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Appendices part I

Appendix 1 Fifteen signals of use of theory by student teachers

The tool

Each of the next fifteen signals of use of theory has been coupled with an example. The examples can be considered as representative cases of a theory, with references to sources of the theory cited.

1. While observing practical situations, student teachers can refer to the theory that comes to mind.
   Example: student teacher points to a teacher who interprets the product of 2 x 5 and, in doing so, employs the rectangle model (Treffers & De Moor, 1990, p. 75).
2. Theory is used to explain (as a means to understand) what occurred in the practical situation observed.
   Example: student teacher explains the method employed by the pupil who is using base ten material as a working model (Gravemeijer, 1994, p. 57).
3. The student reflects the intention of the teacher or pupil(s) with the help of theory.
   Example: student teacher points out the 'mirroring technique' applied by the teacher to help the pupil (Van Eerde, 1996, p. 143).
4. The student teacher substantiates an idea arising from observing a practical situation.
   Example: student teacher explains the process used by the teacher concerning the transition from context to model, based on an idea about the teacher's opinion of contexts (Treffers et. al., 1989, p. 16).
5. The theory generates new practical questions.
   Example: student teacher wonders at which level (stage) of learning multiplication the pupils are (Goffree, 1994, p. 280).
6. Theory generates new questions about the student teachers' individual notions, ideas and opinions.
   Example: in referring to the theory of the next zone of development, the student teacher wonders whether she is approaching her pupils (during fieldwork) at the appropriate level (Verschaffel, 1995, p. 154; Van Hiele, 1973, p. 101).
7. The student teacher can theoretically underscore his personal beliefs about an actual practice situation.
   Example: student teacher explains her opinion about a positive working environment that according to her is created by the teacher and based on classroom environment theory (Marx, De Vries, Veenman & Sleegers, 1995, p. 62; Lampert & Loewenberg Ball, 1998, p. 123).

8. The student teacher estimates the practical knowledge of the teacher and identifies its theoretical elements.
   Example: student teacher describes the practical knowledge (of process shortening) that, according to him, motivates the teacher to employ certain actions (Gravemeijer, 1994, p. 58).
9. The student teacher reaches certain conclusions from his observations based on theoretical considerations.
   Example: student teacher reaches the conclusion that group work and beginning with repeated counting better fit the foreknowledge and experience of the children (Simons, 1999, p. 579; Van den Heuvel-Panhuizen et al., 1998, p. 60).
10. Making connections between practical situations in MILE and own fieldwork experiences with the help of theory.
    Example: student teacher establishes similarities between approaching a pupil in MILE and a pupil in his/her own practical training group (Goffree, 1994, p. 211).
11. (Re)considering points of view and actions on the basis of theory.
    Example: student teacher revises her opinion about a pupil’s approach to multiplication, basing it on a fellow student's reflections on the theory behind the strategy employed (Nelissen, 1987; Van den Heuvel-Panhuizen et al., 2000, p. 47).
12. Constructive analysis (= adapting given teaching material) that is underpinned with theory.
    Example: student teacher adjusts a given course by incorporating contexts that provoke ‘didactic conflicts’ (Van den Brink, 1989, p. 203).
13. The student teacher shows his appreciation of theory.
    Example: student teacher expresses her appreciation of theory when she is able to explain the solution strategy employed by a pupil (Lampert & Loewenberg Ball, 1998, p. 70).
14. Realizing the usefulness of theory as a tool for reflecting on actual practice (‘reflection on action’).
    Example: in a logbook, student teacher describes his modified views on theory in favour of RME (Schön, 1983, p. 278; Korthagen, 1993; Verloop, 1995, p. 137).
15. Developing a personal theory to underpin his interpretation (creation) of a practical situation.
    Example: student teacher develops his/her own theory about open and closed questions (Boekaerts & Simons 1993, p. 208; Von Glasersfeld, 1995, p. 192).

Appendix 2A The development and try-out of the 'Concept list' (short version)

The detailed development and background of the list of concepts has been described in an extended Dutch version (appendix 2B) on the added CD-rom.

In both the small scale and large scale studies a 'Concept list' (see model next page) has been filled in by the students at both the start and the end of the course. There are small differences between the initial and final lists. Section 2.2 of the appendix 2B describes the development of the idea that launched the design of the list of concepts, with an initial description of its functions. The development of the first design is sketched, with an example of the first version (section 2.3). This first version has been tried out with four groups of second year students with a total of 63 students. The yield of that trial is described in detail in section 2.4.

The final two sections of appendix 2B describe the changes in function and content of the list of concepts for both the small scale study (section 2.5) and the large scale study (section 2.6).

This is followed by – a part of – the final version of the final list of concepts used in the final assessment of the large scale study, after which a quotation from the teacher educators' manual is given, containing the guideline for the introduction of the list of concepts at the start of the course.

Model of the 'Concept list' in the final assessment of the large scale study

Name student:
Class:
Name Pabo:

The concepts given below are key concepts from the teaching method of learning to multiply. You have already filled in the list at the start of the course to indicate which concepts did or did not have a meaning for you and for which concepts you believed you knew a teaching narrative. Now, at the end of the course, the question is to indicate which concepts have become better known to you as a result of the course, and have gained enough meaning that you can relate a teaching situation or a teaching narrative which will explain – to others as well – these concepts.
Use the list you filled in at the start of the course as a comparison.
In the list below, check off the concept if the answer is 'yes,' if not leave that line blank. Circle one of the four categories in the third column. Do not work too fast and be conscientious; this is not a test, but a determination of where you stand.

Concept	**This concept has become <u>more familiar</u> for me. I can relate a teaching narrative in which this concept has meaning/becomes clear.** **Check the line below for yes, or leave it blank**	**The narrative is from:** **1=own teaching practice** **2=The Guide** **3=magazine/book** **4=instructions/ discussions at Pabo** **Circle (possibly more categories for each concept)**	**Explanation (optional)**
1. adaptive teaching		1 2 3 4	
2. anchor points		1 2 3 4	
3. automation		1 2 3 4	
4. ...		1 2 3 4	
...		1 2 3 4	
57. visualizing		1 2 3 4	
58. working memory		1 2 3 4	
59. rich problems		1 2 3 4	

Procedure for using the 'concept list'

The following procedure has been discussed during the teacher educators' training day.

The list of concepts:

- Hand out the initial questionnaires and let the student teachers read the text from appendix 1 (p. 33 of the manual). Then read the following text to them: "*This is a self-assessment, intended to gain a first impression of the topic of the course, how much you already know and what you can still learn. For me (as a teacher and researcher) it gives an insight into your starting situation so that I can take it into account in discussions and supervizing.*" It must be especially clear to the students that this is a self-assessment; by pretending to know more than you actually do or by filling it in inaccurately you are putting yourself at a disadvantage.
- Experience has taught that the concept 'teaching narrative' requires a clear explanation. Give the following example of a teaching narrative for the concept 'starting error' (which is not part of this list). "*Tom is 6 years old and is in grade 3. In his arithmetic notebook he has the problem 5 + 3 = 7. The teacher ask him how he knows that 5 plus 3 is 7. 'I use my fingers,' Tom says and he counts on his fingers 'five, six, seven.' Tom makes a starting error, he should have started with 6, not with 5.*" Remind the students again that they must consider well before placing checkmarks or encircling a choice.
- Go through the headers of the list one more time with the students. It may happen that a student does know what a concept means, but has no teaching narrative for it. Also, more than one category can be circled in the final column for each concept.
- Have the students complete the list and hand it in, make copies (the originals are for the researcher) and give the students back a copy; they can use it to make notes during the course if they like.

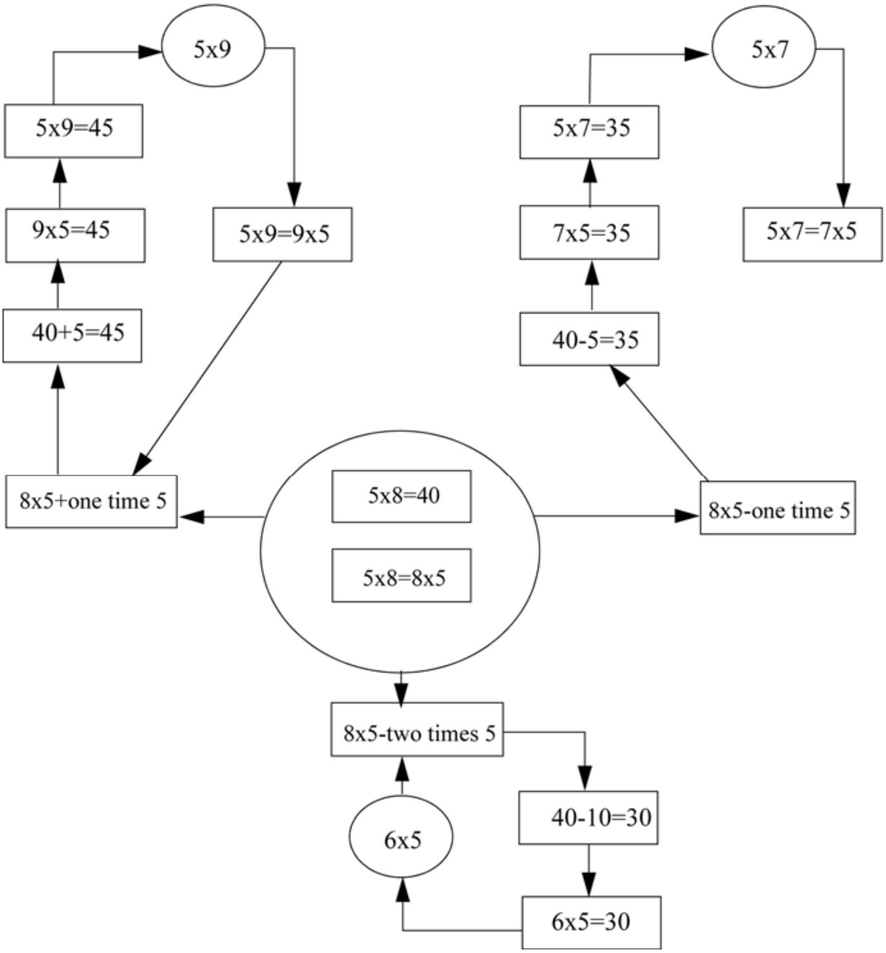
(Quotation from the teacher educators' manual, page 15; see also appendix 22 on CD-rom)

Appendix 3A Try-out of 'The Theorem' (short version)

The detailed development and background of this try-out has been described in an extended Dutch version of this appendix on the added CD-rom (see appendix 3B).
To prepare for the small and large scale studies the activity 'The Theorem' has been tried out with 63 second year students, in the same series of meetings as the try-out with the lists of concepts.
The goal for the student teachers was to gain 'theory-enriched practical knowledge' on the subject of multiplication. 'Designing, defending and refuting a theorem' teaches to defend one's opinions and allows the active acquisition of knowledge (Loughran, 2002).
The goal for the researcher was to find out which variant of that activity – having the students formulate their own theorems or having the teacher educator present a 'ready-made' theorem – would lead to the best result in terms of use of theory.
Appended is a description of the students' assignment, titled 'Designing, defending and refuting a theorem' included in the extended version of this appendix along with the yield of and conclusion drawn from the try-out (appendix 3B, section 3.3).

Appendix 4 Cognitive network of student, constructed by Anne

From Anne's research report: student's times-table network for 5x8



My [= Anne's; w.o.] interpretation.
This part of the times-table network is a bit more complicated than the previous part. You can see that 5 x 8 = 8 x 5 = 40 is the centre that Donna takes as her starting point for these three problems. Again, Donna starts with the reversing strategy and then uses the anchor point 5 x 8 = 8 x 5 = 40. When she finds out that she is dealing with a problem from the five-times table, she knows she can use 8 x 5 = 40. The next steps she takes are jumps of five. Ahead or back on the number line. Or put differently: she uses the strategy 'one time 5 more or less' or even 'two times 5 more or less.' She herself [Donna; w.o.] calls them jumps.

Appendix 5 Two of Anne's teaching narratives for theoretical concepts

If I know that one, I also know the other one

Teaching narrative for the concept 'anchor point'

Today, grade 2 is introduced to a new table, the eight-times table. The teacher wants to use cars with trailers as the context. A car with a trailer has eight wheels. This can be seen clearly in the visual material. De question is how many tires the garage needs for a certain number of cars and trailers. The teacher wants the children to find a solution for the multiplications they do not yet know with the aid of the multiplications they do know.

After the break the children enter the classroom. On their desk is a tray with all kinds of cars with trailers. On the teacher's desk there is also a toy car with trailer. The teacher starts telling a story about a garage where they have to replace all the tires on this car. He asks the children how many new tires the mechanic will need. The teacher asks both for the answers and for the approach the children took. After that, he discusses which times problems are suitable; 2 x 4, 4 x 2, 1 x 8.

Now the teacher tells them which table they will look at. He has written the eight-times table on the blackboard without the answers. Now he asks the children which answers they know already. They know 1 x 8. 2 x 8 is simple as well; 8 + 8. Mark knows another problem; 5 x 8, because he already knows the five-times table very well. "You just reverse it," he tells the teacher, "it becomes 8 x 5 and that is 40."

After all the problems the children know have been filled in, there are a few left. They do not know 6 x 8 and 9 x 8. The teacher says the children should be able to find the answers. "Try to look at the problems you do know. Then you can also do these." The children get to work. Lisa tells what she did: "I know 10 x 8, then 9 x 8 is a jump of 8 back. That is 80 - 8. 8 + 2 = 10 so 72." Esther can calculate 6 x 8. "We already knew 5 x 8 together. That is 40, 40 + 8 is 48." Together they have completed the eight-times table, and they now continue working on several different assignments.

I do it like this… and I do it differently

Teaching narrative for the concept 'strategy'

The teacher is sitting at the instruction table together with a group of four children. The others are working independently on a task. The teacher wants to get an impression of how the children solve a multiplication. This has been looked at with the whole group before, but she is curious which strategies the children use by themselves. She uses the six-times table for this; this table has not yet been treated in class. The 1, 2, 3, 4, 5 and 10 times tables have. She uses the context of six large biscuits in a box. She asks a number of different questions of the children, like “How many biscuits do I have if I buy four boxes?” The children can work out the answer on their own. Afterwards they explain how they did it. Chris says: “1 box is 6 and then another box is 6 + 6 is 12. Four boxes is 12 + 12 = 24.” Hanneke starts: “1 box is 6, plus 6 is 12, plus 12 is 18, plus 6 is… 18 + 2 is 20, 20 plus 4 is 24.” “Hey,” says Chris, “I do it like this…” to which Hanneke replies proudly “… and I do it differently.” “Did you use another way, Henk and Marjolein?” the teacher asks. “Marjolein, how did you do it?” “Like Hanneke, jumps of six.” “And you, Henk?” Henk says he just knew in his head with the problems. The teacher helps him by asking what his first step was. “First I knew that the boxes is twelve. Then I knew 4 boxes is 4 x 6. The reverse problem is 6 x 4 and I already knew that. It is 24.”

After the discussion the teacher lists the strategies the children have used for herself. Chris doubled 2 x 6, Hanneke and Marjolein started with 1 x 6 and took jumps of 6 to get to 4 x 6 and Henk used the reverse rule. Henk turned the problem 4 x 6 into the problem 6 x 4 from the four-times table which he already knew well. So the children use doubling, shortened counting and reversing.

Appendix 6 Anne's reflective note for 'the suitcase full of balls'

The children are given the arithmetic problem of the week. This is clearly linked to current events. The children are offered a realistic situation; a suitcase which is filled with balls and a letter from Saint Nicholas. This fits into realistic mathematics education really well. It assumes that by having the children work within realistic situation they will understand and apply problems better.

A larger degree of involvements is evoked, which stimulates the learning process. It is clear from the sound level that the children join in enthusiastically. The teacher plays into this well by looking what is inside the suitcase. She devotes a lot of attention and time to the introduction of the problem, so that it leaves a lasting impression. By referring back to the instruction in the letter to use the balls for arithmetic, the teacher uses a good bridge to get to the real work.

She creates the problem through having to guess and not count one by one. How do you know how many balls there are exactly. She does not let the children give their own solutions. It is very good to actually do this, but there is a risk of missing the target (the five-times table). The tubes that are shown give the solution for the problem in a very natural way, as there is a boy who immediately mentions the problems in the table.

Here she leaves the children more freedom to solve the problem. One child counts 10, 20, 30, 40, 50. While the other counts with jumps of 5. By discussing these different ways with the whole group, the different strategies are shown. Here the strategy of shortened counting is applied in two different ways.

When all the balls have been placed in tubes on the edge of the blackboard, they count the number of tubes with the class. The children are counting the balls with jumps of five. The teacher stops them and repeats her question. I am glad to say she gets back to that later, but now she has to stick to her own step-by-step plan to get to the corresponding table problem. She wants to hear that problem first. You can see that the boy who answers is already familiar with the way of saying it. You can also say that it shows that he understands well what concrete situation goes with a table problem. He knows that 20x5 implies 20 groups, tubes of five.

Next, they count together in the way the class originally started [jumps of 5; w.o.]. You may ask if this is the right way. If you are working from the children's point of view, it would be good to first follow the children, the problem can be formulated after. The only thing is that the emphasis will be on shortened counting as an activity, rather than a strategy.

If you want to present shortened counting as a solution strategy for multiplication you will have to start with the times problem. You will then use shortened counting to solve it, counting with jumps of 5. Most likely this was her goal and she achieves it. You avoid the

children knowing the answer immediately, which gets the strategy across less well.
The context has been set up really well. Only she could have made the problem even bigger and livelier by making it a real problem. For example, Saint Nicholas wants to give a tennis ball to each child in the area. He wants to know how many tennis balls he has in his suitcase. He wants to know if he has enough. He needs 75. Does he have enough? Will he have any left? This gives the problem even more meaning.

Appendix 7 Characteristics concept map

Students	1=Anne	2	3	4	5	6	7	8
Number of concepts (max. 10)	10	10	9	8	8	10	7	7
Number of relations	9 implications	14 implications, 1 bi-impl.	7 implications	7 impl	9 impl, 2 bi-impl	5 impl	5 bi-impl	3 impl, 8 bi-impl.
Number of explanations	5	9	7	3	13	0	2	11
Other characteristics of ordering	Places all concepts in four successive, logical steps with the realistic method as a start and, cognitive network and memorising at the end. Underpins her order.	Successive ordered placement starting with structure ('Structure fits everywhere'); but also: 'everything goes under cognitive network' Sees anchor point and making concrete as examples of strategies.	Has made a circle with the realistic method and cognitive network at the centre. For 'context' she uses the 'brownies' as the take-off point for the circle.	Sees cognitive network as the core (calls it that too); all arrows start there.	Starts with the realistic method; Bi-impl cont-concr and struct-mental model. Does give meaning, but no logical structuring.	Starts with the realistic method, followed by 'structure' and 'context'. Followed by a 'loose' middle part. Finishes with network.	Group of three resp. four concepts: 'have to do with presenting problems' resp. 'have to do with the way children think'.	She gives meaning to concepts and the relations between them, but not in terms of placing them within a method.

Appendix 8 Key questions for the final interview

Lists of concepts
Which concepts did you find out more about?
What additional things did you learn? (example/story)
Are there concepts of which you think now that you were wrong at the beginning of the course to say that you either did or did not know them?

Final assessment: the suitcase full of balls
Where does this lesson fit into the method/learning trajectory for multiplication?
What would be your next step with/after this lesson, with these children?

Concept map
Can you explain the structure you used?
Can you give short examples for the 'if---then' arrows?
(if you do this as a teacher then...)
Which of these ten concepts do you think belong to the 'suitcase lesson'?

Numeracy test
How did you do? What did you think? Give some thought to that (evoke inquiry).

Evaluation
What did you find difficult in the course?
The questionnaire mentions the concept theory a few times. What do you think of when you hear the word theory? What do you think of theory?
Do you think there is theory in this course?
What do you think is an example of theory that should be part of learning to multiply?

Appendix 14 Descriptive statistics of questionnaire large scale study (*n* = 256)

	N	Min.	Max.	Mean	Std. deviation
1. I found this course difficult/simple	252	1	5	3,17	0,80
2. The course is not/very useful for my teaching practice	256	1	5	3,59	1,03
3. As a result of the course I know nothing/everything about learning to multiply	253	1	5	3,65	0,69
4. This course offered no/a lot of theory	254	1	5	3,59	0,82
5. I did not/did know the theory that was offered	249	1	5	2,80	0,83
6. After this course I do not/do have a better understanding of practice	256	1	5	4,02	0,81
7. The course is boring/challenging	256	1	5	3,31	1,10
8. The course is vague/concrete	251	1	5	3,47	1,09
9. The course is theoretical/practical	252	1	5	3,47	0,92
10. The course does not/does make you understand students' behaviour better	255	1	5	3,80	0,97
11. The course does not help/helps me to supervize the students in my practice class better	254	1	5	3,61	1,13
12. I can not see/see the point of theory after this course	254	1	5	3,84	0,82
13. This course does not/does make it clear that you need theory	251	1	5	3,95	0,82
14. Theory and practice are far apart/have been integrated	248	2	5	4,22	0,75
Valid N (listwise)	229				

Notes

[1] 'Constructive coaching' (Bakker et al., 2008) can be considered as a way of coaching that teaching strategies matches with learning strategies (Vermunt & Verloop, 1999), for example by using the principle of the zône of proximal development (Vygotskij, 1978).
[2] In the same publication, (e.g., 1991, p. 100) Freudenthal shows the relationship between theory and practice in mathematics education by intertwining observing, reflecting, mathematizing and didactizing (cf. Oonk, 2005).
[3] In his publication 'Didactical Phenomenology of Mathematical Structures,' Freudenthal (1983) lays a theoretical foundation for 'realistic teaching' of mathematics. In chapter 4, after a phenomenological reflection on number theories through history, he sketches the building blocks for a didactical phenomenology of numbers and operations with numbers. Characteristic is his view, that in teaching one should not so much try to find realizations that start from the number, but that one has to look for phenomena that necessitate the mental object 'number'. Number is a 'thinking thing' that, according to Freudenthal, students get a grip of through offering 'multiple embodiment' in various situations. In the 1970s this was a view that went against the dominant view of (isolated) development of concept.
[4] Wiskobas stands for 'Wiskunde op de basisschool' (mathematics in primary school). At the time (1971-1981) the Wiskobasteam had, as a part of the IOWO-team ('Institute for the development of mathematics education,' the precursor of the Freudenthal Institute), the task of developing and implementing mathematics education in primary school.
[5] The ideas of the followers of associative psychology were mechanistic and atomistic in their approach. According to them knowledge was caused by one or more sensory experiences. By repeating mental experience over time, sensory information formed connections, was the idea. The Brit John Locke with his 'Association of ideas' (1690) is seen as the founder of associationism.
[6] The Babylonians (ca. 3000 BC) have left clay tablets which among other things contained the tables of multiplication from 1 x 1 up to 59 x 59 from their positional, sexagesimal (base sixty) system. Egyptian writings (papyrus Rhind, ca. 2000 BC) show us multiplication tables that show they calculated partly by heart, particularly through handy doubling and halving; they did not just do this for whole numbers, but also for fractions and decimal numbers. Probably the natural development of multiplication, including the accompanying (mathematical) development of language – the so-called 'practical character' of multiplication – gave no cause to take up the development of a mathematical foundation for the numerical system. That foundation was in fact not laid until about two thousand years later, by Euclid (ca. 300 BC).
[7] Freudenthal says (1984a, p. 122): Multiplication is at first repeated addition, and this repeated addition can be structured very efficiently by pair collection within the rectangular model –

product within set theory, partly to calculate amounts as products. However, this model is insufficient. Not insufficient mathematically (...). But insufficient didactically, because a mathematically obvious restructuring does by no means have to occur within learning processes – either spontaneous or encouraged – and, if it does occur, does not have to be conscious enough to be made explicit and be available.

[8] That the criticism did exist, can be seen among others in publications from the wellknown Dutch pedagogue Ligthart (1859-1916) and from the researchers Brownell and Chazal (1935). Ligthart felt that the then-current approach to education – and not just of mathematics – had deteriorated to lifeless imitating, copying of reasoning and memorization. *'Learning through experience, learning by doing, learning with empathy,'* was Ligtharts' credo (De Jong, 1996, pp. 282-284). He stood for learning in a physical and mental interaction between child, environment and teacher, allowing the child to actively acquire the new material. The influence of American pedagogue and philosopher Dewey (1859-1952) can be recognized in these ideas. De Jong writes that Ligthart learned about Dewey's work in 1908 through the book 'Méthodes Americaines d'education générale et technique' by Belgian author Omer Buyse, and recognized his own ideas in Deweys work, sometimes in great detail. There was only one of Dewey's axioms he disagreed with: the recapitulation theory, according to which students would have to relive events from history to become interested in current culture. Ligthart did not believe in this idea. It was better for didactical reasons to take a starting point as close as possible to the environment of the child, rather than to go back two thousand years. Brownell and Chazal studied different ways of adding and subtracting. They concluded that 'drill activities' have little effect if not preceded by understanding of what has to be learned.

[9] Lankford, 1974; Erlwanger, 1975 and Codd, 1981.

[10] He supports the view of Lesh and Landau (1983) that the clinical interview gives a more complete view of the development of mathematical notions and processes in children and does not agree with some researchers who claim that children are on the whole unwilling to relate their thoughts (Ter Heege, 1986, p. 31).

[11] Among others, Ter Heege (1986) refers to the work of Ebbinghaus – with his influential publication 'Über das gedächtnis' from 1885, in which he gives much attention to the laws of association, Bartlett (1932), who makes a distinction between reconstruction and reproduction, and knowledge, and Van Parreren (1964), on among other things functional and maneuverable knowledge. Furthermore, he cites the researchers Brownell and Chazal, who conclude that 'drill activities' have little effect if not preceded by understanding, Thorntons (1978) on applying mental strategies on their own by children and Baroody (1985) in relation to the dynamic cognitive network.

[12] TAL means Tussendoelen Annex Leerlijnen (A Learning-Teaching Trajectory with

Intermediate Attainment Targets). The publication is the output of the TAL-project, initiated by the National Department of Education, Culture and Science. It has been executed by a group of thirteen experts of the Freudenthal Instituut in cooperation with the Netherlands Institute for Curriculum Development (SLO) and the National Centers for School Improvement (CED).

[13] According to Ter Heege (1986, p. 110), the division between reproduction and reconstruction comes from the psychologist Bartlett. Treffers & De Moor (1990, pp. 72, 87) refer to Baroody (1985, pp. 83-98) for that. Baroody uses these concepts when he discusses dynamic (knowledge) networks.

[14] In the TAL-brochure (Van den Heuvel-Panhuizen et al., 1998, p. 63) an example that gives off such a signal is included. It shows how the table of eight can be reconstructed and subsequently reproduced in a process of shortening and memorizing. An analogous example is given in De Proeve (Treffers & De Moor, 1990, p. 76) which in its turn is derived from the theory of Ter Heege (1985). Next the example from the TAL brochure (p. 63).

‘Table of eight’

1 x 8 to be known [weetje]

2 x 8 to be known (‘the double’ 8 + 8); or through switching (8 x 2)

3 x 8 through 2 x 8 + 8 (‘one time more’); or through switching (8 x 3)

4 x 8 double of 2 x 8, or 5 x 8 - 8 (‘one time less’); or through switching

5 x 8 half of 10 x 8 = 80; or through switching

6 x 8 through 5 x 8 (‘one time more’); or through switching; or doubling (3 x 8 + 3 x 8)

7 x 8 through 5 x 8 + 2 x 8, of 6 x 8 + 8 (‘one time more’)

8 x 8 various, will be a ‘known’ quickly

9 x 8 10 x 8 - 8 (‘one time less’); or through switching

10 x 8 ‘known’

12 x 8 an inquiry problem…

In many of the above cases, access through other tables is possible through the commutative property: 3 x 8 through 8 x 3 if that is already known; 4 x 8 through 8 x 4, and so on.

A signal regarding influences from earlier theories on learning and memory can be found in ‘De Proeve,’ in a reference to Van Parreren and to (via) Ter Heege’s work. The TAL brochure contains no references to these theories, only a general comment on the necessity to integrate the content component with cognitive, social and affective-emotional development (p. 75).

[15] We consider practice as a situation, (learning) environment or domain with materials, tools and actors in which professional actions occur, that is to say adequate action based on (practical) knowledge.

[16] Here the concept of paradigm is interpreted according to the views of Kuhn, namely the paradigm of a scientific community (Kuhn, 1970, a.o. p. 210). This to distinguish it from the

meaning Freudenthal gives it: the paradigm as a representative example of a phenomenon, a concept or a theory (Freudenthal, 1984b, p. 102; Goffree en Dolk, 1995, p. 114).

[17] Ter Heege talks in various terms about making the connection between practice and theory (among others in 1986, p. 5, 170). On page 5 he says: "There is a didactical gap [between theory and practice] that will be bridged with the development of learning materials for elementary multiplications."

[18] Much is being written and said about the complexity of learning and teaching mathematics. Lampert (2001) makes the concept of 'complexity' concrete and debatable.

[19] Boersma and Looy describe a practical theory as the knowledge that describes actions in specific practices and provides guidance for those actions (Boersma and Looy, 1997, p. 16). [Note that these researchers designate theory as knowledge].

[20] For example the environment Ter Heege created: a challenging, open discussion situation about multiplication with student Johan.

[21] Heard from A. Treffers at HKRWO (Historische Kring Reken- en Wiskundeonderwijs – Historical Circle Mathematics Educations) Symposium VIII, May 25, 2002 in Utrecht.

[22] Verschaffel uses the adjective 'powerful' in the meaning of 'efficient,' in the sense that a strong learning environment will lead to efficient acquisition of knowledge and skills.

[23] As from 06-06-2003 the MILE project (meanwhile in version 4) is executed under government of 'The association MILE2' (Den Hertog, 2006).

[24] Oonk, W. Verhalen van reken-wiskundeonderwijs in groep 4 [Telling stories about grade 2], This book functioned as a sourcebook for helping student teachers to find an appropriate research question.

[25] De Wereld in Getallen ['The World in Numbers,' one of the current Dutch teachers guides and textbooks].

[26] By the Dumb August approach the teacher pretends to be quasi-stupid in order to evoke interaction in Class.

[27] Some teachers use free of charge packing materials as egg boxes for grouping on base ten.

[28] During this so-called 'game of concepts' the students discussed, under the direction of the teacher educator, the question of whether there was a demonstrable connection between six given theoretical concepts (context, informal procedure, thinking model, anchorpoint, structure and strategy) and four practical situations. The game element was that each student attempted to defend his or her choice of a concept – written on a colored card – in the plenary session.

[29] The group work was partly stimulated by thinking of, formulating and discussing a 'theorem' based on joint observation of a practical situation. There is an assumption that such activities lead to 'ownership' of knowledge that is directly linked to one's own experience (Loughran, 2002; see also appendix 3AB).

[30] For instance: “Try to recall what you were thinking” and “Say ‘stop’ when you want to react.”
[31] This is a selection of ten from the 59 concepts that occurred in the course. The selection has been made by the researcher based on his assessment regarding an optimal data yield (selection criteria: theoretical ‘load’ of the concepts, coherence and use in the meetings).
[32] Anne is a fictive name.
[33] The reckon reck is a variation on the traditional abacus and is used in realistic mathematics education (Heuvel-Panhuizen, van den (red.), 2001).
[34] In the zero-version, there were five categories, but upon consideration ‘prediction’ was included with response.
[35] As well as his own interpretation of Van Hiele’s (1973) division in levels for thinking respectively reasoning in mathematics, Freudenthal also formulated levels in use of language, with someone’s choice of language being an expression of that person’s level of thinking. An example of the latter is the indication at different levels of the location of a thing or a person by describing the location (active, demonstrative use of language), by using concepts of orientation such as left, right, front, back (active or fact-establishing relative use of language), or by using coordinates (fact-establishing, functional use of language) (see also Van Dormolen 1982, p. 148).
[36] This comparison is based on data from the CBS [Central Statistics Bureau] and the Ministry of Education (OCW).
[37] Drs. K. Olofsen, co-author of the publication ‘*Gecijferdheid’* (Faes et al., 1992); the other judge was drs. K. Tjon Soei Sjoe.
[38] This concerns the reflective note for the final assessment. For the initial assessment the description for a situation was considered as a meaningful unit.
[39] For instance, words such as ‘furthermore’ or ‘also’ are often indications that a sentence should be added to a preceding sentence or paragraph.
[40] Indicator words are usually marks (connecting words, lexical signals) of coherent relations in a text (Pander Maat, 2002); they may give an indication for the type of description being used. It depends on the meaning within the given context whether such a word actually gives an indication and to what degree it does so.
[41] Reflective, contemplative descriptions by the students are often accompanied by a rise in level for the use of theory.
[42] A statement that is seen as unlikely is a statement by a student about a practical situation that is judged to be almost impossible by the expert who judges it, such as a student stating that the teacher ‘apparently feels that the number line is not useful for what is being taught in this lesson,’ while there is no indication that the teacher holds this opinion.
[43] Dr. R. Keijzer and the researcher.
[44] The score list (appendix 16) contains general pedagogical and pedagogical content concepts.

Students also often use certain concepts more than once in their reflection. For that reason a distinction has been made between the total number of general pedagogical and pedagogical content concepts and the number of *different* general pedagogical and pedagogical content concepts. The general total has also been determined for both groups.

[45] From our experiences with the student teachers in the small scale study, we know that 'characteristic dominance' of theory use in relation to one of the four categories exists.

[46] In general, over the last years many mathematics teacher educators in the Netherlands are concerned about – probably related – phenomena such as workload, the decreasing amount of contact time and the decreasing attention to mathematics education in the curricula of their teacher training college (Keijzer & Van Os, 2002).

Curriculum vitae

Wil Oonk (1940) ging na zijn voltooiing van de HBS-B opleiding in 1957 naar de Kweekschool voor Onderwijzers en behaalde daar in 1959 en 1960 de akten voor onderwijzer, respectievelijk volledig bevoegd onderwijzer. Na de vervulling van zijn militaire dienstplicht in 1962, ging hij werken in het lager onderwijs in Enschede en Muiderberg en was leraar wiskunde aan het Woltjer Gymnasium te Amsterdam. In avondstudie behaalde hij de akten Wiskunde MO-A en MO-B.

Zijn betrokkenheid bij de nieuwe ontwikkelingen in het reken-wiskundeonderwijs voor de basisschool leidde in 1971 tot zijn benoeming als docent aan de reguliere en Montessori dag- en avondopleiding van de Gemeentelijke Pedagogische Academie te Amsterdam, voorganger van de tegenwoordige Pabo van de Hogeschool van Amsterdam. Hij werkte daar als opleider, als leidinggevende van de vakgroep wiskunde & didactiek en als cursusleider van de part-time lerarenopleiding Wiskunde L.O. In die hoedanigheden was hij lid van diverse landelijke ontwikkel- en adviesgroepen en examencommissies, onder andere de ontwikkelgroep lerarenopleidingen (OGLO), de veldadviescommissie Wiskunde & Informatica (VALO) van de SLO en de staatsexamencommissie Wiskunde L.O. Ook werkte hij mee aan de ontwikkeling van het standaardwerk 'De Proeve' voor de opleiding rekenen-wiskunde & didactiek op de Pabo. Verder gaf hij mede leiding aan de ontwikkeling en uitvoering van studiedagen voor pabodocenten wiskunde & didactiek en was betrokken bij internationale projecten.

Van 1996 tot 2001 was hij als lid van het landelijk kernteam MILE gedetacheerd bij het Freudenthal Instituut, waar hij na zijn pensionering is blijven werken als gast-onderzoeker.

In het najaar van 2003 verbleef hij op uitnodiging van de School of Education (Universiteit van Michigan) gedurende vier maanden in Ann Arbor. Hij werkte daar als opleider en participeerde in het ontwikkel- en onderzoeksteam van Deborah Ball.

Wil Oonk is auteur van publicaties op het gebied van rekenen-wiskunde & didactiek.

Tegenwoordig geeft hij mede leiding aan de landelijke 'Kerngroep Opleiders' voor dit vakgebied en aan een project voor de vernieuwing van het reken-wiskundeonderwijs in Suriname. Verder is hij redactielid van het 'Tijdschrift voor nascholing en onderzoek van het reken-wiskundeonderwijs' en eindredacteur van een uitgave i.o. voor rekenen-wiskunde & didactiek op de Pabo.

Dankwoord

Een eerste woord van dank verdient eigenlijk de pedagoog en filosoof Dewey (1859-1952). Zijn werk koos ik in 1960 als onderwerp van mijn examenwerkstuk voor de ‘akte volledig bevoegd onderwijzer’, gefascineerd als ik was door zijn vooruitstrevende ideeën over het bij elkaar brengen van theorie en praktijk in het onderwijs.

Enkele decennia later had ik het voorrecht kennis te mogen maken met het op integratie van theorie en praktijk gerichte curriculum van de School of Education van de universiteit van Michigan. In het bijzonder inspireerde het werk van de hoogleraren Magdalene Lampert en Deborah Ball mijn collega’s en mij tot het ontwikkelen van MILE voor de Pabo’s in Nederland. Die bron van inspiratie werkte nog in een ander opzicht door. Op één van de studiereizen naar Ann Arbor ontstond het idee voor dit onderzoek. Ik ben Magdalene en Deborah zeer erkentelijk voor hun gastvrijheid tijdens mijn bezoeken aan Ann Arbor en de collegiale en persoonlijke wijze waarop zij hun expertise met mij wilden delen.

In de eerste fase van mijn onderzoek was het Mileteam – met Maarten Dolk, Willem Faes, ons helaas veel te vroeg ontvallen, Fred Goffree, Han Hermsen en later Jaap den Hertog en Chris Rauws – een klankbord voor mijn ideevorming. Dat gold in het bijzonder voor Fred Goffree in zijn functie als begeleider van het onderzoek.

Het eerste exploratieve onderzoek heb ik uitgevoerd op de Pabo van de Hogeschool van Amsterdam, waar ik toen nog werkzaam was. Ondanks de inbreuk op het werkklimaat door allerlei fusieperikelen in die tijd, voelde ik me daar omringd door veel fijne collega’s. Zonder iemand tekort te willen doen, noem ik hier Ger de Haan als hun representant, de ‘Theo Thijssen’ onder hen.

In totaal hebben 398 studenten aan de vier verschillende onderzoeken deelgenomen. Bijzondere vertegenwoordigers van die groep zijn Dieneke Blikslager en Hayet de Bont, die als ware pioniers de spits hebben afgebeten.

Vanaf die eerste momenten tot en met het vierde en laatste onderzoek konden studenten profiteren van de expertise van de ‘Mile-leraren’ Minke Westveer en Willie van Ouwerkerk.

De studenten vormden de doelgroep van mijn onderzoek. Maar zonder de betrokkenheid en de belangeloze inzet van hun opleiders was het onderzoek niet mogelijk geweest. Zij moesten de onderzoeksbijeenkomsten inpassen in de bestaande programma’s en bovendien bracht het onderzoek veel extra werk met zich mee. Mijn dank gaat uit naar de volgende opleiders en hun Pabo’s, c.q. Hogescholen: Frits Barth (Stenden Hogeschool, Leeuwarden), Hanneke Beemer (Fontys Hogeschool, Eindhoven), Jos van den Bergh en Frans Van Mulken (Avans Hogeschool, Breda), Nico den Besten (Hogeschool Driestar Educatief, Gouda), Mat Bos en Mark Sanders (Hogeschool de Kempel, Helmond), Gert Gelderblom (Gereformeerde Hogeschool, Zwolle), Riny

Kollöffel (Hogeschool van Amsterdam), Ad Peijnenburg en Eric Ansems (Fontys Hogeschool, Den Bosch), Jan Haarsma (Chr. Hogeschool Windesheim, Zwolle), An te Selle (Stenden Hogeschool, Meppel), Jan Stapel (Hogeschool INHolland, Dordrecht), Belinda Terlouw (Katholieke Pabo Zwolle) en Marc van Zanten (Hogeschool Edith Stein, Hengelo).

Kenneth Tjon Soei Sjoe (Hogeschool van Amsterdam) liet van meet af aan zijn interesse voor mijn onderzoek blijken door het stellen van indringende vragen; die leidden vrijwel altijd tot interessante en vruchtbare discussies.

Annette Markusse en Nico Olofsen (IPabo Amsterdam en Alkmaar) hebben hun deskundigheid met volle overtuiging en enthousiasme ingezet voor de try-out en de uitvoering van het kleinschalige onderzoek; zelfs tot in 'de laatste uren' hebben ze mijn onderzoeksactiviteiten ondersteund, in professioneel en persoonlijk opzicht.

Met Ronald Keijzer (IPabo en Freudenthal Instituut) heb ik vele uren gediscussieerd over het analyse-instrument en ook in andere opzichten stond hij me bij. Ik heb veel profijt gehad van zijn inbreng en genoten van de samenwerking met hem.

Het bestuur en het managementteam van het Freudenthal Instituut ben ik zeer erkentelijk voor het feit dat zij mij na mijn pensionering de gastvrijheid schonken om door te gaan met het onderzoek. Al sinds 1971 heb ik een band met het Freudenthal Instituut, eerst vanuit 'het onderwijsveld', later als gedetacheerd werknemer en nu als gast-onderzoeker. Ook in deze werkomgeving ben ik bevoorrecht door de contacten met sympathieke collega's, creatieve mensen met passie voor de lerende mens en een schat aan expertise op het gebied van ontwikkelen en onderzoeken van wiskundeonderwijs. Die werksfeer wordt mede bepaald door de plezierige, dienstbare opstelling van het ondersteunend personeel. Wat de ondersteuning voor mijn onderzoek betreft, gaat mijn dank speciaal uit naar één van hen, Nathalie Kuijpers, voor haar gedegen aanpak van het vertaalwerk en de opmaak van mijn proefschrift.

In de afgelopen jaren was ik regelmatig te gast bij de ICLON-onderzoeksgroep in Leiden. Ik heb veel geleerd van de vaak stevige discussies in de sfeervolle groep van onderzoekers uit diverse disciplines. Een bijzonder woord van dank richt ik tot één van hen, Ben Smit, die me op vele momenten met raad en daad heeft bijgestaan.

Ik heb vanzelfsprekend veel te danken aan mijn promotoren. Koeno Gravemeijer stapte zonder aarzelen in de rijdende trein en inspireerde me met zijn 'theorie-geleide', vakinhoudelijke impulsen. Mijn eerste promotor, Nico Verloop, schonk me van meet af aan zijn vertrouwen. Zijn begeleiding had voor mij het karakter van wetenschappelijk in- en uitzoomen. Met zijn scherpe analyses en gedetailleerde annotaties stimuleerde hij me om te filteren en te focussen.

De begeleidingsgesprekken heb ik steeds ervaren als mijlpalen in mijn onderzoeksproces.

Een voortdurende, positieve respons op mijn werk was er vanuit de thuisbasis. Carla, Lars en Monique luisterden, dachten mee en discussieerden soms met me op het scherpst van de snede. De logeerpartijen van mijn kleinzoons Douwe en Job waren de mooiste onderbrekingen die ik me wensen kon.
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