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Scaffolding small groups

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Presentation structure

- Research context
- Mathematical discussions
- Mathematical level raising
- Group task
- Small-group Scaffolding Tool
- Results

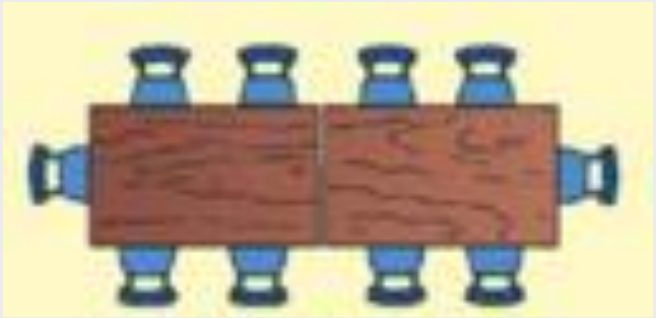
Mathematical Discussions

In mathematical discussions students are challenged to reflect on mathematical activities

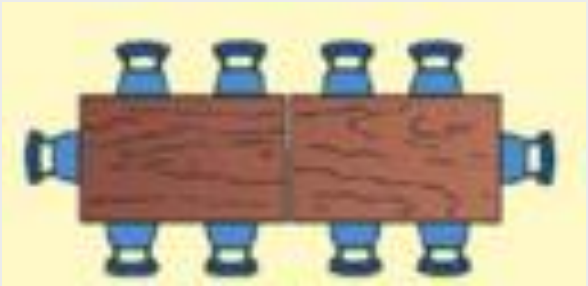
Calor, S. M., Dekker, R., Van Drie, J. P., Zijlstra, B. J. H., & Volman, M. L. L. (2020). “Let us discuss math”; Effects of shift-problem lessons on mathematical discussions and level raising in early algebra. Mathematics Education Research Journal, 32(4), 743–763. https://doi.org/10.1007/s13394-019-00278-x

Mathematical level raising

- Level raising is the process when a mathematical activity performed at a lower level becomes the object of reflection at the next level (Freudenthal, 1991)



Example of Mathematical level raising



- At a lower level patterns of the number of tables and chairs in a table setting are studied

- At a higher level, these patterns themselves are the object of reflection when creating a formula to calculate the number of chairs given the number of tables.

(Calor et al., 2020)

Teachers find it difficult to support small groups

Van Leeuwen and Janssen (2015); Webb (2009)

- Developed a Small-Group Scaffolding Tool (SGS-Tool) to help teachers support small groups
- Designed lessons that evoke mathematical discussions
- Investigated the scaffolding behavior of teachers

Design principles Shift-Problem lessons

- The designer is guided by the learning goal of a deeper understanding of mathematics
- Mathematics has to start at a level that is experientially real to the students
- Reflection can be induced through mathematical discussions (Palha et al., 2013, pp. 148–149).

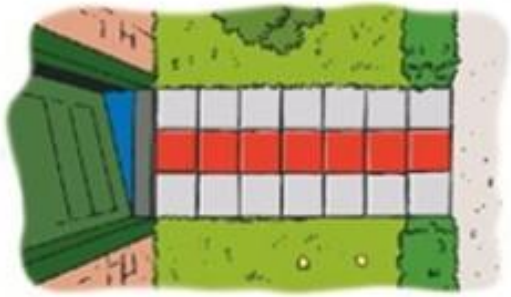
Janvier translation skills

To / From	Situation	Tables	Graphs	Formulae
Situation		Measuring	Sketching	Modeling
Tables	Reading		Plotting	Fitting
Graphs	Interpretation	Reading off		Curve fitting
Formulae	Parameter recognition	Computing	Sketching	

Conventional task in textbook

Conventional Task

1 There is a path of tiles in Marco's front yard.



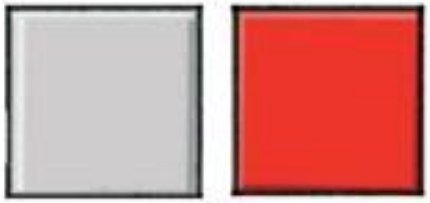
a) How many red tiles lie in the path?
b) And how many gray tiles lie in the path?
c) How many gray tiles lie next to every red tile?

2 If you know the number of red tiles of this path of tiles, you can calculate the number of gray tiles.

a) Fill in the blanks in the following formula of words:
The number of red tiles times ... equals to the number of gray tiles.
b) How many gray tiles do you need for such a path with 8 red tiles?
c) Calculate how many gray tiles you need for such a path with 10 red tiles.

Example adapted task with concrete material

Adapted task, based on conventional tasks 1 and 2.



Students were given a stack of gray and red tiles (cut-outs from prints of the tiles of the conventional task).

Create a tile pattern of red and gray tiles with which you can create a formula in words to calculate the number of gray tiles when you know what the number of red tiles is.

a) Glue this tile pattern on your poster.
b) Write down the formula in words on your poster.
   Create an arrowchain that corresponds to your formula in words.
c) Create a different tile pattern that corresponds to your formula in words and arrowchain.

Glue this tile pattern on your poster.

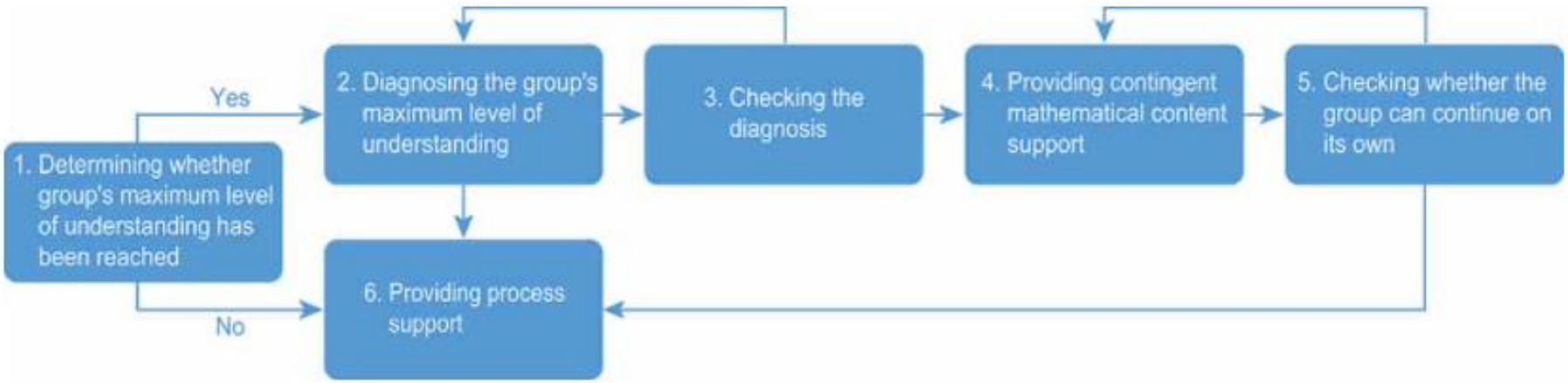
Scaffolding

- Scaffold: a temporary structure that is used to construct a building

- A teacher's temporary adaptation of his or her support to a student's understanding

(Wood, Bruner, & Ross, 1976)

Small-Group Scaffolding Tool



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Explorative study

SGS group	non-SGS group
• 2 seventh grade teachers • 54 students (age 12-15) • 14 small groups of mixed ability	• 2 seventh grade teachers • 55 students (age 12-15) • 14 small groups of mixed ability

Intervention

- Teachers of SGS group were trained on the job
- Students in both conditions worked on a Early Algebra unit of 12 lessons, 5 lessons were replaced with mathematical discussion lessons
- Students worked collaboratively on the same assignment during these 5 mathematical discussion lessons

Data collection

- Videotaped teachers‘ interactions with 1 group in each class during all 5 Math lessons

Interrater reliability

The interrater reliability between two coders (first and second author) regarding teacher turns was determined over approximately 10% of the data; 70 teacher turns of the SGS group, 32 of the non-SGS group.

A high level of interrater reliability agreement was observed (91%), Cohen's kappa value was .82.

Fleiss kappa benchmark (El Emam, 1999)

Research question

- What are the effects of applying the Small-Group Scaffolding Todel on teachers' scaffolding behavior during Mathematical Discussions?

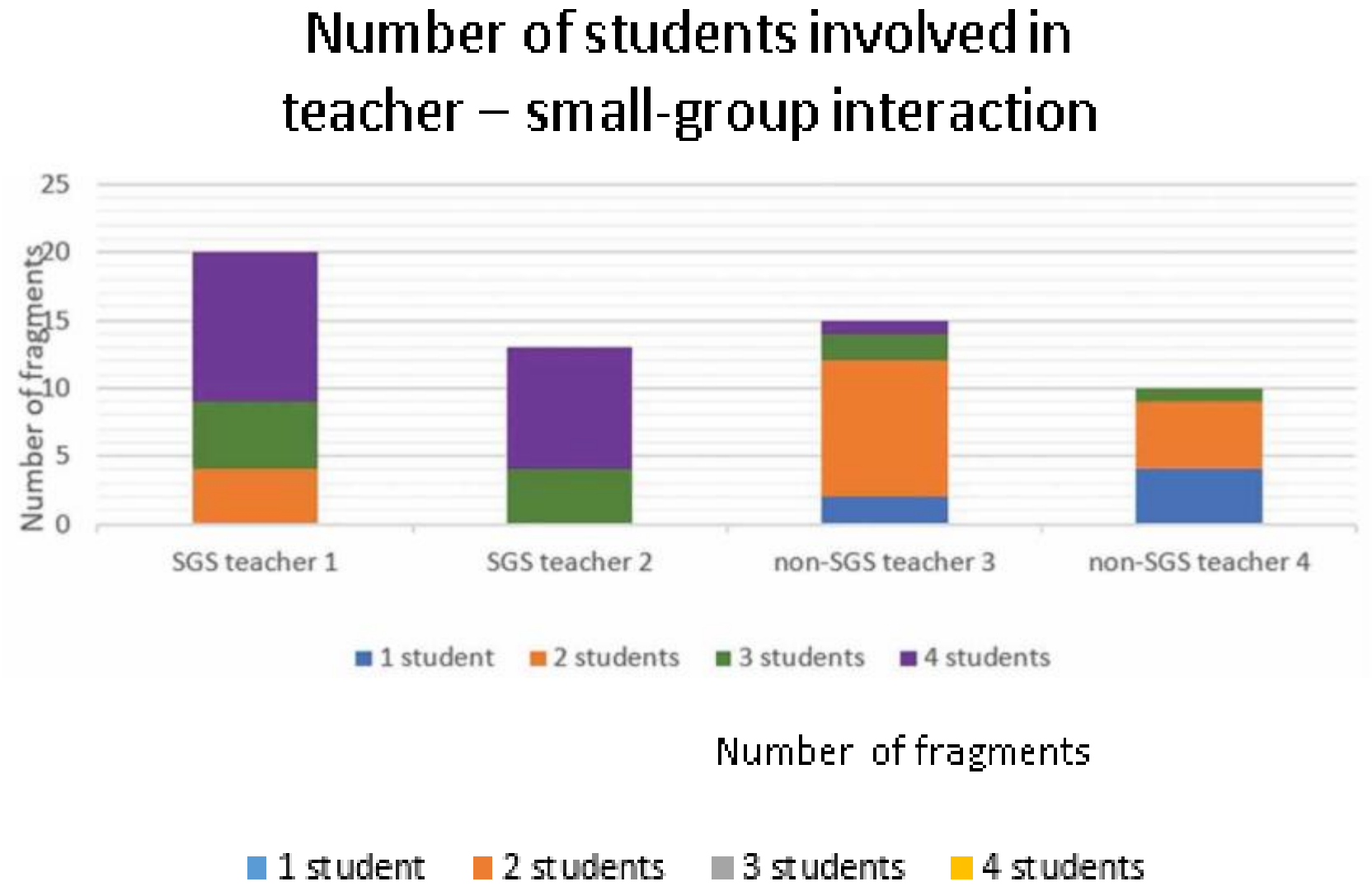
Sequences of steps taken by teachers for SGS group and non-SGS group

Fragment	SGS group		non-SGS group	
	Teacher 1	Teacher 2	Teacher 3	Teacher 4
1	144444456	1244656	44444	44
2	16	124444554	2444444444444	4
3	24444644445	24454	444444	44444444
4	26646	1224444454	24444442444444	42
5	12245	1464	445	4
6	445	1244444454444	44444	54444
7	224	126	4444422444	4
8	124444	12444445	24444	4444
9	1244466	144454445	266	56
10	444454644	4444	244444454	6
11	12446446	444444566	44444	
12	124444444	4654	562444	
13	1244544	244454666666644545465	266	
14	1254644444		2444	
15	26		44	
16	2166666666			

Frequencies and percentages of different steps (utterances) of the SGS-Tool that teachers of the SGS and non-SGS group applied

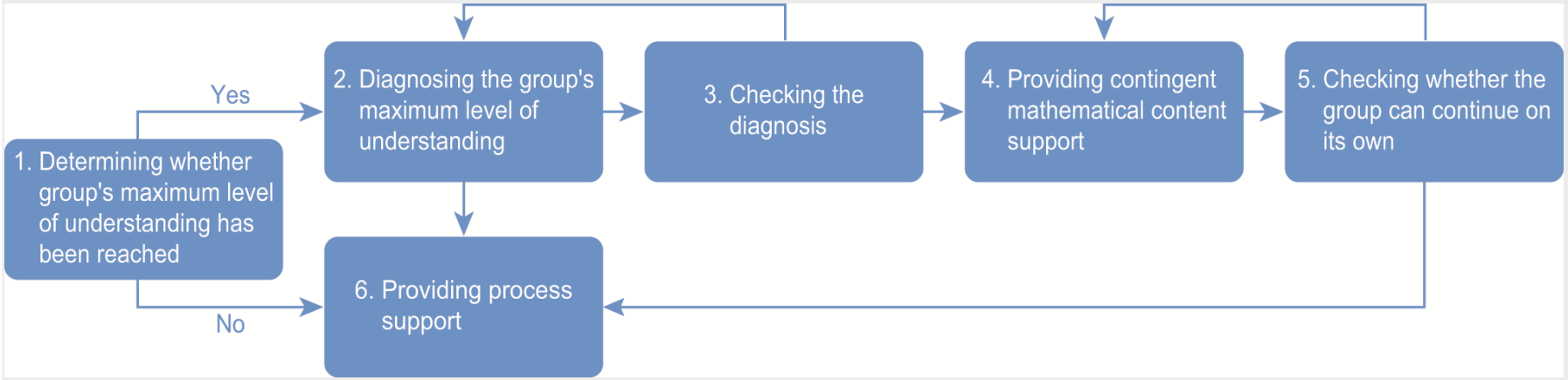
	SGS group		Non-SGS group	
	Teacher 1	Teacher 2	Teacher 3	Teacher 4
Steps	Frequency (%)	Frequency (%)	Frequency (%)	Frequency (%)
Step 1	12 (9.2)	8 (7.3)	0 (0)	0 (0)
Step 2	22 (16.9)	11 (10.1)	12 (12.8)	1 (3.7)
Step 3	0 (0)	0 (0)	0 (0)	0 (0)
Step 4	63 (48.5)	57 (52.3)	74 (78.7)	22 (81.5)
Step 5	9 (6.9)	17 (15.6)	3 (3.2)	2 (7.4)
Step 6	24 (18.5)	16 (14.7)	5 (5.3)	2 (7.4)
Total	130 (100)	109 (100)	94 (100)	27 (100)

Note. Step 1 (Determining whether the group's maximum level of understanding has been reached), Step 2 (Diagnosing the group's maximum level of understanding), Step 3 (Checking diagnosis), Step 4 (Providing contingent mathematical content support), Step5 (Checking whether the group can continue discussions on its own), Step 6 (Providing process support)


Number of students involved in teacher – small-group interaction
25
20
15
10
5
0
Number of fragments
SGS teacher 1
SGS teacher 2
non-SGS teacher 3
non-SGS teacher 4
1 student
2 students
3 students
4 students
Number of fragments
1 student
2 students
3 students
4 students

$(t(56) = 7.96, p < .001)$

Small-Group Scaffolding Tool



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Example SGS group: group's maximum level of understanding has not been reached

Student3: But miss, what does the innumber actually mean?

Teacher: Who knows what the innumber means? [Step 1]

Student1: 5

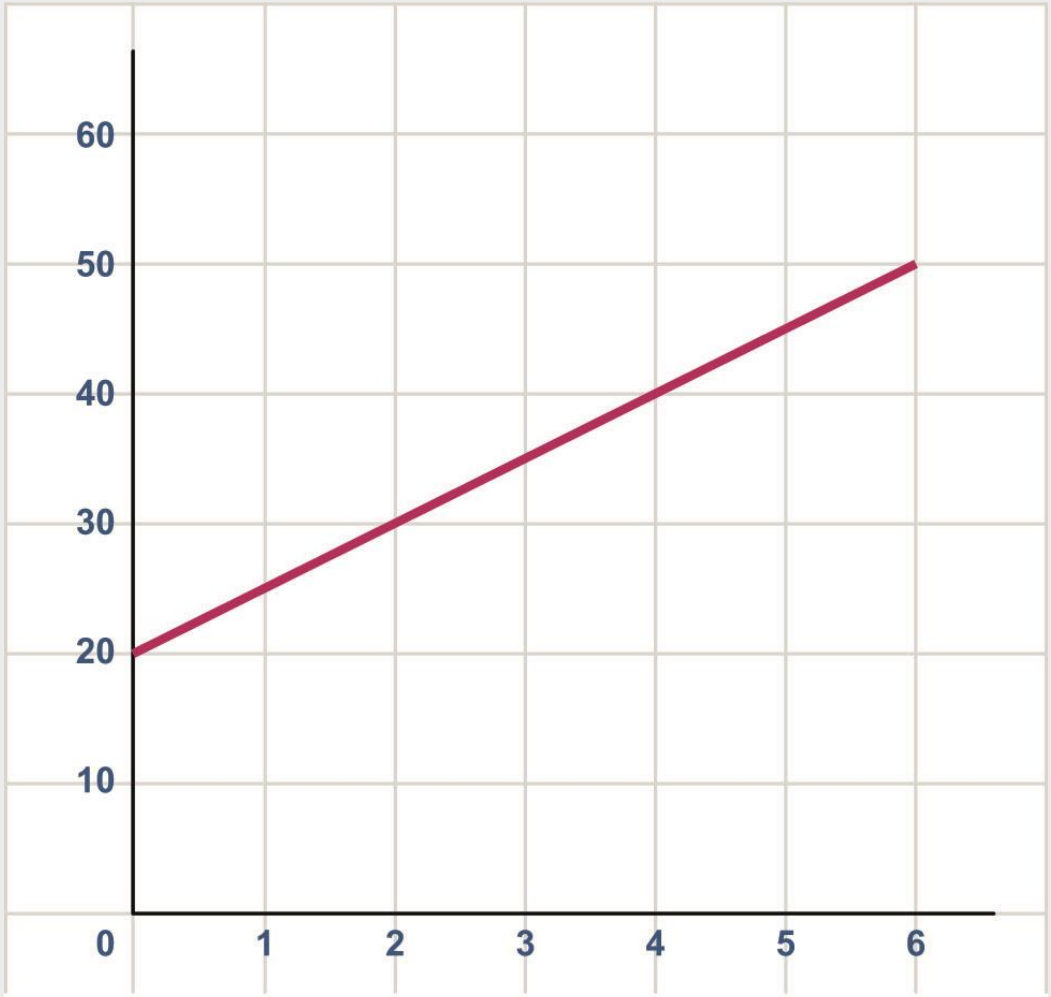
Teacher: Student2, explain that to Student3. [Step 6]

Student2: For example, if you buy 5 drinks, than the innumber is 5.

Student4: Isn't 5 the innumber?

Student5: 5 is the innumber.

Teacher nods and walks away.



a) Create a story together that corresponds to the graph.

b) Create a formula together that corresponds to the graph.

Example SGS group: group's maximum level of understanding has been reached

T: Are you progressing?
S4: No.
S2: No.
S3: No, we do not really have a story.
S2: We don't have a story, but we do know the formula.
T: You know a formula?
S2: Yes.
T: How does it look like?
S3: Times 5 plus 20.
T: Okay, given that, what can you come up with, what kind of stories?
S2: Have the handyman.

Example SGS group: group's maximum level of understanding has been reached

continued

T: What?
S2: I only have the handyman.
S1: Yes, but we also had donuts yesterday.
S4: We also have donuts.
S2: Yesterday, we had …
T: So you had that already yesterday. Okay, what kinds of examples does the textbook include?
S4: People who buy donuts.
T: People who buy donuts, okay.
S3: But, there it says 20 euros (pointing to 20 at the intersect of the graph with the y-axis).
S2: Yes, but …
S4: Yes, what could that 20 be for?
S2: And who is … no …
T: But, you also had stories about a swimming pool, didn't you?

Example SGS group: group's maximum level of understanding has been reached

continued

S4: No, but that is …
S3: And golf.
T: Zoo, golf.
S2: Oooooh, membership (relieved because she understands the hint about the swimming pool exercise)
T: Try to be a little creative (slowly walking backwards).
S3: Why membe, membership? (S3 talks to S2, after seeing that S3 has asked S2 about the membership, for which the 20 at the intersection with the y-axis could be used; the teacher walks away).

Example excerpt non-SGS group

Student 4: Teacher, do we have to incorporate more expenses than cost of entry and consumption items?

Teacher: Well, now you can make an arrow chain. What is the innumber? [step 4]

Student 4: Is 2 euros.

Teacher: Number of consumption items? Times? [step 4]

Student 2: Oh, 3, 3 consumption items.

Student 4: 3 consumption items, and the number of euros is 2.

Teacher: No, you should leave that open, so consumption items is your innumber. Write down, number of consumption items arrows, times . . . [step 4]

Student 4: 2.50.

Teacher: Times 2.50. Then, you have a betweennumber plus . . . [step 4]

Student 2: Plus entrance, oh like that.

Teacher: Look, there you have it, literally. The innumber, the arrow with multiplication, the betweennumber, and the addition. [step 4]

Student 2: Yes (the teacher walks away).

See article for the coding of the example excerpt in the SGS group

Full article: Scaffolding small groups at the group level: Improving the scaffolding behavior of mathematics teachers during mathematical discussions (tandfonline.com)

Future work

- Effect of guiding small groups with the SGS Tool on the quality of mathematical discussions and mathematical level raising.

Thank you!

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