STIMULATING STUDENTS' ACADEMIC LANGUAGE

Opportunities in instructional methods in elementary school mathematics

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Abstract
Mastering academic language (AL) by elementary school students is important for achieving school success. The extent to which teachers play a role in stimulating students' AL development may differ. Two types of AL stimulating behavior are distinguished: aimed at students' understanding and at triggering students' production of AL. As mathematics requires abstract language use, AL occurs frequently. The instructional methods teachers use during mathematics instruction may offer different opportunities for AL stimulating behavior. In our first study, based on expert opinions, instructional methods were categorized according to opportunities they offer for stimulating students' AL development. In the second study, video-observations of mathematics instruction of elementary school teachers were analyzed with respect to AL stimulating behavior and instructional methods used. Results showed that actual AL stimulating behavior of teachers corresponds to the expert opinions, except for behavior shown during task evaluation. Teachers differ in time and frequency of their use of instructional methods and therefore in opportunities for stimulating AL development. Four teaching profiles, reflecting different AL stimulating potential, were constructed: 'teacher talking', 'balanced use of methods', 'getting students at work' and 'interactive teaching'. Teachers showed more types of behavior aimed at students' AL understanding than at production.

Keywords: academic language, instructional methods, teacher behavior, teaching profiles, elementary school.

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1. INTRODUCTION

School subjects are taught through academic language. Different studies have shown that students, who are proficient academic language users, achieve better in school (Kleemans, 2013; Smit, 2013; Snow, Cancini, Gonzalez, & Shriberg, 1989). Academic language (AL) can be defined as a specific language register that is used in cognitively demanding and decontextualized situations and has specific features at the lexical, morpho-syntactical, and textual level (Aarts, Demir, & Vallen, 2011). Not only is the subject taught by using AL, the assessment of students' understanding and knowledge of the subject is also displayed in AL. In addition, knowledge about AL itself is part of the content of schooling (Bailey, 2007; Halliday, 1994; Hill, 2005; Schleppegrell, 2004).

AL is used in all school subjects, including mathematics. In the last decades language and text comprehension have become important components of mathematics instruction. Firstly, language is not only the primary medium of mathematics instruction, but it is also the foundation of mathematical reasoning (Ball & Bass, 2003). Moreover, mathematical problems are placed in a contextual framework by using language (Bottge, 1999; Prenger, 2005). To solve a math problem, students need to decontextualize it, using higher order thinking skills like reasoning (Mercer & Sams, 2006; Phye, 1997). When reasoning, a specific mathematical discourse (sometimes referred to as mathematical conversation) is used (Caspi & Sfard, 2012; Sfard, 2001, 2012). Therefore, interactive instruction methods have become increasingly important in mathematics (Lewis & Smith, 1993; Prenger, 2005). As a consequence, teachers have to find effective ways to organize discourse in the mathematics lesson, in which students are stimulated to engage in cognitive complex processes (Henningsen & Stein, 1997). They orchestrate whole-class discussions where students' thinking becomes public and as a consequence can be guided by the teacher and used by other students to advance the mathematical learning of the whole class (Stein, Engle, Smith, & Hughes, 2008). Students need to learn specific language features of mathematics before they can really participate in such conversation (Bailey, 2007; O'Malley & Chamot, 1994). This language is part of the AL register and it differs substantially from the language most students learn at home (Aarts, Demir-Vegter, Kurvers, & Henrichs, 2016; Bailey, 2007; Cummins, 1980; Henrichs, 2010; Schleppegrell, 2004). According to Dutch national standards for mathematics, students should start learning to speak in formal, mathematical language in first and second grade (i.e., age 6-8) (Buijs, 2008).

Teachers play an important role in the development of students' AL, firstly by offering AL input (Schleppegrell, 2004; Tomasello, 2000), secondly by helping students to understand this input and thirdly, by triggering students to produce AL. Together, this can be defined as AL stimulating behavior. During mathematics instruction, teachers use different instructional methods that may vary in the opportunity they provide to stimulate students' AL development. The goal of this research is to gain insight into opportunities to improve AL stimulating behavior of teachers in first and second grade within different instructional methods available in mathematics instruction. It is not clear which methods provide most opportunities for showing AL stimulating behavior, in what way these opportunities are used by teachers and how instructional methods are used during mathematics instruction.

2. ACADEMIC LANGUAGE

In this section the features of AL, the concept of AL stimulating behavior and instructional methods used during mathematics instruction will be described. The AL register, also referred to as *Cognitive Academic Language Proficiency* (Cummins, 2000) or *language of schooling* (Schleppegrell, 2004) is extensively described at various language levels by Aarts, Demir, and Vallen (2011), Henrichs (2010), and Uccelli, Barr, Dobbs, Phillips Galloway, Meneses, and Sánchez (2015). At the lexical level, teachers may use diverse language with infrequent lexis and a big variety of words. AL can also be characterized by the use of lexically dense language with morphologically complex words. Language is dense when lots of content words are used, for instance in lexical subjects/objects and elaborated noun phrases. On the morpho-syntactic level, the use of complex and varied sentences, by using connectives and clause combining, and explicit reference to time and place identify the academic register. On the textual level, AL is characterized by the use of decontextualized language and cohesive devices in order to create coherence between utterances. On the meta-linguistic level, teachers may show awareness of the academic register by demonstrating and verbalizing the use of the AL register. During mathematics lessons all these features may occur, e.g. subject specific words like 'multiplication' may be infrequent for students, cohesive devices may be used when explaining that 'two and eight makes a nice number, because it makes ten' and teachers may name the register during the instruction: 'I will write this down in mathematical language'.

Besides offering AL input, two categories of AL stimulating teacher behavior can be distinguished: behavior aimed at students' understanding of teachers' AL and behavior aimed at triggering students' AL production. To help students understand their AL use, teachers may show specific behavior aimed at stimulating AL understanding (Krashen, 1985; Nagy & Townsend, 2012; Zwiers, 2008). Students also need to be given opportunities to use AL by themselves. Giving students the opportunity to negotiate actively about the meaning of language stimulates them to learn language at a deeper and longer lasting level (Swain, 1985; Zwiers, 2008).

Based on recent studies a typology of AL stimulating teacher behavior was constructed within the above mentioned categories, i.e. aimed at students' AL understanding and aimed at students' AL production. When teachers aim at stimulating students' AL understanding they may model their language use by verbalizing how to use language in a specific situation. They do not only show students how to act during a task, but they reveal their thinking process by talking about it at the same time. Zwiers (2008) describes this type of behavior as ‘modeling with think-alouds’. Hajer (2004) and Van Eerde (2009) both mention that teachers stimulate AL understanding by giving meaning to their language use by explaining it. They may also reformulate or repeat their own utterances (Van Eerde, 2009) and use visualizations (Smit, 2013) in order to stimulate AL understanding by students.

Teachers may also revoice the language of their students, creating participant frameworks that promote conceptual understanding by actively involving their students in mathematical discussions. They revoice when they re-utter the students’ contribution through the use of repetition, expansion, or rephrasing (Enyedy, Rubel, Castellón, Mukhopadhyay, Esmonde, & Sedaca, 2008; O’Connor & Michaels, 1993). Some of the types of behavior that Smit (2013) constructed for language during a mathematics lesson are aimed at stimulating AL production by students: reformulate students’ utterances into more academic wording (recasting); ask students to be more precise to improve their (spoken) language; repeat correct students’ utterances (repetition). When teachers reformulate language in order to improve the utterance, for example by expanding it, this is called recasting (Mohan & Beckett, 2003). When they reformulate language by simplifying or by rephrasing (Van den Boer, 2003), this is called reformulating. Zwiers (2008) adds behavior like ‘using provocative statements’ to trigger students’ AL production. Teachers may also give their students directions for language use (Hajer, 2004; Van Eerde, 2009). An overview of AL stimulating behavior with descriptions, examples taken from our own data corpus, is given in Table 1.

Having explored the various ways in which teachers can stimulate AL development by their students, we now turn to the question which instructional methods are best equipped to offer teachers opportunities to show this AL stimulating behavior.

Table 1. Teachers' academic language stimulating behavior

Academic language stimulating behavior		Description with examples
Aimed at students' understanding of teachers' AL	1. Modeling with think-alouds	The teacher demonstrates how to use language by verbalizing it during a task: *There are ten pairs of socks hanging at the washing line; you can also say ten times two.*
	2. Giving meaning	The teacher gives meaning to words or expands the meaning of the words by using language: *A measuring rod is hard and tape measure is softer.*
	3. Recasting own language	The teacher repeats what he/she said, but improves aspects of the utterance. It can be an improvement because of a mistake, but it can also be an improvement towards a more academic register: *This is a bus. How many people are there in the bus? How many passengers do you see in the bus?*
	4. Repeating own correct language	The teacher repeats exactly what he/she said emphasizing the correctness of the utterance: *This is a twenty square, a twenty square.*
	5. Reformulating own language	The teacher repeats the message in another way, making it simpler or keeping it at the same language level: *Make a note alongside it. Write it down.*
	6. Visualizing	The teacher uses materials or gestures to visualize the used language.
Aimed at students' AL production	1. Asking to be more precise	The teacher asks the student to formulate his utterance more precise: *Can you say this differently?*
	2. Giving directions	The teacher focuses the attention of the students on aspects of the language: *In this word you see another word you definitely know.*
	3. Provocative statement	The teacher uses a provocative statement like a contradiction or a controversial idea: *So kilometers is the same as millimeters.*
	4. Recasting language of the student	The teacher repeats what was said by the student, but he improves aspects of the utterance. It can be an improvement because of a mistake, but it can also be an improvement towards more academic language. *St: There are three cones. They are in the box.* *T: Yes, the three cones can all be found in the same box.*
	5. Repeating language of the student	The teacher repeats exactly what the student said emphasizing the correctness of the utterance. *Listen to what B. says: it is all odd!*
	6. Reformulating language of the student	The teacher repeats the message in another way, making it simpler or keeping it at the same language level. *St: We should not forget to count the flowers in the back of the truck!* *T: You are right, we should not forget that.*

3. INSTRUCTIONAL METHODS

Teachers can use different instructional methods to organize their teaching. Hoogeveen and Winkels (2005) distinguish five basic instructional methods: explaining, interacting, task instruction, cooperative learning and gaming. In this study we focus on the three teacher led instructional methods: 'explanation', 'interaction' and 'task instruction'. 'Explanation' can take two forms: 'explanation of content' and 'explanation of procedures' (Nijland, 2011). 'Explanation of procedures, rules and preconditions' is necessary for organizing the lesson. In our study, this will be called *organization*. Within interaction, two instructional methods can be distinguished: 'task evaluation' and 'discussing content'. Teachers can interact with their students by talking about tasks they fulfilled. In this case, content steers the interaction and language is used as "a vehicle of getting somewhere" (Nijland, 2011, p. 53). The function is instrumental. This form will be called *task evaluation.* Language can also function pedagogically, to "provide and seek intellectual guidance" (Nijland, 2011, p. 53) when experiences, information or questions of students determine the subject of the interaction (Niederdorfer & Kroon, 2014). In our study, this will be called *discussion.* The different ways of interacting may influence AL stimulating behavior, therefore in this study *task evaluation* and *discussion* are both used. In Table 2, descriptions and examples are given of the five selected instructional methods.

Instructional methods can be analyzed according to opportunities they offer to stimulate AL and to actual AL stimulating behavior teachers show. AL stimulating behavior can be expected to occur in situations that require academic language, when teacher and students interact on content. According to Gibbons (2002) interaction is at the heart of the learning process and it is a significant factor in language development. However, the way in which interaction in the discourse during mathematics instruction takes place differs (Barwell, 2016; Gibbons, 2002; Niederdorfer & Kroon, 2014; Nijland, 2011). In mathematics lessons a global shift to goals around higher levels of mathematical proficiency and problem solving is taking place. Traditionally, a dialectic approach, where students try to find the right answer and where speakers arrive at an intersubjectivity of shared truth, is used (Langer-Osuna & Avalos, 2015). Barwell (2016) argues that through the multiple discourses that take place in the dialogic approach, where students reach understanding instead of a right answer by negotiating ideas, mathematical meaning emerges. Besides expanding their mathematical meaning, students will be equipped to think creatively to take mathematics further in a dialogic approach (Bakker, Smit, & Wegerif, 2015). Dialogic talk clarifies how students learn and it can be used by teachers to encourage students to account for their answers, engaging them in a dialogic process (Dièz-Palomar & Cabré Olivé, 2015).

Table 2. Categorization of instructional methods

Instructional method	Description with examples
Explanation	Lecturing about how something works or how to do something. Examples: The teacher is teaching/ telling/ demonstrating/ showing a video.
Discussion	Teacher and students interact with each other on a mostly student initiated subject with the purpose of exchanging experiences, information or questions or to negotiate meaning. Examples: The teacher and (one of) the students having a discussion/ conversation/ educational conversation/ talking to each other/ asking questions to each other.
Task instruction	Students are told to do an assignment by themselves. The teacher guides the students verbally through the process and the goals of the assignment. Examples: The teacher says: do this notebook task/ write a text/ calculate the sums.
Task evaluation	Teacher and students interact with each other on a specific task or an assignment after finishing it, with the purpose of exchanging experiences, information or questions and negotiating meaning that relates to the task. Examples: The teacher and (one of) the students are discussing tasks from the notebook, are talking about a task from the smart board.
Organization	Talking to students about the necessary preconditions. Examples: The teacher tells students where they can find it in the book, what to do when they are ready or hands out notebooks. The teacher keeps order.

Zwiers (2008) claims that negotiating meaning is a basic aspect of language acquisition that takes place in dialogically organized interaction. This type of interaction is more interactive, more conversation-like and more coherent than monologically organized interaction, where the main speaker, mostly the teacher, operates from a predetermined script. In dialogically organized instruction, the learning of knowledge is seen as a transformation of understandings instead of as a transmission of knowledge (Nystrand, 2003). Considering the need for negotiating meaning to learn AL, dialogically organized instruction can be expected to be effective for stimulating AL development.

The literature above seems to suggest that the instructional methods *discussion* or *task evaluation* give more opportunities for developing AL than *explanation, task instruction* or *organizing* the instructional part of the mathematics lesson. Besides that, teachers, who design their mathematics instruction using more *discussion* than *explanation,* may also stimulate the development of their students' AL more effectively. But so far, research has not dealt with the question which instructional methods offer the best opportunities for stimulating AL development and whether teachers actually show AL stimulating behavior during these instructional methods in actual classroom practice.

Furthermore, it is unknown to what extent different instructional methods are used in mathematics instruction. This leads to the following research questions:

1. *Which instructional methods, according to experts, offer opportunities to stimulate students´ academic language development during whole class mathematics instruction?*
2. *In which instructional methods in whole class mathematics instruction do teachers show types of academic language stimulating behavior?*
3. *To what extent do teachers use (combinations of) instructional methods in practice and what does this imply for AL stimulating teacher behavior?*

4. METHOD

To answer these questions two studies were conducted. In a survey we investigated experts' judgments on which instructional methods offer opportunities to stimulate academic language (Research Question 1). In an observational study we investigated which academic language stimulating teacher behavior was used within instructional methods during whole class mathematic instruction (Research Question 2) and how instructional methods were actually used in 52 mathematic lessons (Research Question 3). The method for each study is described below.

4.1 Expert survey

Participants. A total of 33 (elementary school) teacher trainers with expertise in three different disciplines that all relate to the subject of the research (11 mathematics teacher trainers, 10 language teacher trainers and 12 educational science teacher trainers) participated in the expert survey. For each instructional method, they were asked (based on their own experience and expertise) to indicate which AL stimulating behavior they considered possible while employing this method.

Instruments and procedure. For each instructional method, the participants were asked to tick in a coding-scheme which of the twelve categories of AL stimulating behavior could be expected to occur while using the method (see Table 4). To prevent different interpretations of the categories, descriptions of AL stimulating behavior categories (as in Table 1) and instructional methods (as in Table 2) were provided.

Analysis. The scores of the experts were coded as 0 (AL stimulating behavior not to be expected) or 1 (AL stimulating behavior to be expected) for each aspect of AL stimulating behavior during each instructional method. The total means of the two categories, AL stimulating behavior aimed at students' AL understanding and AL stimulating behavior aimed at students' AL production, were calculated for all five instructional methods for the expert group in total and for the three expert groups separately. The highest means indicate instructional methods that are likely to contain AL understanding and/or AL production stimulating behavior opportunities.

To analyze differences between the three expert groups, an analysis of variance was conducted with the judgment scores as dependent variable and the three expert groups as independent variable.

4.2 Classroom observation

Participants. 27 teachers (24 women and 3 men) of 17 different elementary schools in the Netherlands participated in the research project and gave permission to record two math lessons. Eleven teachers taught first grade, ten teachers taught second grade and six teachers taught a combined first/second grade. The mean age of the teachers was 43, ranging from 23 to 61. The number of years of teaching experience varied from 2 to 39, with a mean of 17.5 years. The number of students in a class varied from 12 to 30 with a mean of 21 students.

Instruments and procedure. Two whole class mathematic lessons of the 27 teachers were videotaped by the researcher using a camera with external microphone that was attached to the teacher's clothes. Two recordings could not be used because of technical problems.

The instructional part is defined as the period in which the teacher interacts with the students in a whole-class situation, beginning when the mathematics lesson starts and ending when the students are assigned to work independently or when the lesson ends. For each instructional method the duration in minutes and seconds and the content was noted on a form (see Table 3 for example).

Table 3. Example three minutes of coding instructional methods

Time		Activities	Instructional method
0:00	0:47	Talking about goal of the lesson	Explanation
0:47	1:17	Switch on timer and get teaching materials	Organization
1:17	1:40	Do-activity: the bus	Explanation
1:40	2:05	Que up the students	Task instruction
2:05	2:26	Talking about the assignment	Explanation
2:26	3:09	Talking about left or right	Discussion

In order to evaluate quality and consistency of the coding of instructional methods of the 52 lessons by the researcher, ten lessons were also coded by a second rater. The inter-rater reliability turned out to be reasonable with a Cohens' kappa of 0.58. The coding of *explanation*, *discussion* and *organization* was similar. The two raters differed in some cases on the coding of *task evaluation* and *task instruction*. For coders to be able to distinguish between these two instructional methods more clearly, rules were stated more clearly by adding explanations.

For each instructional method the researcher, by watching the videos repeatedly, coded whether the 27 teachers showed actually occurring types of AL stimulating behavior. For quality and consistency control, a second rater also coded types of AL stimulating behavior in the different instructional methods in six randomly chosen lessons. The raters agreed in 77% of the cases.

Analyses. The instructional methods used during the lessons were coded. The teachers' behavior was coded as 0 (AL stimulating behavior did not occur) or 1 (AL stimulating behavior did occur) for each aspect of AL stimulating behavior during each instructional method. The total means and standard deviations were calculated for all types of AL stimulating behavior in all five instructional methods, aimed at students' understanding and production of AL. A t-test comparing AL stimulating behavior in first grade and second grade did not show significant differences (p = .52).

The time spent on each instructional method was added up for each lesson and (because total instruction time varied) calculated as a percentage of the total instruction time. Descriptive statistics were applied to present the use of the different instructional methods during the lessons. To investigate whether teachers differed in their relative use of the different instructional methods aimed at stimulating students' understanding and production of AL, a hierarchical cluster analyses was conducted in order to establish different teaching profiles combining AL stimulating behavior and instructional methods. To analyze actually shown AL stimulating teacher behavior within a teaching profile, the mean percentage and the standard deviation within the profiles were calculated.

5. RESULTS

5.1 Expert survey

When comparing the scores of the three expert groups (Dutch language, mathematics and educational science), analysis of variance did not reveal clear differences for most of the instructional methods. The groups only differed significantly in their judgment of stimulating AL production during *task instruction* ($F(2, 30) = 3.43$, p = .046) and during *organization* ($F(2, 30) = 4.82$, p = .015). Post hoc analysis revealed that the Dutch language teacher trainers saw significantly more opportunities for stimulating AL understanding during *task instruction* than the educational science teacher trainers did (p = .034). The group of Dutch language teacher trainers also saw significantly more opportunities for stimulating AL understanding during *organization* than the mathematics (p = .019) and educational science teacher trainers did (p = .045). No other significant differences were found although the language teacher trainers saw slightly more opportunities overall than the mathematic and educational science teacher trainers. All experts' judgments were taken together, because significance was only found within instructional methods with little opportunity for showing Al stimulating behavior. Table 4 presents the opportunities for teachers' AL stimulating behavior as judged by the experts within each of the instructional methods. The higher the score, the more experts expect opportunities for AL stimulating behavior to occur.

Table 4. Percentage of experts who see opportunities for teachers' AL stimulating behavior within instructional method (mean scores of 33 experts)

AL stimulating behavior	Types of behavior	Explanation	Discussion	Task instruction	Task evaluation	Organization	*Total mean*
Aimed at students' understanding of teachers' AL	1. Modeling with think-alouds	91	48	48	64	33	57
	2. Giving meaning	88	79	52	91	21	67
	3. Recasting own language	64	67	52	85	18	57
	4. Repeating own correct language	70	55	42	70	18	51
	5. Reformulating own language	73	58	45	70	18	53
	6. Visualizing	94	55	73	70	45	67
Total mean understanding		80	60	52	74	26	58
Aimed at students' AL production	1. Asking to be precise	33	88	18	97	06	48
	2. Giving directions	61	73	52	85	30	60
	3. Provocative statement	76	82	48	88	15	62
	4. Recasting student language	39	91	18	91	09	50
	5. Repeating correct language of student	39	76	18	88	06	45
	6. Reformulating student language	39	94	15	88	03	48
Total mean production		48	85	28	89	12	52
Total mean percentage of AL stimulating behavior		64	73	40	83	19	56

The judgments of the experts confirm that some instructional methods may give better opportunities for showing AL stimulating behavior than others (RQ1). In all methods except for *organization,* half or more of the experts see opportunities for stimulating AL understanding. The best opportunity for stimulating AL understanding according to the experts, exists during *explanation*, closely followed by *task evaluation*. The methods that scored highest for stimulating AL production were *task evaluation* and *discussion*. When combining the scores of AL understanding and AL production stimulating behavior, *task evaluation* offers the best opportunity for AL stimulating behavior according to the experts. *Discussion* also offers good opportunities. *Task instruction* does not offer many opportunities according to the experts, mainly because the AL production score was low. *Organization* was considered the instructional method with the least opportunities for AL stimulating behavior.

The paired t-tests revealed that for each of the instructional methods the scores for stimulating AL understanding differed significantly from the scores for stimulating AL production. For *explanation*, *task instruction* and *organization*, the opportunities for stimulating AL understanding were significantly higher than for AL production (respectively $t(32) = 6.00$, $p < .001$; $t(32) = 4.16$, $p < .001$ and $t(32) = 3.08$, $p = .004$). For *discussion* and *task evaluation* triggering AL production was judged significantly higher than stimulating AL understanding ($t(32)$ respectively -5.18, $p < .001$ and -3.67, $p = .001$).

Table 5 presents types of AL stimulating behavior for each of the instructional methods. If a behavior type was found during an instructional method, it got a score of 1. If it did not occur, it was scored 0. The higher the score, the more teachers showed that type of AL stimulating behavior.

In all instructional methods there are teachers who show behavior that may stimulate students' AL (RQ2). Most teachers showed types of AL stimulating behavior in *explanation*, *discussion* and *task evaluation.* During *organization* a few teachers used AL stimulating behavior. The method in which most teachers showed types of behavior aimed at students' understanding was during *explanation*, followed by *task evaluation* and *discussion*. The most types of AL stimulating behavior aimed at production were shown in *discussion.* Remarkable are the low scores of the types 'modeling with think-alouds', 'provocative statements' and 'reformulating student' in all methods, where the type 'reformulating own language' scores rather high in all methods (see Table 5).

When comparing the experts' judgments to the actual behavior of the teachers, similarity is found in the methods where only little opportunities are expected by the experts. In *organization* and *task instruction* experts see few opportunities for AL stimulating behavior and only a few teachers show stimulating behavior there. Methods that show higher percentages by the experts (*explanation*, *discussion* and *task evaluation*) show the highest percentages overall of actually occurring AL stimulating behavior. In *explanation* types of behavior aimed at AL understanding (experts .80, actual behavior .50) and in *discussion* types aimed at AL production (experts .85, actual behavior .30) score best.

Table 5. Percentage of teachers showing the type of AL stimulating behavior in instructional methods (mean scores of 27 teachers)

AL stimulating behavior	Types of behavior	Explanation	Discussion	Task instruction	Task evaluation	Organization	*Total mean*
Aimed at students' understanding of teachers' AL	1. Modeling with think-alouds	19	04	0	15	0	08
	2. Giving meaning	63	33	22	33	15	33
	3. Recasting own language	48	44	22	48	15	35
	4. Repeating own correct language	30	22	30	30	07	24
	5. Reformulating own language	63	56	56	63	26	52
	6. Visualizing	78	44	33	67	19	48
Total mean understanding		50	34	27	43	14	34
Aimed at students' AL production	1. Asking to be precise	15	26	07	22	07	15
	2. Giving directions	37	15	07	11	0	14
	3. Provocative statement	0	22	07	07	0	07
	4. Recasting student language	22	41	11	26	0	20
	5. Repeating correct language of student	33	56	11	37	0	27
	6. Reformulating student language	07	22	04	04	0	07
Total mean production		19	30	08	18	01	15
Total mean percentage of AL stimulating behavior		35	32	18	30	07	24

In summary, some differences are found between the experts' judgments and the actual behavior of the teachers. Teachers show more types aimed at understanding AL than at producing AL and experts see opportunities for both. While most experts see opportunities for AL stimulating behavior in *task evaluation,* only a few teachers show types of AL stimulating behavior there. The types 'modeling with think-alouds' and 'provocative statements' are shown by a few teachers only, while experts see lots of opportunities.

5.3 Instructional methods used in mathematics instruction

To answer Research Question 3, i.e. to what extent do teachers use instructional methods that offer opportunities for AL stimulating behavior, the percentage of time used on each of the instructional methods was examined. Table 6 presents the time spent in the five instructional methods that were used in the 52 mathematic lessons.

Table 6. Mean percentage, standard deviation and range of time spent on instructional methods (N=52)

	Mean	SD	Range
Explanation	20.46	16.43	0-60
Discussion	15.08	14.44	0-68
Task instruction	32.10	17.90	0-67
Task evaluation	21.42	18.74	0-83
Organization	10.83	8.53	0-38

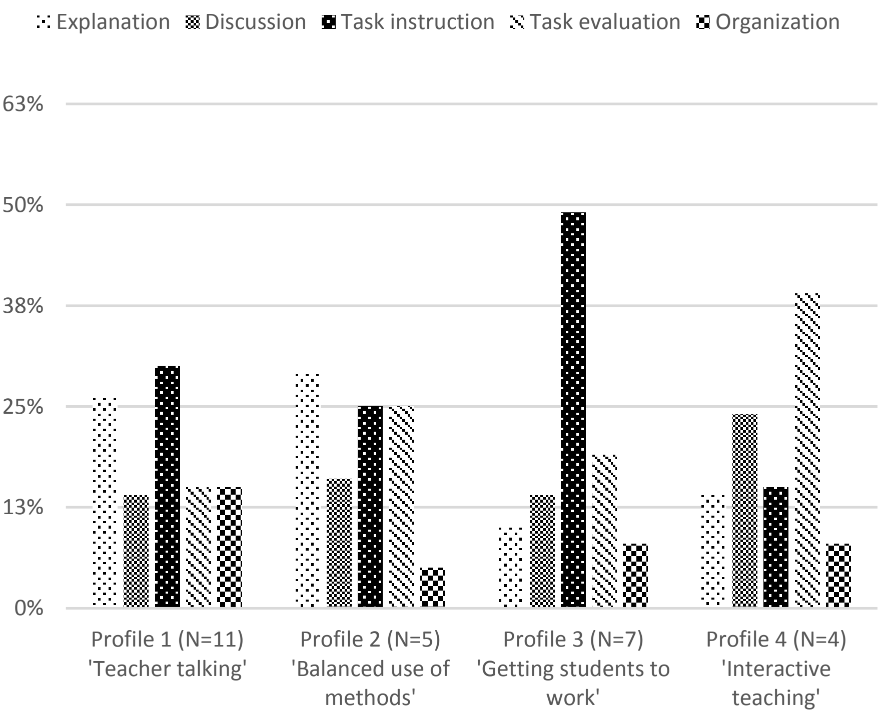
On average the most time was spent on *task instruction* and the least time was spent on *organization*. Overall, about 36% of the time was spent on *discussion* and *task evaluation*, i.e., the instructional methods that, according to theory and experts, provide opportunities for showing AL stimulating behavior aimed at AL understanding and production. Of these two methods, *task evaluation* offers most opportunities for AL stimulating behavior and this method was used 21% of the time. On the other hand, *task evaluation* was the method where teachers hardly showed actual AL stimulating behavior. *Explanation*, in which there are lots of opportunities as well as actual behavior to stimulate AL understanding but less so for triggering AL production by students, was used on average in 20% of the time. *Task instruction,* a method that gives some opportunity for stimulating AL understanding, little opportunity for stimulating AL production and that showed hardly any actual AL stimulating teacher behavior, amounted to 32% of the time. 11% of the instruction time was filled with *organization*, the instructional method that, according to the experts' survey, provides the least opportunity and that showed almost no actual AL stimulating behavior. The high standard deviations and the range of time spent on the instructional methods indicate a large variety in the lessons; for example in some lessons no time was spent on *task evaluation* or *task instruction*, while in other lessons most of the time was spent on these instruct-ional methods.

5.4 Teaching profiles

In order to make it possible to use the above outcomes to design a method for improving teachers' AL stimulating behavior, teaching profiles of opportunities for AL stimulating behavior in specific instructional methods were established. To identify these profiles, we used a hierarchical cluster analysis after checking whether the use of one of the different instructional methods differed for teachers teaching first grade or second grade, or for teaching in a single grade or in a combined grade class. No significant differences were found between different grades (all *p*'s > .60) nor between single and combined grades (all *p*'s >.12). The cluster analysis was based on the percentage of time spent on each of the instructional methods, averaged over the two lessons of each teacher. Teachers within the same cluster resemble each other in the relative use of each of the instructional methods.

At the highest level of clustering the dendrogram revealed one big cluster of 23 teachers, and a small group of 4 teachers. Besides this small group, the group of 23 teachers could on a lower level of analysis be divided in three subgroups of 11, 5 and 7 teachers respectively. Figure 1 represents the percentages of time teachers in each of the clusters spent on the different instructional methods.

Figure 1. Teaching profiles



The four teaching profiles can be characterized as follows:

1. 'Teacher talking': in this profile teachers spent most of their instructional time on *explanation* and *task instruction*. Compared to all other groups, the percentage of time spent on *organization* is relatively high.
2. 'Balanced use of methods': like the teachers in profile 1 in this profile teachers spent relatively much time on *explanation* and *task instruction*. The difference is that they also spent much time on *task evaluation*. The least time is spent on *organization*.
3. 'Getting students to work': teachers in this profile spent about half of their time on *task instruction*. The other instructional methods are only used a little.
4. 'Interactive teaching': in this profile teachers spent, compared to the other groups, the most time on *discussion* and a lot of time on *task evaluation* as well.

Considering the experts' judgments and the types of AL stimulating behavior that actually occurred, teachers in profile 1 and 3 mainly have opportunities to stimulate AL understanding by the students because of the use of *explanation* and *task instruction*. Teachers in profile 2 have opportunities for stimulating both AL understanding and AL production. Profile 4 gives the possibility to stimulate AL production by students more often because of the use of *discussion* and *task evaluation*.

As a check the actually shown types of AL stimulating behavior of teachers within a teaching profile were analyzed. In Table 7 an overview is given of the mean percentage, the number of teachers and the standard deviation of the teachers' behavior within each profile.

Table 7. Mean percentage and standard deviation of AL stimulating behavior within teaching profiles

Profile number	Aimed at students' understanding of teachers' AL	Aimed at students' AL production	Total AL stimulating behavior
1 (*N* =11)	38 (*SD* 8)	15 (*SD* 13)	27 (*SD* 9)
2 (*N* =5)	29 (*SD* 6)	17 (*SD* 11)	23 (*SD* 6)
3 (*N* =7)	38 (*SD* 12)	16 (*SD* 9)	27 (*SD* 9)
4 (*N* =4)	22 (*SD* 8)	15 (*SD* 8)	17 (*SD* 8)

Teachers in profile 1 and 3 indeed show similar behavior; mostly aimed at students' understanding of teachers' AL and a little at triggering students' AL production. Teachers in profile 2 show less types of behavior aimed at production than expected by the experts' judgments, probably because of the extensive use of *task evaluation* where less types of AL stimulating behavior actually occurred than expected. The teachers in profile 4 show the least AL stimulating behavior in both categories, where most types of behavior aimed at students' AL production were expected.

6. CONCLUSION AND DISCUSSION

In this study we focused on the academic language stimulating behavior of elementary school teachers in mathematics instruction. By negotiating ideas, students expand their mathematical meaning and they will be equipped to think creatively to take mathematics further in a dialogic approach (Bakker et al., 2015; Barwell, 2016). Students need to learn specific AL features before they can join the whole class mathematical discourse in a proper way (Bailey, 2007; O'Malley & Chamot, 1994; Sfard, 2012; Stein et al., 2008). Teachers can stimulate the development of this specific AL register not only by giving students AL input, but also by giving specific instructional behavior that helps the students understand teachers' AL (Nagy & Townsend, 2012; Zwiers, 2008) or that stimulates them to produce AL by themselves (Nystrand, 1997; Zwiers, 2008).

A number of studies suggest that some instructional methods might offer more opportunities for AL stimulating teaching behavior than others. Teachers can design a mathematics instruction with more possibilities for stimulating AL, when using the instructional methods with the best opportunities. This study provides insight into the opportunities to improve AL stimulating behavior of teachers in first and second grade within different instructional methods used during mathematics instruction. For this study we constructed a model to analyze AL stimulating behavior that turned out to be useful and reliable.

The first research question, i.e., which instructional methods, according to experts offer opportunities to stimulate students' academic language development during whole class mathematics instruction, was answered by using an expert survey. Results showed that the majority of experts agreed with current theories that *discussion* gives good opportunities for stimulating both AL understanding and AL production by students, that *explanation* mainly offers opportunities for stimulating AL understanding and that *task instruction* and *organization* did not offer much opportunities for stimulating AL at all. In addition to the current theories *task evaluation* was considered to offer opportunities for behavior aimed at stimulating AL understanding as well as behavior aimed at triggering AL production by students.

The second research question, i.e., in which instructional methods during mathematics instruction do teachers show types of AL stimulating behavior, was answered by observing the AL stimulating behavior of 27 teachers. In accordance with the experts' judgments the least types of AL stimulating behavior occurred during *organization* and *task instruction*. During *discussion* teachers did indeed show types of behavior aimed at stimulating AL understanding and production. Therefore this instructional method offers lots of opportunities for stimulating AL development during mathematics instruction. Unlike the experts' judgments, teachers showed most types of AL stimulating behavior during *explanation* and less than expected by the experts during *task evaluation.*

The third research question, i.e., to what extent do teachers in first/second grade use the different instructional methods during the instructional part of the mathematics lesson, was answered by observing and coding 52 lessons of 27 teachers, and calculating for each teacher the mean percentage of time spent on each of the instructional methods. Overall, most of the instructional part of the lessons was used for *task instruction,* an instructional method that offers little opportunities for showing AL stimulating behavior, according to the experts' judgments and in practice: teachers hardly show types of AL stimulating behavior during this instructional method. A lesser part of the instruction was used on *task evaluation* and *explanation*. Experts judged *task evaluation* more promising for AL stimulating behavior aimed at triggering students' AL production than teachers demonstrated. Additional research is necessary to explain this difference. For *explanation* the experts' judgments are in accordance with the actual behavior of the teachers, although 'modeling with think-alouds' hardly occurred. It mainly offers opportunities for showing AL stimulating behavior aimed at understanding. In regards to the instructional method *discussion,* according to the experts this method offers opportunities for both categories of AL stimulating behavior. In practice, teachers did indeed show both categories of behavior during discussion. Unfortunately it was used only in 15% of the mathematics instruction. The least part of the instruction was used for *organization.* It offers the least opportunities for showing AL stimulating behavior according to the experts and teachers indeed showed hardly any AL stimulating behavior here.

To improve students' AL development and teachers' AL stimulating behavior it might be helpful to increase the use of instructional methods that give opportunities for behavior aimed at students' AL production. However, in the design of the lessons teachers differ a lot in the alternation of the different instructional methods. In order to make it possible to use the above outcomes, four teaching profiles with different opportunities for showing AL stimulating behavior could be established: profile 1 'teacher talking', profile 2 'balanced use of methods', profile 3 'getting students at work' and profile 4 'interactive teaching'. When designing their mathematics instruction, teachers can choose to use a combination of instructional methods (a profile) which offers most possibilities for stimulating their students' AL production. Teaching profiles 2 and 4 are the ones that offer the most possibilities for setting up an AL stimulating mathematics instruction with opportunities for stimulating behavior aimed both at students' AL understanding and at students' AL production. Teaching profiles 1 and 3 offer good possibilities for showing behavior aimed at students' AL understanding. However, the opportunities during task instruction are not clear, because expert opinions and actually occurring behavior do not coincide.

In profiles 2 and 4 teachers showed less types of AL stimulating behavior aimed at AL production than was expected. In profile 2 this might be explained by the extensive use of *task evaluation,* although more research is needed her. We found unexpectedly low scores for types of AL stimulating behavior aimed at students' AL production in profile 4, in which we had only 4 teachers. Therefore we cannot be conclusive about the AL stimulating opportunities of this teaching profile.

A limitation of this research is the relatively small groups of teachers included and the sample of recorded lessons (only 2 lessons per teacher). Moreover, we chose to use the actual occurrence of a type of AL stimulating behavior as a measure for AL stimulating behavior. The frequency of occurrence of each type of AL stimulating behavior has not been taken into account. Therefore, we can conclude that teachers do use different types of AL stimulating behavior in different instructional methods during mathematics instruction, but it is yet unclear how often these types occur. Teachers might for example show the same type of AL stimulating behavior repeatedly in a short time. Besides this, teachers' own AL use may influence the AL stimulating behavior they show. Further analyses in which the frequency of AL stimulating behavior and the AL use of teachers is taken into account, will shed more light on these issues.

We found teachers' behavior to be aimed more strongly at stimulating AL understanding than AL production by the students. This could imply that teachers use a more monologic than dialogic type of interaction, which may require less behavior aimed at triggering production (Nystrand, 2003). When supporting teachers in improving their AL stimulating behavior during mathematics instruction, we need to take teaching profiles, use of instructional methods and also types of interaction into account.

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