Module 8

THE RELEVANCE OF LANGUAGE FOR MATHEMATICS EDUCATION
This module is based on the work within the project Intercultural learning in mathematics and science initial teacher education (IncluSMe). Coordination: Prof. Dr. Katja Maaß, International Centre for STEM Education (ICSE) at the University of Education Freiburg, Germany. Partners: University of Nicosia, Cyprus; University of Hradec Králové, Czech Republic; University of Jaen, Spain; National and Kapodistrian University of Athens, Greece; Vilnius University, Lithuania; University of Malta, Malta; Utrecht University, Netherlands; Norwegian University of Science and Technology, Norway; Jönköping University, Sweden; Constantine the Philosopher University, Slovakia.

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General overview and aims

In this module student-teachers in ITE (initial teacher education) at lower secondary level are introduced to relevance of language in mathematics education and it provides them with background and tools to teach mathematics in a language-oriented (or language-sensitive) way.

Background

For students of all backgrounds (both mono-lingual and multilingual students) it is important to develop the subject-specific (academic) language of mathematics. This language is needed for conceptual understanding and ‘meaning-making’ in mathematics. The development of subject-specific language can be facilitated by adopting a language-sensitive approach to mathematics. Although multilingual students will encounter other and maybe more problems than monolingual students, this approach is aimed to benefit all students in developing their mathematical proficiency.

Aim

The aim of this module is twofold:

1. To make student-teachers aware of the relevance of language for learning (and teaching) mathematics.
2. To provide them with background theory, resources, skills and tools to support their student’s development of relevant academic language, and thus equip them to enhance mathematics learning in classrooms where students’ levels and background in academic language proficiency may differ.

This module is part of:

- Mathematics and Science Subject dimension: (inter)cultural perspectives on the subjects themselves;
Relevant topics

In this module, the following topics will be addressed:

- The distinction between 'everyday' language, general academic language and the specific language of mathematics;
- Some background and characteristics of language-sensitive mathematics teaching;
- The relevance of interaction, contexts and language-support for the learning of (the language of) mathematics;
- Tools to analyse teaching materials and classroom interaction (scaffolding) on the use and support of language in mathematics teaching;
- Tools and activities to support future teachers in designing language sensitive lessons and activities.

Learning Outcomes

Through this module prospective teacher will be able to:

- Understand difficulties student face with language in mathematics (especially multilingual students).
- Become aware of the role and relevance of language in mathematics education (everyday language, general school language and subject-specific language of mathematics).
- Develop knowledge about the approach of language-sensitive mathematics teaching and its tools.
- Analyze language in classroom materials and teaching practice.
- Learn to value the role of various representations and visualizations as a bridge for understanding and developing linguistic skills in mathematics education.
- Learn to know and use scaffolding strategies to support students in language-sensitive mathematics lessons.
- Design classroom activities that support students' language proficiency as well as their mathematical understanding.
Flowchart and Module plan

This module involves three sections, all structured into several activities, including interactive presentations, (small) group discussions and student presentations. The structure is as follows:

- Introduction into the topic – 2 activities (60 minutes)
- Background and tools – 3 activities (90 minutes)
- Connection to practice – 3 activities (120 minutes)

The activities can be distributed over 3 sessions of 60-120 minutes with 90 minutes of homework as follows:

- Session 1 – activities 1.1, 1.2, 2.1 + 30 minutes homework reading
- Session 2 – activities 2.2, 2.3, 3.1 (and 3.2) + 60 minutes homework designing
- Session 3 – activity 3.3

Depending on your local situation you may want to adjust this.
## I. Introduction into the topic: The relevance of language for mathematics education

### 1.1 Types of language

<table>
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<tr>
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<th>Duration: 30 minutes</th>
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</table>

This is a “warming-up” activity. The intention is for pre-service teachers to become aware of how - in subject specific (mathematical) language - some words from daily language are given a new meaning. In small groups they study a collection of words from STEM-subjects (see worksheet for activity 1.1) and discuss the differences in meaning these words have in daily language as compared to the meaning in mathematics. They illustrate these differences in meaning by making sentences (typical expressions) using these terms. They use the question on the worksheet to discuss what this means for their students (what difficulties will they face?) and for their teaching. The findings of the small groups will be shared in a whole class discussion.

This activity contributes to the achievement of the following learning outcomes:

- Understand difficulties student face with language in mathematics (especially multilingual students)
- Become aware of the role and relevance of language in mathematics education (everyday language, general school language and subject-specific language of mathematics)

### 1.2 Student difficulties – an example

<table>
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<th>Duration: 30 minutes</th>
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</table>

In this activity pre-service teachers study an example (transcript) of a student solving a task and facing language difficulties he himself is not aware of.

Student-teachers are first presented with the mathematical task (see part 1 of activity 1.2 on the worksheet) and solve this themselves. Next, they think of difficulties related to language aspects this task may present to students (grade 6-7). This can be done either in small groups or with the whole group.

Then they read the transcript of a student explaining how he solved the task (see part 2 of activity 1.2 on the worksheet), and they discuss the language abilities as well as the language problems of this student. Below some background information is given on the transcript.
1. The excerpt is part of Dutch research (van den Boer, 2003) into the problems second generation immigrant students (in multicultural schools) encounter in mathematics education and the factors that cause these problems.

2. The student is a boy (aged 12) born in the Netherlands of Moroccan parents.

3. It is a dialogue between a Student and a Teacher-researcher. The student has read the task aloud and solved it and now explains what he did.

The pre-service teachers connect this example to their own teaching: do they recognize the example? Can they give similar examples from their teaching? They relate this to what they discussed in activity 1.1.

This activity contributes to the achievement of the following learning outcomes:

- Understand difficulties student face with language in mathematics (especially multilingual students)
- Become aware of the role and relevance of language in mathematics education (everyday language, general school language and subject-specific language of mathematics)

II. Background: language and mathematics education

2.1 Lecture on the relevance of language in mathematics education

<table>
<thead>
<tr>
<th>Activity</th>
<th>Duration: 30 minutes</th>
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</table>

The educator presents theory about language in mathematics and language-sensitive mathematics teaching (see separate ppt). This presentation includes the following topics:

- Why language is crucial for (mathematics) learning
- The distinction between daily language, general academic language (school language) and subject specific academic language and difficulties students may have with each
- Characteristics of the language of mathematics and the importance of subject-specific language objectives
- How teachers stimulate students to speak and write (language production) for the learning of mathematics
- Scaffolding language
- Tools to support language development
- Optional: discussion on statements, such as:
  - All teachers are language-teachers
  - Restricted talk becomes restricted learning (Barwell)

Homework
The re-service teachers may be asked to read an article on language-sensitive mathematics education as homework. Suggested article is from the proceedings of CERME 4 (Bosch, 2006) p.1215-1225


http://www.mathematik.uni-dortmund.de/~erme/CERME4/CERME4_WG10.pdf

You can replace this by an article in your own language. It is important that the article you chose contains classroom examples or has direct practical value for teaching. You could present the following home-work task to your students:

Write a paragraph of about 300-500 words based on this article in which you make clear how you could make your own mathematics lessons more language-sensitive.

This activity contributes to the achievement of the following learning outcomes:

- Become aware of the role and relevance of language in mathematics education (everyday language, general school language and subject-specific language of mathematics)
- Develop knowledge about the approach of language-sensitive mathematics teaching and its tools
II. Background: language and mathematics education

2.2 Analysing a textbook problem

The pre-service teachers analyse a textbook problem to identify the types of language used in this problem and predict difficulties students may face when working on this problem.

The exemplary problem (see worksheet for activity 2.2) is set in the everyday context of doing the laundry. Preservice teachers, in pairs, analyse the problem guided by the following questions:

1. What kind of language is used in the problem of the washing powder? Identify daily language, mathematical language (words) and symbols and general academic language.
2. Consider the problem (language and picture) through the eyes of a student: what might be difficult for the students?

Discuss in the whole group the types of language the pairs have identified as well as the problems they expect their students may have. Do they expect different types of problems for first and second language learners?

You may replace this textbook problem by a similar one. It is important that the problem you select is set in a familiar context, that all three types of language are used in the problem and that the mathematics that the pupils need for solving the problem is not too complex.

This part contributes to the achievement of the following learning outcomes:

- Understand difficulties student face with language in mathematics (especially multilingual students).
- Become aware of the role and relevance of language in mathematics education (everyday language, general school language and subject-specific language of mathematics).
- Analyze language in classroom materials and teaching practice.
The relevance of language for mathematics education

II. Background: language and mathematics education

2.3 The role of the teacher: scaffolding language

The intention of this activity is twofold, first to present pre-service teachers with examples of a teacher scaffolding language and second to present them with tools to scaffold students' language in classroom interaction.

In the first part of the activity pre-service teachers read a dialogue (part 1 of activity 2.3 on the worksheet) and discuss in pairs strategies the teacher uses to scaffold students' language.

Next pre-service teachers read a text in which seven scaffolding strategies are presented and explained. For each strategy one example is provided (see part 2 of activity 2.3 on the worksheet). You can either discuss these with the whole group or you may have student-teachers do this in pairs. A guiding question for understanding the strategies is: For each strategy think of another example that fits the topic you are teaching now.

You may also want to explore with the group which strategies they use in their teaching.

In the third part of the activity pre-service teachers identify these scaffolding strategies in two exemplary dialogues. They first do this individually and then compare and discuss their scoring in pairs.

Note: It would even be better to use a video of teacher-classroom interaction with a teacher scaffolding language in a mathematics lesson in your own language (preferable a video of the pre-service teachers in your group). If this is available, you may want to use this instead of the written dialogues.

This activity contributes to the achievement of the following learning outcomes:

- Understand difficulties student face with language in mathematics (especially multilingual students).
- Analyze language in classroom materials and teaching practice.
- Learn to know and use scaffolding strategies to support students in language-sensitive mathematics lessons.
### III. Connecting to practice

#### 3.1 Tools for supporting language

<table>
<thead>
<tr>
<th>3</th>
<th>Duration: 30</th>
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</thead>
</table>

In this activity pre-service teachers explore eight tools and activities that support language proficiency in mathematics lessons. They explore these activities and analyse how these contribute to language development integrated in mathematical understanding. They also think about which subject-specific language goals can be addressed using each of these activities. See worksheet for activity 3.1.

This activity contributes to the achievement of the following learning outcomes:

- Develop knowledge about the approach of language-sensitive mathematics teaching and its tools.
- Learn to value the role of various representations and visualizations as a bridge for understanding and developing linguistic skills in mathematics education.

### III. Connecting to practice

#### 3.2. Analysing and redesigning a textbook lesson

<table>
<thead>
<tr>
<th>1</th>
<th>or</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>![Clock] 60 minutes</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The aim of this activity is to have pre-service teachers (individually or in small groups) design their own language-sensitive lesson.

Working in small groups participants first select and analyse a paragraph from a mathematics textbook from a language perspective, identifying difficulties this may provide for their students’ mathematical understanding. In activity 2.2 they have practiced analyzing one single textbook problem. Now they will analyze a paragraph (consisting of some theory as well as problems), again focusing on language. Preferably -if possible- ask your pre-service teachers to bring their own mathematics textbook (used in their school) and let them analyze a paragraph they will teach within the next two weeks.

The pre-service teachers analyze the paragraph guided by the questions on the worksheet and they predict problems their students might have. These problems may depend on the background of their students. They also discuss ways to overcome the...
difficulties they have foreseen. This will be the input for the (re)design of a lesson based on this paragraph.

Next pre-service teachers (re)design the lesson/teaching activity. For this lesson the pre-service teachers will:

- Formulate one or two content-related (mathematical) language goals for this lesson.
- Design one or two activities providing ‘language support’ to the students in reaching these goals (see activity 3.1).
- Justify their choices, based on what they learned about language sensitive mathematics teaching

During the session the pre-service teachers can only make a start with this design. It is helpful to have them work together in small groups even if they prepare a different lesson.

At the end of this session have all student groups present, in a short 1-minute pitch, their plans for the lesson/activity. If time permits in this session you may also ask them to give peer feedback.

Finishing the design (goals, teaching activities, materials) and trying the lesson out in class (if possible) is homework. The pre-service teachers fill in a short evaluation form (see worksheet 3.3) and they prepare to share the design and experiences in the next (and last session). Ask them for example to reflect on these questions:

- What are your content-related mathematical language goals?
- What activities did you have students do? Why these?
- What was your role as a teacher?
- What are your experiences: successes and challenges?

You may also ask them before or after that session to write and hand in a (brief) report you can use as assessment. It is also possible to assess the pre-service teachers based on the presentation of their experiences.

This activity contributes to the achievement of the following learning outcomes:

- Understand difficulties student face with language in mathematics (especially multilingual students);
- Analyze language in classroom materials and teaching practice;
- Learn to value the role of various representations and visualizations as a bridge for understanding and developing linguistic skills in mathematics education:
- Design classroom activities that support students' language proficiency as well as their mathematical understanding.
III. Connecting to practice

3.3. Sharing experiences and feedback

Duration: 30-60 minutes

The aim of this activity is to have the pre-service teachers share their design and the experiences with trying out their lesson.

You may have each of them give a short presentation (ppt or poster or oral communication – see activity 3.2) while the others react by providing feedback in the form of tips and tops.

In the whole group you can evaluate what students learned in this module, by discussing the arguments (justification) they had for designing the lesson (see worksheet 3.3) and connecting this to the other activities and theory in this module.

This activity contributes to the achievement of the following learning outcomes:

- Design classroom activities that support students' language proficiency as well as their mathematical understanding.

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Materials and resources

Two presentations (pptx). Teacher Educator.

- PPT 1: Sheets to guide all sessions.
- PPT 2: Lecture on the relevance of language for mathematics teaching (activity 2.2)

Worksheets: Include all activities and links for this module.

Textbooks: brought by pre-service teachers (or the teacher educator)

Access to computers for internet research, accessing some of the resources with worksheets and collaborative work.

Optional (if available): video of mathematics lesson with teacher-classroom interaction (see activity 2.3)
Granularity

If fewer time is available:

- Skip the lecture/presentation in activity 2.1 and instead have the pre-service teachers read an article on language-sensitive mathematics teaching (as homework) and discuss the main characteristics in the whole group.
- Select fewer tools in activity 3.1 or divide the tools between pairs of pre-service teachers and use the cooperative learning strategy ‘expert-groups’ (see references) to share findings.
- Have pre-service teachers do the analysis in activity 3.2 as homework and bring the result to the session. In the session have them (re)design the lesson to make it more language-sensitive.

If more time is available:

- Have groups give each other peer-feedback in activity 3.2 during the design process.
- Include an extra session for sharing and discussing the designed lessons and teaching activities.

References


Further readings


In this article a plan for a PD-course is presented based on research. It is suitable for the educator.


In this article authors describe research on a language-sensitive approach to the learning of fractions. It includes examples of student work and dialogues as well as theoretical background. Example form this article can be used in the sessions.

Assessment

For assessment, you may either use the presentations (activity 3.3) of the pre-service teachers about their experiences when trying out in class the language-sensitive lesson (teaching activities) they designed.

If there is no opportunity for the students to try out a lesson. You may assess the preservice-teachers report on the design of the teaching activity for a language sensitive mathematics lesson (activity 3.2 + homework). This report needs to include:

- Subject-specific language goals.
- A justification of how this activity supports the development of mathematical language and mathematical understanding.
- A lesson plan and all teaching materials.
Module 8

THE RELEVANCE OF LANGUAGE FOR MATHEMATICS EDUCATION

Worksheets
This worksheet is based on the work within the project Intercultural learning in mathematics and science initial teacher education (IncluSMe). Coordination: Prof. Dr. Katja Maaß, International Centre for STEM Education (ICSE) at the University of Education Freiburg, Germany. Partners: University of Nicosia, Cyprus; University of Hradec Králové, Czech Republic; University of Jaen, Spain; National and Kapodistrian University of Athens, Greece; Vilnius University, Lithuania; University of Malta, Malta; Utrecht University, Netherlands; Norwegian University of Science and Technology, Norway; Jönköping University, Sweden; Constantine the Philosopher University, Slovakia.

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I. Introduction into the topic: The relevance of language in mathematics

Activity 1.1: Types of language

Duration: 30 minutes

Look at the words below.

- What do you notice? What kinds of words do you see?
- Individually select about 5 words that are typical for your subject (mathematics).
- Share these in a small group and discuss the questions below:
  o Which of these words are also part of our daily language? What is the difference in meaning in mathematics compared to in daily life? What is a typical expressions (or sentence) using this word in daily language and what is a typical expression in mathematics?
  o What problems do you expect your students may have regarding this ‘shift of’ meaning? Is this different for students who are native speakers in your language and for students who are not?
- In the whole group share the problems that your small group identified.
I. Introduction into the topic: The relevance of language in mathematics

Activity 1.2: Student difficulties

Part 1  
• Study the mathematical problem below and solve it

In a region there are 4 primary schools. The number of pupils in 1996 and 1997 for each school is presented in the table below.

<table>
<thead>
<tr>
<th>Number of students</th>
<th>School 1</th>
<th>School 2</th>
<th>School 3</th>
<th>School 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>In 1996</td>
<td>338</td>
<td>182</td>
<td>220</td>
<td>203</td>
</tr>
<tr>
<td>In 1997</td>
<td>237</td>
<td>160</td>
<td>270</td>
<td>227</td>
</tr>
</tbody>
</table>

For which school is the increase in pupils the highest?

• Discuss in a small group what problems students (grade 6 or 7) may have when solving this problem? Are some of these problems language related?

Part 2  
• Study the excerpt below. It is a dialogue between a Student and a Teacher-researcher. The student has read the problem above aloud, solved it and now explains what he did.

S: For which school, for which school the increase is the highest? Then you need to look... School1, in 1996 and 1997, in 1996 they had 338 and 237, this you add together, then you go to school 2....  
T: Why do you choose to add?  
S: Because they ask for which school the increase is the highest, so I have to for those 4 schools, you have to add the number of pupils in 1996 and in 1997, those you have to add together and then, you see, if you have those four results, then you look which number is highest and let’s say.. School 1 is highest, this you write here.  
[...]  
T: and what, for example, does increase mean?  
S: Eh, for which school ... eh ... where is it highest, let’s say, where is it .... actually ....[not clear] ... of which ... [not clear] schools...  
T: But that, how do you do this? You read it and then you think ‘it must be this and ...
S: yes...
T: or do you say ‘no, I’m sure this is meant by increase’.
S: sometimes I forget. But for this problem it is easy, because you already hear ‘highest’, then you know. Then you do not really need to look at increase. Then you have to see for which school it is highest. So actually you can leave out increase and then you can just calculate it.
T: and if you leave it out, then it says ‘for which school the highest’?
S: Yes
T: The highest. And then?
S: Yes, but then you actually don’t know what it is about. Yes. Here it is about pupils. Eh, the highest.
[....]
T: but here for example, increase is an important word.
S: ....
T: isn’t it?
S: yes, here it is.
T: Here it is.
S: yes, but even so I understand it. I got it.

- Discuss the following questions in your small group.
- How do you value the students’ language abilities in general?
- What strategies does the student use to overcome language difficulties?
- What do you notice about the student –teacher/researcher interaction?
- Do you have similar experiences? What would you do in such a situation?
- How would you provide language support for this student?
II. Background: language and mathematics education

Activity 2.2: Analysing a textbook problem

Duration: 30 minutes

The problem below is taken from a Dutch mathematics textbook for pupils in grade 6 or 7 (age 11-12). You see the original Dutch problem with the illustrations and a translation of the text in English.

Study the problem and answer and discuss the questions below:

**Washing-powder**

a. With every washing you use 1 measuring cup of washing-powder. How many washings can you do with 1 pack of washing-powder?

b. If the clothing is very dirty you need 1 ½ cup per wash. How many ml is that? And how many grams?

c. How often can you clean extra filthy laundry with 1 pack of washing-powder?

Translation of significant text in the illustrations.

- on the illustration with the measuring cup you see: = 150 ml = about 100 g.
- on the pack detergent you can read: 4 kg

Questions for the analysis of the problem

- What kind of language is used in the problem of the washing powder? Identify: daily language, mathematical language (words, symbols, ...) and general academic language.
- Study the problem from a pupils’ perspective: what might be difficult for the pupil?
- Think of ways to make the language more accessible to the pupil.
II. Background: language and mathematics education

Activity 2.3: The role of the teacher scaffolding language

Part 1

Scaffolding language is: *Adaptive linguistic support that helps students in developing the language abilities that enables students to think and communicate independently in school subjects.* (see Gibbons, 2002, 2009)

Read the excerpt below and discuss in pairs the strategies the teachers (T) uses to scaffold students (S1-3) language.

Fragment 1

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>S1</td>
<td>The sunflower grows gradually (points to the first segment of the graph). Is this like mathematical language? (Teacher nods.) Rises gradually. And then here (points to the second segment of the graph), then it grows fast. Yes, it grows fast. And that was it.</td>
</tr>
<tr>
<td>T</td>
<td>All right. And you can tell from the graph because...?</td>
</tr>
<tr>
<td>S1</td>
<td>Because it, that line, it just shows that it grows very fast.</td>
</tr>
<tr>
<td>T</td>
<td>And that, what would we call that in mathematical language?</td>
</tr>
<tr>
<td>S2</td>
<td>Rise.</td>
</tr>
<tr>
<td></td>
<td>It rises quickly. OK. S3, next two ones.</td>
</tr>
<tr>
<td>S3</td>
<td>Here you can see that it changes direction again (holds his fingers at a segment on the graph), it goes little more to the right. And then it rises again to thirteen (moves his finger along the line graph until he meets the next segment). And then, it rises gradually up to constant.</td>
</tr>
<tr>
<td>T</td>
<td>It changes direction. And then what would you say, ‘it’? What would you say about this (points to the third segment)?</td>
</tr>
<tr>
<td>S3</td>
<td>Then it goes gradually. Rising.</td>
</tr>
<tr>
<td>T</td>
<td>The graph rises.</td>
</tr>
<tr>
<td>S3</td>
<td>Up to thirteen.</td>
</tr>
<tr>
<td>T</td>
<td>Yes, the graph rises gradually.</td>
</tr>
<tr>
<td>S3</td>
<td>Gradually.</td>
</tr>
<tr>
<td>T</td>
<td>Gradually. And then what happens to the sunflower?</td>
</tr>
<tr>
<td>S3</td>
<td>Then it just stays like this (Abdul moves his hands in horizontal direction).</td>
</tr>
</tbody>
</table>

Part 2
Explore the strategies for scaffolding language in the table below.
For each strategy think of another example that fits a topic you are teaching now. Also discuss in a small group which of these strategies you use and which you want to use.

Table 1. Strategies for scaffolding language and examples for each strategy

<table>
<thead>
<tr>
<th>Strategy</th>
<th>Example</th>
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<tbody>
<tr>
<td>1. Reformulate pupils’ utterances (spoken or written) into more academic wording</td>
<td>In response to the graph goes higher and higher up: Indeed, the graph rises steeply. What do you mean by ‘it’?</td>
</tr>
<tr>
<td>2. Ask pupils to be more precise in spoken language or to improve their spoken language</td>
<td>The graph descends slowly indeed.</td>
</tr>
<tr>
<td>3. Repeat correct pupil utterances</td>
<td>Into how many segments can we split the graph?</td>
</tr>
<tr>
<td>4. Refer to features of the text type (interpretative description of a line graph)</td>
<td>For example, gesturing a horizontal axis when discussing this concept</td>
</tr>
<tr>
<td>5. Use gestures or drawings to support verbal reasoning</td>
<td>Look, the word you are looking for is written down for you here.</td>
</tr>
<tr>
<td>6. Remind pupils (by gesturing or verbally) to use a designed scaffold (i.e., word list or writing plan) as a supporting material</td>
<td>How can we rewrite this in more mathematical wording?</td>
</tr>
<tr>
<td>7. Ask pupils how written text can be produced or improved</td>
<td></td>
</tr>
</tbody>
</table>


Part 3
Read the two fragments below of teacher-student interactions and individually score the teachers utterances according to the strategies from the table above. Do the same for fragment 1 in part 1 of this worksheet. Compare and discuss your results in pairs.

The interactions are about this graph

Fragment 2
T: How can he tell his age? Where does he see that? S1.
S1: Down below.
T: Can you speak up? We cannot hear that.
S1: Down below, at (…?).
T: And down below, for that we know proper mathematical language. S2?
S2: Horizontal axis.
T: Why don’t you put that in a sentence. It’s just a word on its own like this.
S2: Along the horizontal axis it says age in years.
T: That’s a beautiful sentence, isn’t it? OK.
Fragment 3
S1 When he was thirty and thirty-five, he just stayed at seventy-six kilograms (points at numbers along the axis).
T Wait a minute. How can we formulate this in the proper wording? When he was thirty and thirty-five? What you, S2?
S2 Thirty till thirty-five, he just stayed the same.
T Do we say thirty till thirty-five?
S3 From.
T From. From, and now put this in a beautiful sentence. Just face the class, because then this lovely sentence will come out!
S1 From thirty till thirty-five Uncle Kees stays constant.
T From thirty till thirty-five. When Uncle Kees is between thirty and thirty-five years old, or... from thirty till thirty-five.
S1 Uncle stays, uncle stays constant, uncle Kees stays constant.
T Yes. But do I keep standing “constant”? What remains constant? Remember, I’m uncle Kees again (acts out uncle Kees).
S1 The kilograms.
T And how, what was that again? Not my kilograms.
S1 Uncle Kees’s weight just stays at seventy-six kilograms.
T Yes. His weight remains the same. As you can tell from the graph?
S1 Which remains constant.
T That’s it. Now you have used proper mathematical language. All right. In a few minutes’ time we’ve actually come to know a lot about Uncle Kees, who we haven’t even met. By looking at the graph’s change in direction. OK.

III. Connecting to practice

Activity 3.1: Tools for supporting language

Duration 30 minutes

Study the eight tools and activities below for stimulating language proficiency in mathematics. For each of these:

- Indicate how it contributes to the development of language proficiency and to the development of mathematical understanding. Try to generalize from the specific example to a more general use of the tool/activity.
- Formulate a subject-specific language goal you can address with this activity.
- Discuss your findings in a small group.

1. **Asks students to make a mind-map for a concept**

   ![Mind-map example](image)

   Chocolate bar divided by friends:  
   | 1 bar - 2 friends | My Picture |
   | 1 bar - 3 friends |
   | 1 bar - 4 friends |
   | 1 bar - 5 friends |

   Also encourage students to make this kind of drawings, schemes, graphs etc. themselves.

2. **Provide visual models and different representations for better understanding**

   ![Visual models and representations](image)

   ![Graph and equation](image)
3. Present a writing-frame to help students write (example for a graph)

When Niek is born, he is .................................................................
In his first years ..............................................................................
You can tell as the graph .................................................................
From the age of 2 onward .................................................................
The graph .........................................................................................
After his sixth birthday .................................................................
You can see .....................................................................................
When Niek is about 8 years old .....................................................
The graph .........................................................................................
In the end Niek ...............................................................................  

4. Have students make vocabulary lists – dictionary
- Students make their own vocabulary list with new words for a certain chapter. For each word they write a definition or explanation, formulate a typical sentence/expression, write related terms and symbols (e.g. percent-percentage-%) give an example, make a drawing etc.
- Have students exchange their lists and give feedback.

5. Organize peer-review on written work (solutions, definitions etc.)

Have students write an explanation or solution and hand in their work. Redistribute these to students in class and have them comment on the quality of the written texts (peer feedback).
6. **Use games combined with collaborative learning**

These activities require students to talk about mathematical concepts.

**Games using cards, for example:**
- matching text & representations;
- matching daily language-mathematical language;
- classifying mathematical objects.

**Guessing games, for example:**
- Guess what? (Based on Guess who?). Instead of names/persons you use shapes, graphs, formulas or other mathematical objects.
- Describe a shape (2D or 3D) or a graph (using mathematical terms) without using its name.
- Pictionary with mathematical words: a student present clues in a drawing another student guesses.

7. **Evaluating statements and reasoning**

This form can be applied to any topic.

<table>
<thead>
<tr>
<th>Are these expressions always-sometimes-never true?</th>
</tr>
</thead>
<tbody>
<tr>
<td>( p \div 12 = s + 12 )</td>
</tr>
<tr>
<td>( 2t - 3 = 3 - 2t )</td>
</tr>
</tbody>
</table>

8. **Have student create problems**

- Ask students to create problems/questions fitting the topic of the lesson.
- Ask students to create variants of questions from textbook or tests.
- Ask students to write questions/problems that lead to a specific answer. For example: make three different equations for which is \( x = 3 \) is a solution; draw three different triangles that each have an area of \( 8 \text{ cm}^2 \); etc.
III. Connecting to practice

**Activity 3.2 Analyse a textbook and design a lesson**

Duration 60 mins

**Part 1 - analysing**

Select a paragraph from a mathematics textbook used in your (future) classes.

In pairs analyse this paragraph and identify language ‘problems’ your students may meet.

Guiding questions to use are:

- What types of language are being used? What are typical mathematical words and expressions? What about general academic language and daily language?
- Where do you expect problems to occur? Is this different for different types of students? Distinguish: native speakers and second language learners.
- Is attention paid to the meaning of words/concepts/expression? Are formulations clear? Are schemes, representations and visuals used, are they used in a clear way? If not: what problems do you foresee?
- Do the activities provide opportunities for language production (speaking and writing)?

Next think of ways to make the language more accessible to your students: what language goals can you formulate? How would you provide language support (scaffolding)? What tools or activities (see activity 3.1) can you use to make the lesson more language-sensitive?

**Part 2 – (re)designing**

Based on your analysis (re)design a lesson fitting the paragraph you analysed. You will:

- Formulate one or two content-related (mathematical) language goals for this lesson.
- Design one or two activities providing ‘language support’ to your students in reaching these goals (see activity 3.1).
- Justify your choices and decisions based on what you learned about language sensitive mathematics teaching.

Prepare a 1-2 minute pitch about your plans for the lesson/activity, to present at the end of this session. Be sure to address the way you support language development of your students.

Finish the design as homework, include goals, teaching materials and student materials. If possible, try it out in your class. After you used it in class fill out the evaluation form on worksheet 3.3.
### III. Connecting to practice

#### Activity 3.3: Sharing experiences and feedback

**Duration:** 30-60 minutes

Fill in the evaluation form below about your design and your teaching experiences. Prepare a presentation about these, reflecting on:

- What are your content-related mathematical language goals?
- What activities did you have students do? Why these?
- What was your role as a teacher?
- What are your experiences: successes and challenges?

<table>
<thead>
<tr>
<th>Name</th>
<th>School</th>
<th>Topic</th>
<th>grade</th>
</tr>
</thead>
</table>

Which activity did you (re)design? Give a brief description of resources, characteristics of the (language-related) goals, the student activities and the teaching method(s).

How does your activity /lesson contribute to the language development in connection to mathematical understanding? What tools did you include?

How and why do you think that your lesson/activity connects to your students’ language and mathematical abilities?

Experiences during the try out: what student behavior did you observe (different than normal)? How did your students react to the activities? What did you observe with respect to language development?
The relevance of language for mathematics education

Initial teacher education of prospective mathematics teachers
Overview
Structure of the module

Three sections:

I. Introduction into the topic – 2 activities (60 minutes)
II. Background and tools – 3 activities (90 minutes)
III. Connection to practice – 3 activities (120 minutes)

Homework optional between sessions
Overview

Introduction
- Activity 1.1: Types of language
- Activity 1.2: Student difficulties

Background and tools
- Activity 2.1: lecture on relevance of language in mathematics education
- Activity 2.2: analysing a textbook problem
- Activity 2.3: the role of the teacher: scaffolding language

Connecting to practice
- Activity 3.1: tools for supporting language
- Activity 3.2: analysing and redesigning a textbook lesson
- Activity 3.3: sharing experiences and feedback
Overview

• The distinction between 'everyday' language, general academic language and the specific language of mathematics;
• Some background and characteristics of language-sensitive mathematics teaching;
• The relevance of interaction, contexts and language-support for the learning of (the language of) mathematics;
• Tools to analyse teaching materials and classroom interactions (scaffolding);
• Tools and activities to support future teachers in designing language sensitive lessons and activities
Learning outcomes

• Understand difficulties student face with language in mathematics (especially multilingual students);
• Become aware of the role and relevance of language in mathematics education (everyday language, general school language and subject-specific language of mathematics);
• Develop knowledge about the approach of language-sensitive mathematics teaching and its tools;
• Analyze language in classroom materials and teaching practice;
• Learn to value the role of various representations and visualizations as a bridge for understanding and developing linguistic skills in mathematics education:
• Learn to know and use scaffolding strategies to support students in language-sensitive mathematics lessons;
• Design classroom activities that support students' language proficiency as well as their mathematical understanding.
Introduction into the topic: The relevance of language for mathematics education

Activity 1.1
Types of language
Study the wordcloud – it is on your worksheet as well
To do: also see worksheet

• Individually select about 5 words that are typical for mathematics.

• Share the words you selected and discuss the questions below:
  • Which of these words are also part of our daily language? How is the meaning different in mathematics compared to daily life? What is a typical expression (or sentence) using this word in daily language and what is a typical expression in mathematics.
  • What problems do you expect your students may have regarding this ‘shift of’ meaning? Is this different for students who are native speakers in your language and for students who are not?

• In the whole group share problems your small group identified.
Collected problems identified by small groups

• Make a list of the collected problem
Introduction into the topic: The relevance of language for mathematics education

Activity 1.2
Student difficulties – an example
Part 1: A mathematical problem – see worksheet

In a region there are 4 primary schools. The number of pupils in 1996 and 1997 for each school is presented in the table below.

<table>
<thead>
<tr>
<th>Number of students</th>
<th>School 1</th>
<th>School 2</th>
<th>School 3</th>
<th>School 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>In 1996</td>
<td>338</td>
<td>182</td>
<td>220</td>
<td>203</td>
</tr>
<tr>
<td>In 1997</td>
<td>237</td>
<td>160</td>
<td>270</td>
<td>227</td>
</tr>
</tbody>
</table>

For which school the increase in pupils is the highest?

Read and solve this problem individually.

Next discuss the following questions:
- What problems do you expect students (grade 6 or 7) to have when solving this problem? Are some of these problems language related?
- Explain why many pupils give ‘school 1’ as the answer.
Part 2: student work

Study the excerpt on the worksheet. It is a dialogue between a Student and a Teacher-researcher. The student has read the problem (about the schools) aloud, solved it and now explains what he did.

Source: The excerpt is part of Dutch research (van den Boer, 2003) into the problems second generation immigrant students (in multicultural schools) encounter in mathematics education and the factors that cause these problems.
Discussion

Discuss the following questions about the excerpt in your small group.

- How do you value the students’ language abilities in general?
- What strategies does the student use to overcome language difficulties?
- What do you notice about the student – teacher/researcher interaction?
- Do you have similar experiences? What would you do in such a situation?
- How would you provide language support for this student?
Background: language and mathematics education

Activity 2.1
Lecture on the relevance of language in mathematics education
Topics in this lecture (separate ppt)

• Why language is crucial for (mathematics) learning
• The distinction between daily language, general academic language (school language) and subject specific academic language and difficulties students may have with each
• Characteristics of the language of mathematics and the importance of subject-specific language objectives
• How teachers stimulate students to speak and write (language production) for the learning of mathematics
• Scaffolding language
• Tools to support language development
• Optional: discussion on statements, such as:
  • All teachers are language-teachers
  • Restricted talk becomes restricted learning (Barwell)
Homework

• Read an article on language-sensitive mathematics education (see list with references)

• Write a paragraph of about 300-500 words based on this article in which you make clear how you could make your own mathematics lessons more language-sensitive.
Background: language and mathematics education

Activity 2.2

Analysing a textbook problem
The washing-powder problem (see worksheet)

a. With every washing you use 1 measuring cup of washing-powder. How many washings can you do with 1 pack of washing-powder?

b. If the clothing is very dirty you need 1 ½ cup per wash. How many ml is that? And how many grams?

c. How often can you clean extra filthy laundry with 1 pack of washing-powder?
Types of language in the washing powder problem

- General academic language: measuring cup, about/roughly
- Mathematical language: 100 g., 150 ml., 4kg.
- Everyday language: washing powder, pack, extra dirty.
- Formulations: If the clothing is very dirty you need 1 ½ cup per washing.

Hoe snel is een pak wasmiddel op?

a Bij elke wasbeurt gebruik je 1 maatbeker waspoeder. Hoeveel wasbeurten kun je doen met 1 pak waspoeder?

b Als de was heel erg vies is, heb je 1 ½ maatbeker per keer nodig. Hoeveel ml is dat? En hoeveel gram?

c Hoe vaak kun je extra vuile was wassen met 1 pak waspoeder?
Potential difficulties of students

• The context:
  • the pack of washing powder
  • the measuring cup

• They do not know:
  • words: washing, laundry, per
  • the measuring cup
  • measurement units like g and ml
  • that the formulation ‘very dirty’ is the same as ‘extra filthy laundry’.

• They do not realise that they need the ‘4 kilo’ on the pack to answer the questions.
Background: language and mathematics education

Activity 2.3
The role of the teacher: scaffolding language
Seven scaffolding strategies

Table 1. Strategies for scaffolding language and examples for each strategy

<table>
<thead>
<tr>
<th></th>
<th>Reformulate pupils’ utterances (spoken or written) into more academic wording</th>
<th>[In response to the graph goes higher and higher up:] Indeed, the graph rises steeply. What do you mean by ‘it’?</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Ask pupils to be more precise in spoken language or to improve their spoken language</td>
<td>The graph descends slowly indeed. Into how many segments can we split the graph?</td>
</tr>
<tr>
<td>2</td>
<td>Repeat correct pupil utterances</td>
<td>For example, gesturing a horizontal axis when discussing this concept</td>
</tr>
<tr>
<td>3</td>
<td>Refer to features of the text type (interpretative description of a line graph)</td>
<td>Look, the word you are looking for is written down for you here.</td>
</tr>
<tr>
<td>4</td>
<td>Use gestures or drawings to support verbal reasoning</td>
<td>How can we rewrite this in more mathematical wording?</td>
</tr>
<tr>
<td>5</td>
<td>Remind pupils (by gesturing or verbally) to use a designed scaffold (i.e., word list or writing plan) as a supporting material</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Ask pupils how written text can be produced or improved</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Task (see worksheet)

• Individually: Read the two fragments of teacher-student interactions on the worksheet and ‘score’ the teachers utterances according to the scaffolding strategies from the table.

• In pairs: Compare and discuss your ‘scoring’ of the scaffolding strategies.

• Whole group: which of these strategies do you use?
Connecting to practice

Activity 3.1
Tools for supporting language
See worksheet for activity 3.1

- In small groups study the eight tools and activities that support language proficiency in mathematics lessons.
- Indicate how each tool contributes to the development of language proficiency and to the development of mathematical understanding. Try to generalize from the specific example to a more general use of the tool/activity.
- Formulate a subject-specific language goals can be addressed using each of these activities. Give examples.
- Discuss your findings.
Examples of mathematical language goals

List examples of goals from the group
Connecting to practice

Activity 3.2.
Analyzing and redesigning a textbook lesson
Part 1 – analysing a paragraph – see worksheet

• What types of language are being used? What are typical mathematical words and expressions? What about general academic language and daily language?

• Where do you expect problems to occur? Is this different for different types of students? Distinguish: native speakers and second language learners.

• Is attention paid to the meaning of words/concepts/expression?

• Are formulations clear? Are schemes, representations and visuals used, are they used in a clear way? If not: what problems do you foresee?

• Do the activities provide opportunities for language production (speaking and writing)?
Discussion

• Discuss your analysis with your peers.

• What ways did you come up with to make the language more accessible to your students:
  • what language goals did you formulate?
  • How would you provide language support?
  • What tools or activities can you use to make the lesson more language-sensitive?
Part 2 - (Re)designing a lesson

- Formulate one or two content-related (mathematical) language goals for this lesson.
- Design one or two activities providing ‘language support’ to the students in reaching these goals.
- Justify your choices and decisions based on what you learned about language sensitive mathematics teaching.
- Prepare a 1-2 minutes pitch about your plans/design.
Homework

- Finish the design (goals, teaching activities, materials) and try the lesson in class (if possible)
- Fill in the evaluation form on worksheet 3.3
- Prepare to share/present your design and teaching experiences reflecting on:
  - Your content-related mathematical language goals.
  - The activities you had students do. Why these?
  - Your role as a teacher.
  - Your experiences: successes and challenges.
Connecting to practice

Activity 3.3.
Sharing experiences and feedback
Presentations

• Briefly present your lesson-design and your experiences using it in class reflecting on:
  • Your content-related mathematical language goals.
  • The activities you had students do. Why these?
  • Your role as a teacher.
  • Your experiences: successes and challenges.
This presentation is based on the work within the project Intercultural learning in mathematics and science initial teacher education (IncluSMe). Coordination: Prof. Dr. Katja Maaß, International Centre for STEM Education (ICSE) at the University of Education Freiburg, Germany. Partners: University of Nicosia, Cyprus; University of Hradec Králové, Czech Republic; University of Jaen, Spain; National and Kapodistrian University of Athens, Greece; Vilnius University, Lithuania; University of Malta, Malta; Utrecht University, Netherlands; Norwegian University of Science and Technology, Norway; Jönköping University, Sweden; Constantine the Philosopher University, Slovakia.

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Background: language and mathematics education

Activity 2.1
Lecture on the relevance of language in mathematics education

With special thanks to Dolly van Eerde, expert in language-sensitive teaching, Utrecht University
Overview

• Features of the language of mathematics
• Types of language in mathematics education
• Difficulties of (second language) learners
• Development of academic language
Functions of language

Two functions:

- Social function: communication and learning together
- Individual function: thinking

Discussion, interaction and argumentation are the basis for reasoning and reflection.

(Vygotskij, 1986)
Features of the language of mathematics

• Every school subject has its own language.

• The language of mathematics is different from the language of other school subjects.

• Mathematical language has specific features
Multi-semiotic nature

\[ a^2 - b^2 = (a + b)(a - b) \]

| scheppen zand | 6 | 30 | 3 | 45 |
| scheppen compost | 10 | 50 | 5 | 75 |
Multi-semiotic nature of mathematics

- Language: question e. What percentage of the Italian working population under 25 is unemployed?
- Mathematical symbols: 11 %, 0, 10, 20 etc.
- Visual representations: bar graph

1. Lees de tabel.

<table>
<thead>
<tr>
<th>Werkloosheid in Europa (in 2000)</th>
<th>% van de beroepsbevolking</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>totaal</td>
</tr>
<tr>
<td>%</td>
<td></td>
</tr>
<tr>
<td>70</td>
<td></td>
</tr>
<tr>
<td>60</td>
<td></td>
</tr>
<tr>
<td>50</td>
<td></td>
</tr>
<tr>
<td>40</td>
<td></td>
</tr>
<tr>
<td>30</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

- a. In welk land is de werkloosheid het laagst?
- b. Hoeveel procent van de beroepsbevolking is in Frankrijk werkloos?
- c. In welk land is ongeveer 11% van de beroepsbevolking werkloos?
- d. In welke groep van de beroepsbevolking zijn in alle landen de meeste werklozen?
- e. Hoeveel procent van de Italiaanse beroepsbevolking onder de 25 jaar is werkloos?
Dense noun phrases

• A prime number is a number that can be divided by one and by itself.
• Percentages can be expressed in fractions.
• The sum of the angles of a triangle is 180º.
• These expressions are interpersonally alienating
Logical relations

• If you double one term you have to half the other one (multiplication).

• One of four, one out of four, one in four, 7 is to 14 as 8 is to 16 (proportions).

• The graph is rising that means that the amount of cyclists increases (graphs).
Words with a specific mathematical meaning

Some words have another meaning in mathematics than in other school subjects and in daily life

• Root
• Function
• Relation
• To solve
• Odd
Words with different meanings in different domains

**Function**

- **Mathematics**
  - The relationship between an independent and a dependent variable

- **Biology**
  - What purpose does it serve? (f.e. the function of the kidneys)

- **Daily life**
  - For what kind of function did he apply?
Overview features of mathematical language

• Multi-semiotic nature: natural language, mathematical symbols, visual representations (graphs, charts, diagramms)
• Specific academic vocabulary
• Dense noun phrases
• Expresses logical relations
• Some words have another meaning in mathematics than in other school subjects and in daily life (based on Schleppegrell, 2007)
Types of language in mathematics

• General academic language
  • increase, relation, gradually, pattern, process

• Subject specific language (mathematical language)
  • Percentage, millimeter, proportion, axis, angle, cube, function

• Everyday language
  • passengers, ingredients, parquet
Difficulties of (second language) learners

• Solution of some teachers: Decrease the language in mathematics
• “Simplification or avoidance of specialised language may be seen as a positive strategy to enable learners to access mathematical ideas, but without such specialised language, they are denied access to the forms of mathematical knowledge that are most highly valued.”

Morgan (2007)
Math in multilingual mathematics classes

Some results of former studies:

• Teachers are not aware of the nature of students’ language problems and underestimate the problems (Van den Boer, 2003).

• Students have difficulties in understanding math textbooks and in expressing themselves in the math class (Prenger, 2005).

• Teachers do not use a lot of academic language and do not support their students to develop this language (Van Eerde & Hajer, 2009).

• Teachers can learn to support students’ to develop both their linguistic and mathematical skills and understanding. (Smit, 2013).
THIS GUY CAN'T READ!

THIS GUY CAN'T COUNT!
Academic language

• Academic language is the language used in school to learn, speak and write about academic subjects.

• It provides access to specialised forms of reasoning that are needed to optimally participate in particular school subjects. (Gibbons, 2009).

• It is not only a question of learning new words but also of learning new styles of meaning and modes of argumentation. (Schleppegrell, 2010).
Development of academic language

L1 students can build on the foundations of their first language to develop the academic registers associated with academic learning.

L2 students cannot build on their first language to develop the academic registers and hardly develop academic language as a by-product of classroom discourse.
Why do students need to learn language at school?

- They need language to understand:
  - Written language (methods, assessments)
  - Oral language (what the teacher and other pupils say)
- They need language to talk and write
  - Talk: to participate in the math classroom
  - Write: to make notations (on the thinking).
Attention for language development

• If we want students to have access to learning mathematics they need to the required language.

• All pupils should have access to the language of mathematics in order to learn mathematics.

• Second language learners need extra support
Students' difficulties with language

• understanding written language
• understanding oral language of the teacher
• speaking in the mathematics lesson
• writing in the mathematics lesson
Understanding written language

Wheat, grown by the farmer and manufactured in the factory, is processed to flour.

100 kg wheat → 75 kg flour → 100 loafs of bread

• How many kg of flour is needed for 60 loafs of bread? Write down your calculation.

What language might be difficult?

• Specific academic language: the notation with arrows
• General academic language: processed, grown, wheat
• Daily language: flour (in Dutch flower, having two meanings), loaf
Understanding oral language of the teacher

Do students understand the following spoken language by the teacher?

• How often does 18 go into 1782?
• 7 is to 14 as 8 is to 16.
• Make the numbers twice as small and check your answer.
• Copy the table and add the missing data.
Speaking in the math lesson

T: How did you calculate 24-16?
S: I take 24 away. That 6 from the 4 is 2. Then take away from 10, is 8.

T: How do you calculate 25%?
S: I take the first of half. Then again. Then a quarter, is the answer.

T: Describe the course of the graph.
S: The graph first goes straight there, it goes down and then up.
Writing in the math lesson

Make a sentence with the word gradual

• ‘The temperature in The Netherlands is gradual’.
• ‘If two lines are at the same height you call them gradual’.
• ‘If a graph does not rise nor descend but stays at the same height we say it is gradual’.
• ‘I go gradually to the library’.
• ‘80 out of 100 is gradually 100%’.
Development of academic language: Integrating language in math education

Necessary is promoting a change from informal oral language to more formal language. (Gibbons, 2002)

f.e. The line goes straight → the graph remains constant

Informal: Basic Interpersonal Communication Skills (BICS)
Bridging between BICS and CALP

Daily language
BICS

Academic language
(CALP)
“If it comes to language – an important but not the only aspect of school and life – one would call the combination of the subjects mathematics – mother tongue ideal for future teachers”

H. Freudenthal (1984)
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