, and cognitive elaboration theory. Social theory indicates that an individual's cognitive structure is the result of the internalization of external social activities (Vygotsky & Cole, 1978) such as collaborative group discussion. Through social interaction or group discussion, group members become aware of each other's weaknesses, correct each other, and adjust themselves based on the understanding of others. Thus, group discussion among students can promote growth because students of similar ages have similar basic developmental zones and can relate to each other. In general, collaborative learning has advantages over individual learning to support students' learning of mathematics.

The social imitation theory indicates that individuals learn new behaviors and modify previous behaviors via observation and imitation (Bandura, 1989). Research shows that students who learn by observing peer demonstration develop better self-efficacy and skills than students who learn by observing teacher demonstration (Määttä et al., 2012). From this perspective, collaborative group learning provides students with opportunities to observe and imitate peer demonstrations to support their development in important ways. In particular, struggling students of mathematics could benefit more from learning via observing and imitating than better-achievers in heterogeneous-ability collaborative groups.

Finally, in cognitive elaboration theory, individuals must use some learning strategies to reorganize and master new information. Group interaction is used to amplify individual processing information such as rehearsal and retrieval (O'Donnell & Dansereau, 2000). Explanation is one of the most effective means of elaboration (Slavin, 2015) because when the explainer explains the information he needs to organize it to explain it to others. Therefore, explanation requires the elaboration of the teller's cognition, which then enhances the effect of collaborative learning. This perspective of explanation provides a basis to account for the benefits of the better-achievers in group work when they provide assistance to others as in the case of this study.

Based on these three theories, the theoretical framework for collaborative group learning in this study consists of collaborative group discussion, observation and imitation of peers, and explanation. These characteristics are important to account for the learning of both the struggling students and the better-achievers. For example, learning is supported for both from the group discussions, more for the struggling students from the observation and imitation, and more for the better-achievers from the explanations.

Conjecturing-Based Teaching

Conjecturing-based teaching provided the context for the collaborative group learning in this study. This teaching approach was developed by the author (Lin, 2018) and consists of the following five stages:

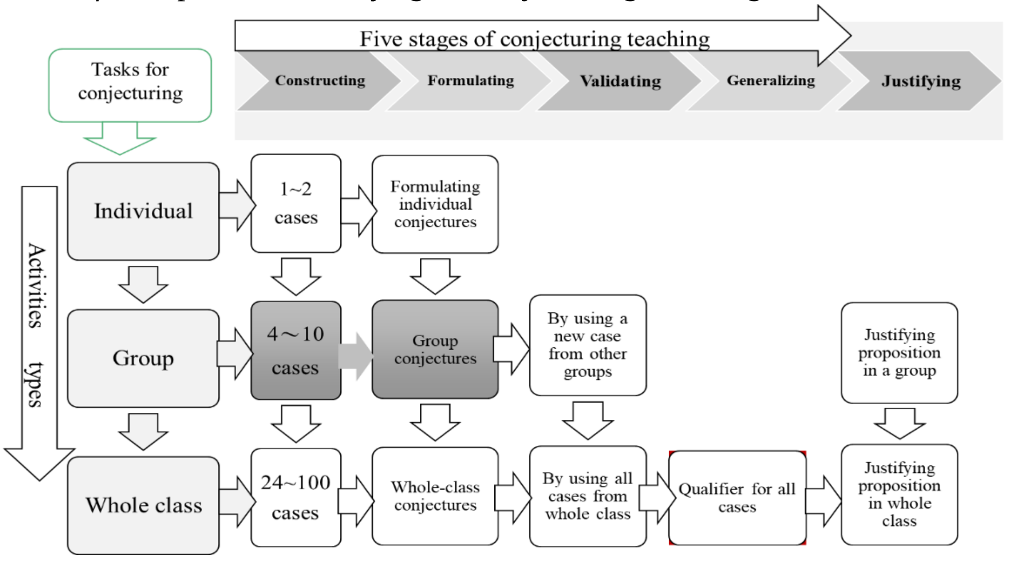
1. *Constructing cases* – emphasizes that the cases are constructed by individuals followed by collecting the cases for working in the group.
2. *Formulating conjectures* – emphasizes that the conjectures must be based on the group-cases constructed in the first stage. Incorrect or non-data-based individual conjectures could occur, thus it is necessary to check them in a group.
3. *Validating conjectures* – means that the truth of a conjectures needs to be validated with more cases beyond the group cases.
4. *Generalizing conjectures* – means that the non-true class conjectures for all cases are generalized into true conjectures via restricted conditions.
5. *Justification* – is for convincing others to accept the conjectures.

The relationship among the five stages of conjecturing-based teaching as used in the study is shown in Figure 1.

Group learning is conducted in the first two stages of conjecturing-based teaching. In the first stage, group discussion is for checking the correctness of individual cases. Likewise, group discussion in the second stage is for checking the correctness of the individual conjectures. Besides, generating group-conjectures from individual-conjectures is essential group work in the second stage. The group discussions in the first two stages, as the focus of conjecturing teaching, are depicted in the shadow areas of the Figure 1.

Figure 1

Roles of Group Activities Playing in Conjecturing Teaching



Methods

A case study (Stake, 1995) was conducted to explore group learning of one group of students. The focus was on the research question regarding how better-achievers in mathematics raised struggling students' psychological safety while they engaged in group discussion during conjecturing-based teaching.

Participants

Four students in a group (Group 3) were intentionally selected from six groups in a sixth-grade class to be the participants of the study. The intentional selection was based on two reasons: First, the study aimed to identify what raising the psychological safety looked like among students in a group. Second, the teacher, Kent, was familiar with conjecturing-basic teaching. The four students consisted of two lower-achievers, LS4 (boy) and LS15 (girl), and two better-achievers, HS2 (boy) and HS12 (girl). Students in the class were seated into groups of four. Their seats were rotated every month to create changes in the groups. However, in order to allow this study to explore the long-term interactions, the four participants were asked to be seated in the same group throughout the semester.

A Circle Task

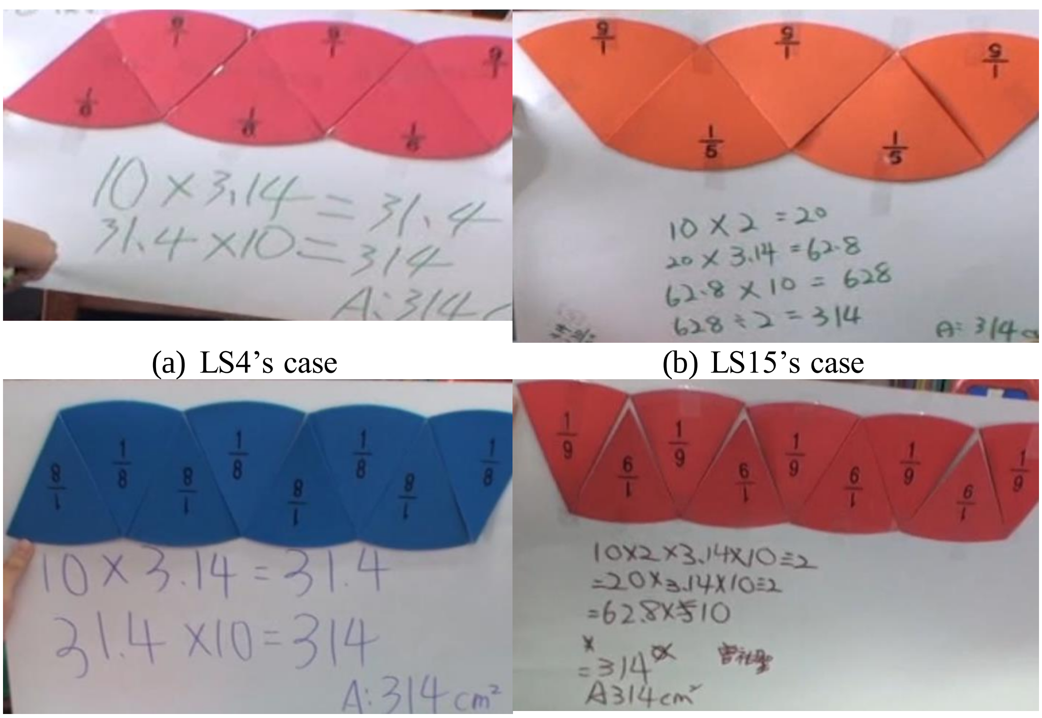
The objective of the lessons in this study was to derive the area formula of a circle. The prior knowledge for this task included the area formula of a rectangle, triangle, parallelogram, and trapezoid and the circumference of a circle with $\pi \approx 3.14$. Each student in a group was given various partitions (such as 5, 6, 8, and 9 parts) of a circle with radius 10 cm. They were asked to find the area of the circle before formally learning the area formula of a circle. To be successful, it was necessary for them to rearrange the small pieces (circle partitions) up and down in a row into a parallelogram-like, triangle-like, or trapezoid-like shape.

Data Collection

The data included verbatim transcripts of video and audio recordings of the groups' activities and discussions and the students' individual and group worksheets. Data were collected for five 40-minutes sessions of teaching "the derived formula of circle area." This paper adopted only part of the data that was required for the goal of the study being reported. For example, the individual cases constructed by the Group 3 students based on stage 1 of the conjecturing-based teaching approach are shown in Figure 2.

Figure 2

Individual Cases Constructed by Individuals in Group 3



(a) LS4's case (b) LS15's case

(c) HS12's case (d) HS2's case

Data Analysis

The *X-Mind* software was used as the tool for analyzing the group discussion. A total of 13 clips cut from the first two stages of conjecturing teaching were analyzed. Discourse analysis was used to analyze the meaning of talks among the group members. The questions asked by students were also analyzed. However, due to limitations on the length of the paper, only the group discussion in the first stage of conjecturing teaching is reported. The group discussion data were organized and analyzed in the following five steps.

1. The participants' group discussions from the two 40-minutes lessons were cut into 13 clips. The length of a clip was determined by an episode of a mathematics concept. The first six clips of the group discussion that occurred in the first stage of conjecturing teaching included: (a) Clips 1-3 consisting of the episodes of LS15's solution, (b) Clip 4 consisting of the episode of LS4's solution, (c) Clip 5 consisting of the episode of HS12's solution, and (d) Clip 6 consisting of the episode of HS2's solution. The students' worksheets are shown in Figure 2 (a)-(d). The other seven clips, not addressed in this paper, were cut from the second stage of conjecturing teaching in which they shared their own conjectures.
2. The videotapes were transcribed verbatim.
3. Comments were made on the meanings of the verbal or non-verbal interactions and who gave help and to whom were identified (e.g., right two columns of Table 1). Table 1 also provides an example of researcher's comments.

Table 1

Example of Researcher's Comments for Analyzing the Episode of "10x2"

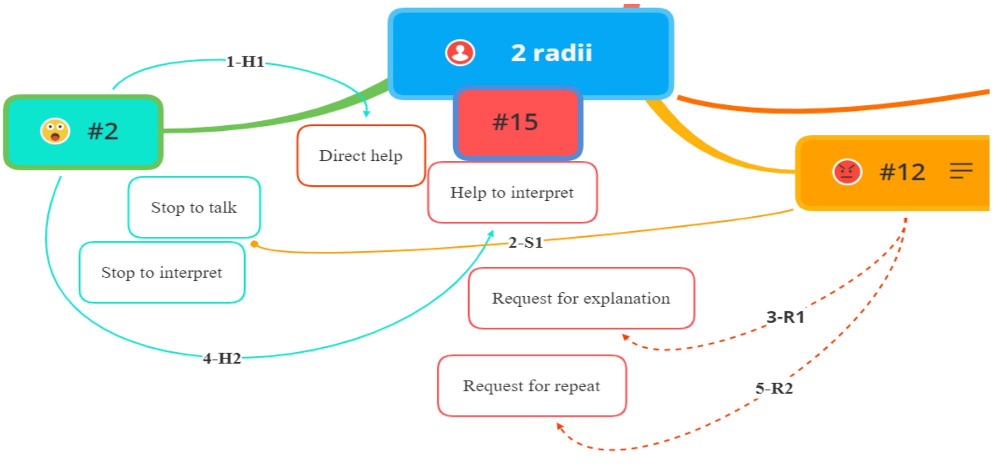
Student #15 Reporting Her Solutions (time：00:25-1:20)			Peer Interaction		
	Scenario 1：2 radii	**Researcher's comments**	**Line**	**Who helps**	**To whom**
1.	My solution is 10 times 2 equals 20.				
2.	10 is that, a sector's, radius				
3.	Then, multiplied by 2, because it has 2 radii	Disagreement and doubts appeared on #12's face. It is expected to say 2 radii in length equals to the length of a diameter.			#15
4.	Then 20, multiplied by 3.14.	#2 is trying to give a hand.	Line 1	#2 give a help	#15
5.	Wait a minute, what are there 2 radii.	#12 asked #15 to say clearly her disagreement on 2 radii.	Line 2 Line 3	#12 stop #2 to speak #12 request #15 for explanation	#2 stopped talking #15 explaining the 2 radii
6.	Multiplied by 2, It should be radius plus radius equals a diameter.	# 2 assisted #15 to explain the meaning of 2 radii	Line 4	#2's help #15 with the interpretation	#15 listening
7.	Then, then, then a diameter. multiplied by 3.14 equals to a circle[circumference].	Students' speaking is not completely The help from student #2 is always about the knowledge related to a circle.			
8.	Say it again	# 12 has tolerance to wait for #15 with understanding	Line 5	#12 request 2 for repeating	#15 explaining with understanding
9.	Radius plus radius equals a diameter	#15 gained understanding on radius +radius instead of 2 radii.			

4. The X-Mind map was drawn. As an example, Figure 3 shows the interaction map drawn from the episode of LS15's explanation of "10 x 2". The different colored lines/arrows stand for different students. The green arrow (i.e., →)

means giving information directly; the brown line ending with a circle (i.e., ⊸) means prohibiting someone to talk; and the red dashed arrow (i.e., ⇢) means to have a request to answer.

Figure 3

Group Interaction of 4 Students by Drawing X-Mind Mapping

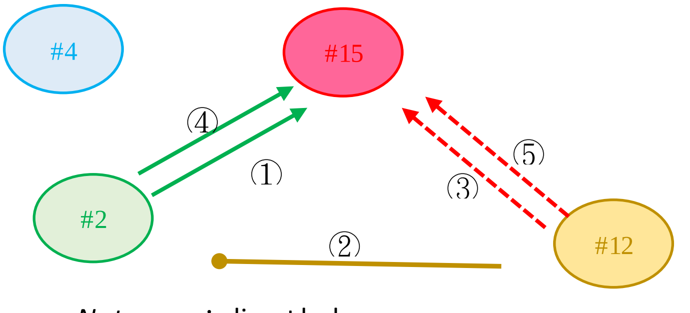


Note. →: direct help; ⊸: prohibit; ⇢: request
5-R2: 5th request for LS15 to answer. 1-H1:1st direct help to LS15.
2-S1: 2nd stop giving direct help to LS15

5. Simplified interaction map, as shown in Figure 4. The circled numbers (i.e., 1 to 5 inclusive) represent the sequential interactions. The colored ovals represent the students' seating number.

Figure 4

Simplifying Interaction Map



Note. → : direct help
⊸ : forbid
⇢ : request
④ : the 4th interaction in the group

After the researcher made the comments on the transcripts and drew the X-Mind map, one graduate student was asked to check if she agreed and to note her findings in the marginal space for the inter-rater's comments. Not considering the questions needed to be negotiated between the two inter-raters, the agreement of the inter-raters' reliability of data analysis was 98%.

Results

Engaging in the conjecturing-based teaching process requires each student in a group to first complete and report what solutions they generated. The sharing of their work is immediately followed by categorizing each other's similar solutions. In general, the solutions given by struggling students were mostly included in those of the better-achievers. Thus, the order of sharing in a group is suggested to start from the struggling students in order to preserve the struggling students' opportunity of sharing. The participants of the study followed this process. This section reports the findings on their interactions and relationships to psychological safety and cognitive learning.

Interactions between Struggling Students

For group discussion, non-verbal was the main interaction between the two struggling students (LS4 and LS15), as shown in Figure 5. The non-verbal included one of them watching and listening carefully to the other or observing the hand gestures. In episodes 1 to 3, LS4 always kept silent but watched carefully LS15's worksheet throughout the interaction, as shown in Figure 5(a). In the episode 4, when LS4 shared "31.4 x 10" as part of computing the area of a parallelogram-like shape, LS15 interacted with LS4 via hand gestures on the worksheet by pointing out the radius, as shown on Figure 5(b). LS4's behavior also reflected the social imitation theory in that, even though there was no verbal interaction between him and LS15, he observed and imitated LS15's ways of explaining her solution. This could be one reason why he spent only 58 seconds to explain his solution, which was much shorter than LS15's 3 minutes and 57 seconds.

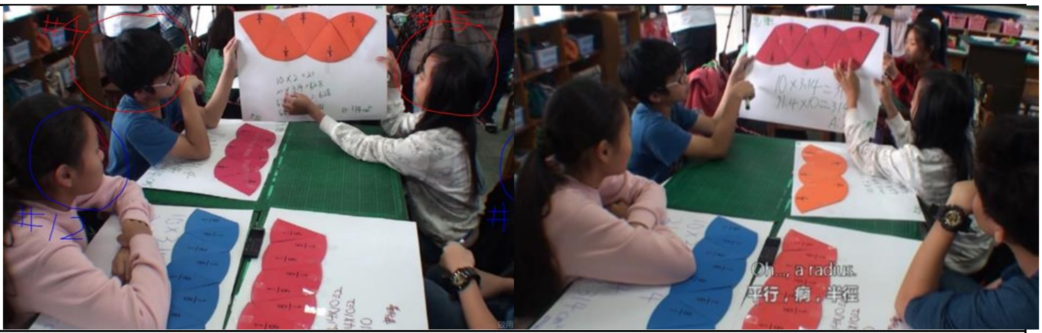
Raising Struggling Students' Psychological Safety

It was found that not offering direct answers to the struggling students and asking questions were two ways of raising psychological safety. The relaxed facial expression was used an indicator of the struggling students' psychological safety in the group.

In episodes 1 and 3, an interaction occurred between the two better-achievers (HS2 and HS12) when HS2 was giving LS15 an answer directly, shown in Figure 3. When giving the direct answer, HS2 was immediately prohibited to do so by HS12. HS12's prevention of offering a direct answer was intended to wait for LS15 to provide an answer. This prevention of giving a correct answer provided a way of raising LS15's psychological safety in the group discussion by giving her time to think.

Figure 5

Nonverbal Interactions Between the Two Struggling Students



(a) LS4 Watching and Listening Carefully at the Left Upper Corner	*(b) LS15 Interacting with LS4 via Hand Gesture at the Right Upper Corner*

In episode 2, when HS12 asked LS15 for further explanation of "the meaning of 20 x 3.14 = 62.8", LS15 said "very hard" with a little smile and her body leaning back on the chair. LS15's emotion of ease revealed no threat from the environment in group discussion, which indicated a means of raising her psychological ease and safety. In another interaction, LS15 uncertainly asked, "is that right?" which led HS12 to tell her that "the circumference of a circle" was being transformed into "the sum of upper base and bottom base of the trapezoid-like". Likewise, when LS15 with little confidence explained the meaning of "62.8 x 10", HS12 helped her to distinguish the meaning of "10" standing for "the height of the area formula of a trapezoid" from "the radius of the original circle".

In episode 3, asking questions was the other way of raising LS15's psychological safety; for example, asking her: "Do you understand?" and "[Could you] say it again?" to allow her to repeat or restate her explanation to confirm her understanding. In episode 4, the two better-achievers asked questions for helping LS4 to understand the meaning of "10 x 3.14 = 314, 314 x 10 = 628". The questions they asked showed their patience, tolerance, and no discrimination in waiting for LS4 to explain that created an atmosphere for raising psychological safety.

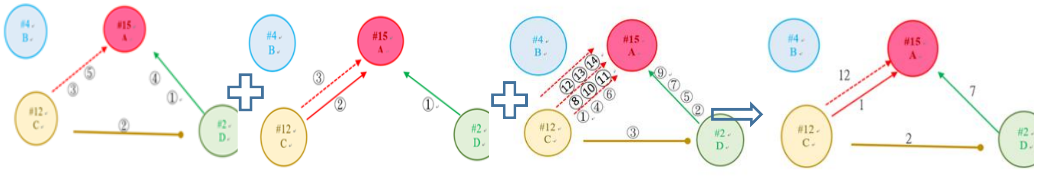
The group interactions revealed that the struggling student LS15 did not feel discriminated against in the group, so she took risks to ask questions in the group discussion. The two better-achievers created for LS15 an environment that required them to wait, listen, share, respect, care, have tolerance, and have empathy. Thus, the supports from the two better-achievers resulted in raising LS15's psychological safety and then enhancing her cognition.

Supports of LS15's Cognitive Learning

Figure 6 shows the number and sequence of interactions with LS15. To help LS15 to speak mathematics correctly and precisely, there were 20 verbal interactions that were mostly from the two better-achievers, as shown in Figure 6(d). Of these verbal interactions, 12 questions were asked by HS12 with different purposes and eight answers were given directly by HS2. For instance, HS12 asked nine questions for "628 ÷ 2?", as shown in Figure (c).

Figure 6

Verbal Interactions with the Struggling Student LS15



(a) Meaning of 10x2

(b) What does 62.8 and 62.8x10 stand for

(c) Meaning of 62.8 ÷2

(d) 10x2=20, 20x3.14=62.8 62.8x10=628 62.8 ÷2=314

Better-Achievers Assisting LS15's Understanding with Direct Contribution and Quetioning

In episode 1, to enhance LS15's understanding, better achiever HS2 gave two answers directly (line 4 and line 6, Table 1), while HS12 asked various questions with different purposes, including asking by explaining for understanding and asking by reiterating for checking. The two better-achievers helped LS15 to understand that "10 x 2" means by "the length of 2 radii" instead of "2 radii". There were five interactions that occurred in episode 1: HS2 telling → HS12 prohibiting → HS12 requesting → HS2 telling → HS12 reiterating. The interactions started with HS12's disagreement and doubts (line 3, Table1). She expected LS15 to speak clearly that "2 radii equals to the length of a diameter" and asked "what there are 2 radii" (line 5, Table 1), shown in Figure 6(a). In addition, HS12 asked LS15 to reiterate for HS12 to check if she really understood what she learned just a few minutes before, as shown in Table 1 (line 5 and line 8).

Better-Achievers Helping LS15 Unerstanding a Number Expression with Different Meanings

Episode 2 is related to the discussion of "20 x 3.14 = 62.8, 62.8 x 10 = 628". Better-achievers tried hard to assist LS15 to understand that a number can only represent one meaning and a number expression can represent two different meanings. For instance, "10" in "62.8 x 10" can only represent one meaning in the "62.8 x 10" as "the height of the trapezoid-like shape. But sometimes, a number expression can represent two different meanings. For example, "20 x 3.14" can represent "the circumference of a circle", or it can represent "the sum of the two bases of a trapezoid-like" shape.

In episode 2, there were three interactions with LS15 for clarifying the meaning of "20 x 3.14". They were sequenced as: HS2 telling → HS12 telling → HS12 reiterating, depicted in Figure 6(b). LS15 was able to recite the area formula of a trapezoid, but she uncertainly asked "is that right?". This led HS12 to tell her that "the circumference of a circle" was being transformed into "the sum of upper base and bottom base of the trapezoid-like" shape.

These examples of group interactions indicated that due to no discrimination against her in the group, LS15 was able to take risks in asking questions in the group discussion. This was more evidence of support from the two better-achievers to raising LS15's psychological safety and enhancing her cognition.

Better-Achievers Assisting LS15's Understanding with Questions for Different Purposes

Episode 3, with respect to"628 ÷ 2", revealed that the better-achievers asked LS15 various questions with different purposes to enhance her understanding, The questions required her to explain, reiterate/repeat/restate, retrieve, interpret, reconfirm, and summarize. The various questions asked by HS12 were the main means of verbal interactions. The 14 verbal interactions of the two better-achievers interacting with LS15 were sorted into three categories: 4 direct helps, 9 requests, and 1 interaction, depicted in Figure 6(c). To help LS15 correctly understand"628 ÷ 2", the sequence of 14 verbal interactions consisted of:

> HS12 for explanation → HS2 help → HS12 stopped → HS12 for retrieving → HS2 help → HS12 for reconfirming → HS2 help → HS12 for reconfirming → HS2 help → HS12 for reconfirming → HS12 for restating → HS12 for reconfirming → HS12 for summarizing → HS12 for reconfirming.

This interaction sequence started with HS12 asking the question, "why is 628 divided by 2?" (①Figure 6(c)). It is immediately followed by HS2 offering an answer (②, Figure 6(c)), but the direct help was prohibited by HS12 with saying "Hold on" (③, Figure 6(c)) to give time for LS15 to think. HS12 then reminded LS15 to recall the area formula of a trapezoid by asking "what is area formula of a trapezoid?" (④, Figure 6(c)). The divisor "2" can be the 2 in the trapezoid area formula (top base +bottom base) x height ÷ 2 (⑥, Figure 6(c)). HS2 gave the direct interpretation that it also can be half of a parallelogram which is decomposed by 2 congruent trapezoids (⑤,⑦,⑨, Figure 6(c)). Then, HS12 repeatedly confirmed LS15's understanding by asking "Do you understand?" (⑫, Figure 6(c)) and "Do you know what you are writing about?" (⑧,⑩, Figure 6(c)). HS12 asked her one more time to restate her mathematical expression with "You say it again" (⑪,⑫, Figure 6(c)). In the end, HS12 asked LS15 to repeat what her solution means (⑬,⑭, Figure 6(c)). Finally, LS15 was able to explain her entire solution clearly.

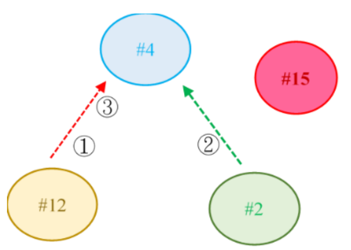
This interaction, based on asking different questions, allowed LS15 to feel that she was not ignored but that her understanding received attention. This made her feel warm and connected, thus increasing her psychological safety. Raising LS15's psychological safety by students' questioning was a good way for bridging the cognitive diversity between the group members and reduce conflict in their group relationship. The cognitive learning of LS15 was also enhanced through the questioning approach.

Enhacing Better-Achievers' Academic-Related Skills and Interpersonal Skills of Groupwork

In episode 4, the discussion of "10 x 3.14 = 31.4" was the basis of the verbal interactions that involved struggling student LS4 explaining his solution, shown in Figure 7. He started with a stammer to explain "10 x 3.14 = 31.4" and said that "31.4 is a semi-circle". It was followed by HS12 asking "what is 10?" (①, Figure 7). LS4 answered with little confidence by a stammer "31.4 x 10" and "That is, oh…ten, oh… a diameter". Then, HS2 asked him to speak clearly "what is 10 in this parallelogram?" (②, Figure 7). LS4 with a stronger stammer answered "oh,…a radius, …height, height, height, height". Then, HS12 asked him to say it again (③, Figure 7). Through the two better-achievers' questions, LS4 was finally able to distinguish the difference between the "10" in "10 x 3.14" and in "31.4 x 10" in the context of the task.

Figure 7

Verbal Interactions with the Struggling Student LS4



The interaction indicated that the better-achiever HS2 improved his skill of helping the struggling students by asking questions instead of giving the answer directly. His help to struggling student LS4 via asking questions was a departure from giving direct correct answers as was done to LS15 in the previous 1 – 3 episodes. This shift in his approach indicated that his skills of the academic-related task and interpersonal skills of teamwork were improved through observing and imitating the other better-achiever HS12.

Discussions

This study contributes an exemplar of researching the psychological safety and cognitive learning of struggling students in group discussion when engaged in conjecturing-based teaching. It demonstrates how group discussion is beneficial to raise students' psychological safety. It is distinct from previous studies on psychological safety in that the participants were primary school students in a mathematics classroom rather than employees at a workplace (Bienefeld & Grote, 2014; Leroy et al., 2012; Tynan, 2005). In general, the findings of the study suggest important ways in which students of diverse mathematical ability or achievement can work in a collaborative group to support and enhance each other's learning of mathematics meaningfully. Following are six salient conclusions that summarize these key findings.

First, verbal iteration was the main way of the better-archivers interacting with the struggling students, while non-verbal was the main interaction between the two struggling students. Nonverbal interactions included watching and listening carefully, hand gestures, and facial expressions while verbal interactions consisted of *direct contribution*, *indirect contribution*, and *questioning*. Direct contribution was the most obvious way in which one of the better-achievers (HS2) directly gave correct information to the struggling students. The indirect contribution was done to prevent a better-achiever from giving an answer to the struggling students in order to wait for the struggling students to answer or to think. Indirect contribution was the main interaction between the two better-achievers.

Questioning consisted of a request for action, information, or statements. It was not only for examining and clarifying the struggling students' thinking in order to help them to gain more complete mathematical understanding, but also a way for creating a safe environment to raise their psychological safety. Examples of these questions, frequently asked by better-achiever HS12, were classified into eight different purposes: for a description, for an idea, for an explanation, for an iteration or a repeat, for a retrieval, for a reconfirmation, and for a summary. Of these purposes, requesting explanation was a common way of questioning in the group discussion. This explanation took the form of making an interpretation. The questions helped the struggling students to realize that a number in a mathematics expression can only represent one meaning and sometimes a number expression can represent two different meanings. For instance, the number 10 in "62.8 x 10" only represents "the height of the trapezoid-like" shape while the number expression "20 x 3.14 = 62.8" represents the circumference of a circle, or it can represent "the sum of the two bases of a trapezoid-like".

Second, the study demonstrated students' questioning in group learning. While previous studies found that students rarely asked questions in classrooms (Franke et al., 2009; Hiebert, 2003), this study differed in that students did engage in questioning but it was done in a group rather than in a whole-class setting. The group discussion in a conjecturing-based teaching context created for higher-achieving students the opportunity to engage in questioning without the three obstacles (limited knowledge, social disorder, lack of questioning skills) noted by Hiebert (2003) as follows:

1. The better-achievers with richer knowledge in a group played the role of judging and identifying when missing information was needed for clarification. Thus, the obstacle of lack of knowledge was not an issue.
2. The better-achievers with higher position in the heterogeneous group were not afraid of asking a question, whether good or bad. Thus, the obstacle of social disorder in the group was not an issue for them given this position.
3. The better-achievers improved their skills of questioning and leadership (regarding interpersonal skill) based on the role they played in the group. Thus, they overcame the obstacle of lacking questioning skills in group discussion. However, why the group discussion conducted in conjecturing-based teaching contributes to students' questioning was not explored in this study and should be addressed in future research.

Third, students' questioning was not only a way of raising the struggling students' security, but also a way of allowing them to take risks to ask questions. For example, at the end of group discussions, struggling student LS15 taking risks to ask questions for help was an indicator of her psychological safety being raised and her interpersonal skill being improved. The other indicator of the psychological safety in group discussion was the struggling students' relaxed facial expression.

Fourth, lower-achieving and better-achieving students in a group, without the teacher's assistance, are able to collaborate functionally in autonomy throughout the entire group discussion and positively impact psychological safety. For example, the better-achiever HS12 in the group discussion played an important role of raising psychology safety at the individual level and group level. She helped to create a safe and non-threatening environment of group discussion and assist the struggling students to understand the meanings of their solutions.

Fifth, two ways were used by better-achievers to raise the struggling students' psychological safety. One way was not offering a direct answer to the struggling students. This approach provided wait time for struggling students to think, which allowed them to feel like they were being cared for. The other way was by asking questions. The different questions asked by the better-achievers for different purposes allowed the struggling students to feel that their understanding was respected, which increased their psychological safety. In general, the study indicated that students' questioning occurring in the group discussion of conjecturing-based teaching was a good way for bridging the cognitive diversity between group members, reduce conflict in group relationship, and enhanced the struggling students' cognition. Besides, the questions asked by the better-achievers, they showed patience, tolerance, and no discrimination in waiting for the struggling students to explain, which raised their psychological safety. This finding provided evidence that supported Martins et. al.'s (2013) claim that students' cognitive performance can be achieved via raising psychological safety and reducing group relationship conflict within a heterogeneous group with cognitive diversity.

Finally, the better-achievers enhanced their academic-related skills and interpersonal skills of groupwork. For instance, the better-achiever HS2 improved his skill of helping struggling students by asking questions instead of giving the answer directly. The skill was improved by observing and imitating the other better-achiever. As Jung and Schütte (2018) mentioned, giving answer only is not good to achieve students' learning outcomes. The collaborative group learning may bring about the high quality of interaction in a group.

Since this is a case study there are obvious limitations regarding generalizing the findings. However, the intent is to demonstrate what are possible when students of diverse achievement in mathematics work in collaborative groups within a conjecturing-based teaching context. The preceding six findings highlighted these possibilities which offer insights of how students' psychological safety and learning of mathematics can be enhanced. The study also opens up this topic for further consideration in future research as a means of improving mathematics education for both high-achieving and struggling students.

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