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Using the C.I.D. discourse model to develop exploratory talk in the Primary 4 Mathematics classroom

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Abstract

It is a common sight in the Mathematics classroom to see students solving problems in groups. During these discussions, each group then yields a group solution which is submitted to the teacher or presented to the class. However, previous research undertaken (Tay & Lim, 2015) has shown that putting students in a group does not mean that productive discourse will take place. The students still require structure and training to know how to participate in a discourse.

This study explores the effects of the C.I.D. model on students' talk during problem-solving in the Mathematics classroom. The C.I.D. model was developed based on Toulmin's (1958) argumentation model as a possible intervention tool which provides structure for the students during their discussions (Tay & Lim, 2015). Using a pre-, post-intervention experimental research design, 40 Primary 4 students were given problems of similar difficulty to solve in groups before and after the C.I.D. model was taught. During the problem solving, the students' talk was video-recorded and analysed using Wegerif and Mercer's (1997) exploratory, cumulative and disputational talk. Results showed that before the intervention there were more episodes of disputational talk where students disagreed with one another without substantiating their claims and cumulative talk where students agreed with one idea proposed without exploring other possibilities. After, the introduction of the C.I.D. model, there were more episodes of exploratory talk where students were engaging critically but constructively and statements and suggestions were offered and where challenges were justified and alternatives given (Wegerif & Mercer, 1997). In conclusion, this study postulates that students need to be shown and taught how to discuss constructively in a group. The C.I.D. model presents itself as a simple tool which can be readily implemented in an elementary school setting.

Introduction

Vygotsky (1978) proposed that the use of language was a cultural tool during social interaction. He also postulated the use of language was a psychological tool for organising individual thinking. Both roles were closely related. As such, it was highly likely that involvement in joint activities could generate new understandings.

At a tender age, children first play as a group to learn about social norms and behaviours. As they reach school-going age, they begin to work in a group to complete intellectual exercises. Students are expected to jointly produce a piece of writing, complete a quiz, conduct a Science experiment and work on a Mathematics problem. All is well if the process of generating new understandings is simply putting students together to work. More often than not, skills to negotiate or substantiate or challenge and finally to conclude collectively are not automatic in most students. Observing classrooms as teachers over the years has shown us that, most of the time, academic results and popularity serve as the mediating factors for deciding whose answer to agree on. The process is often linear, inequitable and unproductive. We believe that students must learn to differentiate between unproductive talk and productive talk. They must be taught the art of discussion in a structured manner and this paper aims to help students to generate productive talk during problem-solving sessions which take place in the Mathematics classroom through a structured approach and examines the effects the approach has on the type of talk generated.

Literature review

Vygotsky (1978) postulated that learning was a social activity. He also claimed that social involvement in problem-solving activities was a crucial factor for individual development. Increasingly, focus has recently been on the role of language and social interaction in the learning and pursuit of mathematics (Forman & van Oers, 1998). Widely researched contexts include teacher-led student talk and peer talk, such as the effectiveness of teachers' discourse strategies in assisting students' learning and development (Mercer, 1995).

Talk defined

The Oxford Living Dictionaries defines talk as 'communication by spoken words; conversation or discussion' (Talk, 2018). According to Mercer (1995), there are three types of talk which students engage in 1) disputational talk 2) cumulative talk and 3) exploratory talk. The characteristics of disputational talk include disagreement and individualised decision-making. There are few attempts to pool resources or to offer constructive criticism of suggestions or to substantiate disagreement. Cumulative talk on the other hand sees speakers building positively but uncritically on what the other has said. This type of talk tends to be linear. Partners use talk to construct 'common knowledge' by accumulation. The characteristics of cumulative discourse include repetitions, confirmations and elaborations. Exploratory talk refers to a style of interaction characterised by the active participation of all those involved, where they are jointly engaged in explicit reasoning through talk, displaying identifiable hypotheses, challenges, arguments and eventual consensus within a collaborative frame. Exploratory talk in the Mathematics classroom often takes place during collaborative problem-solving tasks. Students are required to talk to solve a problem but are often not taught the nuances of holding a productive talk and their discussions are confined to disputation and cumulative talk.

Collaborative learning

Collaborative learning is broadly defined as "a situation in which two or more people learn or attempt to learn something together," and more specifically as joint problem solving (Dillenbourg, 1999, p. 1). Roschelle and Teasley (as cited in Dillenbourg, Baker, Blaye, and O'Malley, 1996, p. 2) define collaboration more specifically as "mutual engagement of participants in a coordinated effort to solve a problem together". Dillenbourg (1999) postulates that interaction between people triggers learning processes. Collaborative learning situations require instructions, a physical setting, and other kinds of performance constraints. However, the presence of these factors do not guarantee collaboration; they only make it more likely. In order for collaborative learning to take place in the classroom, teachers must be clear about the nature or purpose of the talk they want the children to engage in. In the absence of clarity, children will not have a clear understanding of what they are expected to do – a perception of what constitutes an effective discussion (Mercer, 1996).

Howe and Mercer (2007) found that only a small proportion of the interactions taking place during group work actually contributed to the children's learning. Children are often unclear about what they should be doing and what the aims of the activity are in collaborative learning situations (Mercer, 1996). Findings of research studies have shown that in order for the potential benefits of small group work to be realised in practice, it is necessary to provide structure that enables children to work together effectively (Gillies, 2003). In a study investigating the role of talk in learning science, it was found teaching children language associated with collective reasoning to support talk increased the incidence of cognitively demanding exchanges (Mercer, Dawes, Wegerif, & Sams, 2004).

C.I.D. Model of Discourse

The C.I.D. model of discourse, a structured approach to facilitate oral discussion, is adapted from Toulmin's (1958) model of argumentation to suit the context of our young students. Toulmin's model of argumentation was introduced by Toulmin as an approach to logically presenting arguments as well as a tool for the analysis of arguments (Toulmin, 1958). It has been widely used to improve discourse in Science classrooms (Erduran, Simon, & Osborne, 2004; von Aufschneider, Osborne, Erduran, & Simon, 2008) as well as in composition classes (e.g., Bizup, 2009). The abbreviation, C.I.D., is taken from the various components of the model; Clue (Data), Idea (Claim) and Disagreement (Rebuttal) are used for ease of understanding and assimilation (Figure 1). It teaches students to use data to present and reason their case if they disagree. This structured approach gets students to use target words "from", "so" and "but" associated with each of the components so as to scaffold the process of discussion for the students and enable them to support the ideas they put forward and to put forth valid arguments. The C.I.D. model also serves the theoretical underpinnings for the design of a structured classroom discourse instructional video which is used as the intervention tool in this study. This model and video have been implemented in a previous research study. The study took place in an English composition writing class and results suggested that the structure provided by the model encouraged students to think critically as there were many more episodes of substantiating disagreements with suggestions (Tay & Lim, 2015). This study is interested in looking at the effects of the C.I.D. model on students' talk during problem-solving in the Mathematics classroom.

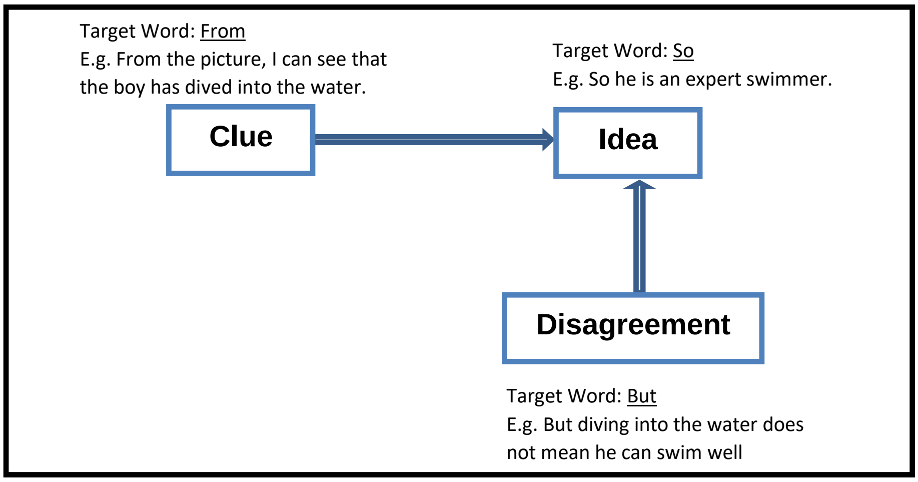

Figure 1. The C.I.D. Model (Adapted from Toulmin, 1958)

Methodology

For this study, convenience sampling of students from a class of 40 10-year old students and one teacher was used. The students were grouped heterogeneously in threes, a typical group size for discourse, with a high progress student, a middle progress student and a low progress student in each group.

There were a total of 12 groups. One particular group was selected based on the clarity of the recording as a fair representation of the class. The students are known as P1, P2 and P3 for the purpose of the analysis.

This research was conducted through the use of a two-tier approach. Data was first gathered using the qualitative research method. The students were video-recorded during their problem-solving discussion sessions. The video-recorded sessions were transcribed and the scripts were further reduced using the data-reduction method (Thomas, 2006). This allows transcribed data to be classified into task-related talk and non-task-related talk for more purposeful analysis.

Before we started the research, detailed discussions between a professor from NIE and the researchers narrowed the search for suitable problems on the topic of 'volume' to ensure that they were sufficiently challenging. The two criteria used for the selection of the problems were that they were 1) Mathematical concepts that the students had learnt from Primary 1, 2) non-routine problems. Non-routine problems are problems that require some degree of creativity or originality to solve. There is no apparent strategy to solve them but they can be solved in multiple ways. Solving non-routine problems requires students to think out of the box, using concepts that they have learnt, to derive the answers. A total of two problems were selected for the pre- and post-intervention. (Appendices A and B).

During the pre-intervention stage, in their groups of three, the students studied the first problem and discussed the best solution within a thirty-minute period. The teacher was only a facilitator, and a guide when there was a need. The first problem required students to use concepts of volume and logical reasoning to obtain the solutions and results. The process was video-recorded.

Subsequently, during the intervention stage, an instructional video which showed some students engaging in discussion while completing a task in the classroom was shown to the students during lessons. The students in the video modelled the use of the C.I.D. model of discourse. The class teacher then used the video to teach students how to use the C.I.D. model in their discussion. Students were taught to use cue words such as 'from' to use evidence to support their rationale, 'so' to put forth their idea and 'but' to signal disagreement.

Lastly, during the post intervention stage, the students were given a second problem-solving task which was also on the topic of volume to solve as a group. The discussion process was also video recorded.

The video recording was handed over to the transcriber who transcribed the video verbatim. Qualitative content analyses were carried out on the transcript of the students' group work video for changes in the use of the three types of talk (disputational, cumulative and exploratory).

Results

Data analysis

For ease of analysis, the videos used in this study will be known as the pre-video and the post-video.

The video recordings were reviewed and a transcriber was engaged to assist in the manual transcription. Adopting the data reduction theory by Thomas (2006), we separated the conversations into episodes, namely non-task-related and task-related. The theory is about a general inductive approach to the analysis of qualitative evaluation data. It helps to (a) present our raw data in a summarised table, (b) link clearly the research objectives and the findings from the data derived, and (c) develop a framework of processes that are evident in the raw data. It provides a simple, straightforward approach to deriving findings with a focus on conversations. In this case, we chose to analyse only the task-related conversations. These are conversations among students that focus on understanding the task and deriving a solution to the problem given.

An example of task-related conversation is:

P2: No, we fill this one then have 1 litre left.
P1: How about half, half? So, half, half. So 4 divided by 2 so
P2: 2, 2.
P1: That's a better way.

An example of non-task-related conversation is:

P2: This one the hardest question I've ever (...) in my entire life (...) easier. Because they do guess and check. Very easy
P1: I don't even get what they're asking.
P3: Then do guess and check lah.

After agreeing on the definition of task and non-task related conversations, the researchers proceeded to independently categorise the transcripts of the videos into task-related and non-task-related. Subsequently, we came together to match our analyses. Then, independently, we proceeded to further categorise the task-related talks into the three types of talk namely disputational, cumulative and exploratory as defined by Mercer (1996) after which we came together to match our analyses of the transcript based on the three types of talk. Where there were discrepancies, we discussed them before deriving a conclusion.

Unlike in the previous research where students used the cue words extensively during their discussion of writing ideas (Tay & Lim, 2015), we found that fewer attempts were made to incorporate the cue words, "from", "so" and "but" in this research. The students were freely using their own vocabulary to engage in discussion. This could be due to the different context of the instructional video that showed students' discussion during English lessons, in which these cue words were used, rather than during a Mathematics lesson.

Table 1

Number of episodes for the various talk types

	Disputational	Cumulative	Exploratory	Coaching
Pre-video	5	6	1	0
Post-video	0	4	3	5

Despite that, findings suggested some positive changes to the types of talk during the students' discussion in the pre-video and post-video. There were no disputational episodes in the post-video at all. In addition, there was a reduction in cumulative talk but an increase in exploratory talk. (Refer to Table 1). Moreover, the students were unable to solve the question in the pre-video whereas they were able to do so in the post-video.

Disputational talk is characterised by disagreement that is not focused on solving the problem collectively but by individual decision making. An example of disputational talk commonly found in the pre-video is as follows:

Pre-Video

P1: Eh, how about this one.
P3: No, 4 litres. So we, we full in (...) then we pour, pour until this one like not enough right? Then we pour this one until it's full. Can already.
P1: No this is 4 litre. This is 3 litre.
P3: No we, if we pour

In cumulative talk, the students' discussions relate to each other's discussions but the talk is done uncritically and positively. An example of cumulative talk is as follows:

Pre-Video

(The students were trying to work out the solution in a linear manner.)

P2: This one has markings. (Takes out highlighter and highlights paper.) This one has marking then this one don't have markings.
P1: So 5 litre. So this one minus 1 then you put here. So if equals that so we keep on making like that.
P3: Yes.
P1: So you put 4 litre then got space right. So we take out this put, I mean like, put a line here lah. So when we use the line here we, ur, forget. (Laughs).

Exploratory talk is the best as arguments and counter arguments are justified. An example of exploratory talk that took place in the post-video is as follows:

Post-Video

P2: 1 times 1, 1, 3 times 3, 9
P4: No, 3 times 4
P2: Hello, this one like that eh, 1,2,3 1,2,3
P3: Yeah
P2: 3 times 3, not 3 times 4
P4: Can you look behind.
P2: No, you see ah. 1, 2, 3. 1, 2, 3. So you take 1
P3: Then 1, 2, 3, 4, [5, 6, 7, 8, 9]
P2: [5, 6, 7, 8, 9]. 3 times 4 is 12.
P2: 5, 6, 7, 8, 9
P4: Ok, ok.
P2: So, 9 plus 1 is 10.

Apart from the three types of talk, the students engaged in a new category, coaching talk. The student who was engaged in this talk was a high progress student. She seemed to be trying to coach and help the other two students who did not understand some parts of the discussion. In this case, she played the role of the skilled peer who is attempting to operate in the zone of proximal development as defined by Vygotsky (1978). This coaching behaviour was recorded during the post-video but not in the pre-video.

An example of a coaching dialogue is as follows:

P3 So 74.
P2 So 9 times 9 is 81. 84 plus 81. Correct?
P4 ((Nods))
P3 ((Writes down the equation)) 84 plus 81 equals to…
P4 Mrs Wee.
P3 Then how about this?
P2 Yeah this is already done.
P4 Wait, wait. I want to write, I want to write. Wait, wait. ((Takes the question paper))
P2 Huh? No. Don't write.
P4 No, cause it say…there's one answer for each question. ((Attempts to answer one of the questions))
P2 Why you take my pencil huh?
P3 Nah, I give you back.
PS ((Talking about P3's pencil case))
P4 We're done.
P2 But you have to find the volume. Volume.
P3 Yeah!
P4 What's the volume?
P3 You don't know what's volume?
T You need to find units right?
P2 165 divided by 1?
P1 We don't even know how much this is.
P4 165 times 1.
P3 165 times 1 equals 165.
P4 Exactly.

Discussion

Based on the observations and results generated, there appear to be positive effects on the students' discussions. Firstly, the awareness of how a productive discussion should look and the occasional use of cue words steered students away from disputational episodes where they disagreed without providing a rationale. Secondly, the awareness of how a productive discussion should look may have also helped them to realise that there is nothing wrong with disagreeing as long as it is based on evidence they can provide. This is especially important for lower progress students who may be accustomed to cumulative talk where they simply agree with the rest of the students in the group. The result of this study echoes that which Tay and Lim (2015) undertook into the use of the C.I.D. model for English composition. The students were engaged in productive talk due to the introduction of the model. Moreover, the capture of the fourth type of talk, coaching talk, suggests the existence of collaboration and the achievement of the goal of collaborative learning possibly leading to individual cognitive development.

Besides the introduction of the C.I.D. model, the increased episodes in exploratory talk may have also been affected by the type of problems that were chosen. Non-routine questions require students to think and provide novel answers which may not be taught in class. The use of routine questions could mean that students might revert to the ways they have been taught during Mathematics lessons resulting in cumulative talk where everyone agrees on one solution. During the video, the students could be seen trying to use this Singapore "model" method which is one of the main heuristics taught in Singapore. Only after failing to find an answer, did they start their exploratory talk to discuss possible solutions.

Data from the video recordings were paramount in capturing the type of talk the students were engaged in. The verbatim transcription of the video recordings was necessary to capture utterances for the analysis. It was also found that data reduction was a good way of managing a deluge of data from the transcription, commonly associated with data collection through video-recording. It provided the researchers with a more purposeful and defined process for analysing the data.

Limitations

The one-shot pre-, post-test intervention design poses a limitation to the reliability of this study. The limited time and number of lessons (30 minutes per lesson; two lessons) might have also rendered the study inconclusive as to whether students' increased episodes of exploratory talk was attributable to the C.I.D. model. Moreover, as the instructional video shows students completing an English task, the difference in the subject might have muted the use of the C.I.D. model.

Conclusion

Vygotsky (1978) postulates that language development is the key to cognitive development. Language is developed through social situations. In this paper, we have shown how the introduction of the C.I.D. model resulted in more collaborative learning where students could learn from one another and, thus, paved the way to individual cognitive development. We believe that for collaborative learning to work, students have to learn the art of productive talk. Schools have to incorporate such "soft skills" into their curriculum and not leave it to incidental learning. Incorporating the teaching of the C.I.D. model provides students with a structure to organise their ideas and thoughts which may result in a far-reaching impact as it is not only cross-subject but also gives students of all progress levels the entitlement to engage in productive talk.

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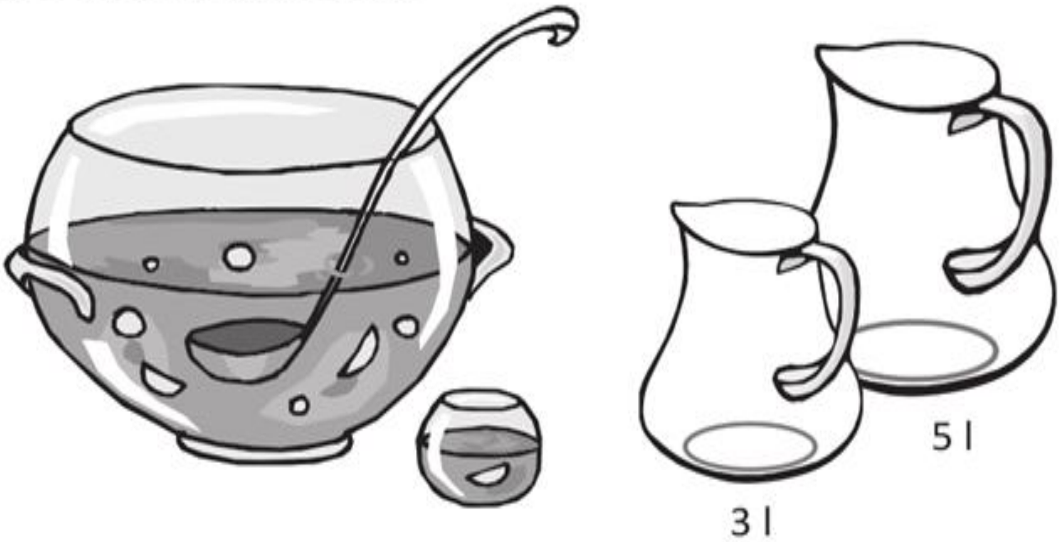
Appendix A: Problem 1

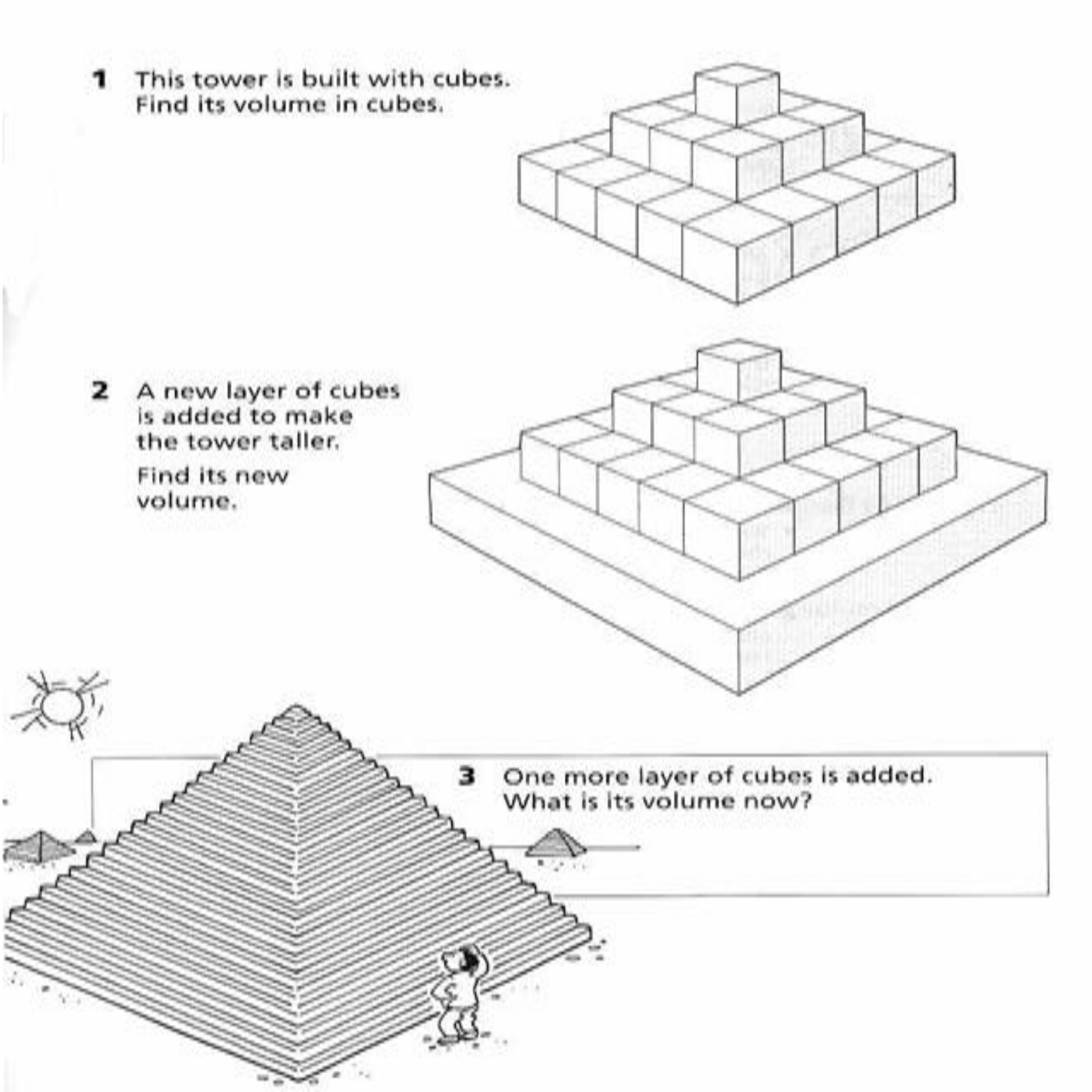
Solve the problems below. Show your working.

Problem 1

Jess is making a ginger punch for her party. Part of the recipe calls for 4 litres of ginger beer. Jess only has a 5 litre jug and a 3 litre jug without any markings. How can Jess use both jugs to get exactly 4 litres in the punch bowl?



Appendix B: Problem 2



1 This tower is built with cubes.
Find its volume in cubes.

2 A new layer of cubes is added to make the tower taller.

Find its new volume.

3 One more layer of cubes is added.
What is its volume now?