PUTTING THEORY INTO PRACTICE

Growth of appreciating theory by student teachers

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Abstract

*This report presents the raw data from an ongoing study into the manner in which student teachers connect theory with actual practice. In this case, practice is primarily used to indicate the digitised teaching practices recorded in the **M**ultimedia **I**nteractive **L**earning **E**nvironment (MILE), a computer-based environment that provides an investigative representation of teaching in an actual classroom setting. A tool has been developed that incorporates 15 signals of expected theory implementation by student teachers. A prototype of the tool will be presented, as well as the considerations that underlie its design. The student teachers' independent group work and subsequent semi-structured interviews with some of the student teachers have been taped (audio recordings). Similarly, the teacher educator's lessons have been videoed. Furthermore, data has been obtained from the analysis of portfolio documents from the student teachers. A selection of raw empirical data is described on the basis of two observations.*

Theory and practice in primary school mathematics teacher training

Primary school teachers in the Netherlands are trained at a PABO (Primary School Teacher Training College), which offer four-year programmes at the higher professional education level. Educating primary school mathematics teachers essentially involves introducing (pedagogical) content knowledge and pedagogics to pre-service teachers, and providing them with the opportunity to conduct interrelated fieldwork in primary schools.

Since the 1970s, mathematics has played a leading role in both the developments in primary education and at PABO teacher training colleges.

In the 1970s and 1980s, a programme for training primary mathematics teachers was developed (Goffree, 1979, 1982, 1983, 1984). This programme was characterised by the attention it focused on the development of student teachers who are educated to acquire– as an integrated whole –the following abilities: solve problems at their own level, learn the didactics of mathematics education and practical teaching techniques (Goffree & Oonk, 1999).

From 1990 – 1995, a team of 10 mathematics teacher educators developed national standards for primary school mathematics teacher training. In 1995, they published their work in the form of a handbook for their fellow teacher educators. In this handbook, three pillars of teacher training are identified: construction, reflectivity and narrative knowing (Goffree & Dolk, 1995). In other words, student teachers are taught to acquire personal (practical) knowledge primarily through reflection on practical situations, which knowledge generally has a narrative character. The idea behind this is that student teachers can integrate the larger theoretical ideas with their practical knowledge by reflecting on (theory-heavy) practical situations. As such, MILE can be viewed as an extension of this new vision of teacher training education.

MILE

The goal of the Multimedia Interactive Learning Environment or MILE (Dolk, Faes, Goffree, Hermsen & Oonk, 1996) is to give student teachers a possibility to investigate teaching practice (primary school mathematics) in a specific way. The developers of MILE were inspired by the Michigan MATH project (Lampert & Ball, 1998). Seven theoretical orientations guided the development of MILE (Goffree & Oonk, 2001).

MILE is comprised of – currently 70 – recorded lessons, discussions with teachers, supervisors and other K 1 – 6 materials. From the archive, it is possible to study each lesson in its entirety or in short fragments. Key word searches of the fragment (clip) descriptions and lesson dialogue (transcripts) can be done using the search engine. Every fragment reproduces a teaching instance and, in MILE, is provided with a short description that provides further elucidation. MILE is intended as an extensive collection of situations, from which the student teachers can acquire practical knowledge (Elbaz, 1983; Verloop, 1991) as a narrative way of knowing (Gudmundsdottir, 1995). Theory can be integrated into practical knowledge by reflecting on ‘theory-heavy’ practical situations.

Experience has shown that student teachers are often not only focused on the actual teaching of mathematics when watching the fragments, but also on general didactic and educational issues. MILE thus offers the possibility to use the school subject mathematics as an arena for theoretical reflections that connect with larger pedagogical ideas.

Research subject

The research, about which is reported in this paper, attempts to answer the question: How do prospective teachers make connections between theory and actual practice when a digital representation of actual practice (MILE) is made available to them?

Considerations in the design of the research tool

How can one demonstrate that theory plays a role in the student teachers' study of practical situations? Schön (1983) has demonstrated that ‘theory in action’ is primarily implicit in nature. Only the astute observer (expert) is in a position to notice signals from suchlike theory in action. We decided to generate a list of possible signals to support our observations of student teachers at work. The signals were developed on the basis of theoretical orientation and discussion, which incorporate

the individual practical knowledge (and wisdom) of the researcher and the results from an explorative study conducted earlier (Oonk, 1999).
The tool assumed a background role during the research and evolved from a scoring list to a frame of reference. After several observations, the tool proved to be too extensive as a scoring list. The idea to use the tool to analyse the data collected came about after it had been used to only indicate the direction observations were to follow. The tool, however, appeared far too crude for this purpose and further refinements are necessary.

The tool
This prototype is a refined version of the first. Each signal is coupled with an example (paradigm of a theory in action) 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 MAB (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 as a means to the pupil reflect his own actions (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 (phase) 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 zône of development, the student teacher wonders whether she is approaching her pupils (during fieldwork) at the appropriate level (Lowyck & Verloop, 1995, p. 154; Van Hiele, 1973, p. 101).
7. The student teacher can theoretically underscore her 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 (Lowyck & Verloop, 1995, p. 62 Lampert & 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. 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 (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 & Ball, 1998, p. 70).
14. Realising 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; Lowyck & 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).

Methodology

The study involved two classes (each with 25 student teachers) at a primary school teacher training college during the testing phase of the MILE course, ‘The Foundation’. Ten 2-hour meetings were held. For the methodology and the development of the tool, the position was taken to conduct this section of the study in such a manner that we could expect to optimise the results in terms of the signals of theory use (Glaser & Strauss, 1967). The method of triangulation was then selected (Maso & Smaling, 1998), 4 pairs of student teachers were observed and interviewed, and a participating study of the group work with two student teachers was conducted.

In addition, the teacher educator was observed during the 10 meetings involving the entire group in order to inventory the incentives offered to stimulate the use of theory by student teachers (their theories in action). The data was recorded on audio and video tape. Furthermore, data was obtained from the analysis of portfolio documents from the student teachers.

The observations described below offer an impression of the results to date. A more detailed report will be presented at PME-25.

THEORY IN ACTION (1)

Discussing Fadoua's mistake

The MILE fragment shows a pupil, Fadoua, and her teacher, Minke, at the instruction table during a grade 2 independent working session. In a diagnostic discussion, Minke wants to attempt to identify the way of thinking behind the mistake (18-6=11) Fadoua made in her written work. It appears that Fadoua counts backwards starting from 18 ('initial error', a well known standard error) and whilst counting backwards also skips two numbers (12 and 14).

The theory that makes this practical situation more comprehensible is a result of research into subtraction strategies employed by young children, in particular the method of counting backwards. Initial errors, counting mistakes and counting too far are well-known problem areas. To avoid problems in the transition from manipulative to mental calculations when learning to shorten procedures, structural models divisible in “fives structures” can be employed to learn to subtract to twenty (Gravemeijer, 1994; Van den Heuvel-Panhuizen et. al., 1998).

After watching and analysing the video, the student teachers, Denise and Marieke, discuss the most appropriate way to assist Fadoua. Denise initially suggests solving the sum using 18 blocks (units). Marieke rejects this, however, since she believes it doesn't solve Fadoua's counting problem. She rejects the second suggestion – using the number line – for the same reasons. Marieke ultimately agrees with Denise when she suggests using the reckon rack.

Denise’s foremost argument is that the fives structure of the reckon rack can help Fadoua either by directly subtracting 6 or by splitting to yield 8-6 or 18-6. ‘And that doesn't involve counting anymore,’ she says.

After analysing another MILE fragment (involving a talk between the two grade 2 teachers, about the transfer), Marieke reaches the conclusion that Fadoua has most likely mastered splitting the numbers to ten. Based on their interpretation of the teaching method for learning to use the reckon rack (doing, seeing, working it out in your head), they list all the points for helping Fadoua.

In the previously outlined discussion between student teachers Denise and Marieke we see theory in action when they compare, face and consider, on the basis of theoretical perspectives, which material or model is (or is not) appropriate and why. A similar process occurs when they design an explanatory approach for Fadoua, partially on the basis of theoretical considerations (the reckon rack teaching method).

THEORY IN ACTION (2)

Considerations on the use of tangible material (manipulatives)

In the workshop part of the second session, the student teachers are given the task of characterising three MILE situations, A, B and C. Using that analysis, they are to attempt to select two of the three situations that bear the closest interrelationship. In fragment A, teacher Minke is teaching her pupils to memorise the five-times table. On the magnetic board, we also see two 2 by 5 and 3 by 5 tile squares Minke used before this part of the lesson. She now asks who knows a multiplication fact by heart. Kimberley knows that 5x10=50 (Minke alters this to 10x5) and Vincent knows that 8x5=40.

In fragment B, teacher Willie has the class count the five-times table by making leaps of 5 on the number line. Dwaen knows that 9x5 is just ahead of 10x5.

In fragment C, we see 20 transparent cylinders, each containing 5 balls, on the edge of the blackboard. Minke asks which multiplication table sum matches this. Clayton's answer is 20x5.

The theoretical background in all three situations concerns the method of teaching multiplication tables and, more specifically, that of memorising the products. One possible factor could be the grid (rectangle) model in situation A, which is represented by the tile squares, which, although visible, are not in use at that point. Situation B is about repeated leaps on the number line, whereas, in the case of 9x5, the 'one less than' the anchor product 10x5 strategy comes into it. In situation C, theory makes an appearance in the form of visualising the multiplication structure based on the context. The structure elicits the use of strategies (Treffers & De Moor, 1990; Goffree, 1994).

To her group partner Loes, student teacher Linda speaks out in favour of the tie-in between situations A and C. The tiles and the tennis balls are 'tangible' (manipulatives), the number line is not (it is very likely that this terminology was borrowed from the educator during the previous plenary meeting). Using the tiles and the tennis balls, the children can assemble groups themselves. You can see the tennis balls as 20 groups of 5, but also as 10 groups of 10. The number line 'always remains a unit'. According to Loes, you can do all that on the number line too, by adding dashes. In her view, the tiles, the number line and the tennis balls are 'three equal aids'. When Linda speaks out for the relationship between situation A and B and the difference with situation C, she demonstrates theoretical notions about (in)tangibility and about grouping and structuring. She has a vague idea of the number line being a more abstract, 'intangible' construct, as opposed to Loes, who seems to see the number line as a tool or working model.

THEORY IN ACTION: SUMMARY

We see theory coming into action in situation (1) as the student teachers (re)assess their viewpoints with regard to the question which is the material or model of choice for coming to grips with a particular problem. That also happens if they substantiate their construction (help for a pupil) by using theory.

In situation (2) signals that theory is being applied become more evident when a student teacher (Linda) compares practical situations and justifies the relationship between two situations by basing her reasoning on theoretical considerations.

Conclusions

Intended to portray the connection between theory and actual practice made by student teachers, the research tool evolved into a data analysis instrument. As the study progressed, overlap was eliminated and new signal characteristics were added. Further refinement of the characteristics is considered necessary.

The interim results of this ongoing study reveal that student teachers use theory as a means to understand and explain practical situations. The frame of reference of second-year student teachers (comprised of personal experiences as pupil and trainee, supplemented with theoretical information about education and training from lectures at the PABO teacher training college) appears somewhat diffuse and fragmented. It remains difficult to draw a boarder line that separates practical wisdom from theory.

The mental ability to articulate observations of and reflections on practical situations in theoretical terms remains largely undeveloped. The current culture reigning at the teacher training colleges also seems to hamper the development of this. As a result, there is a real danger that student teachers will hang on to their personal (subjective) theories undesirable for professional development.

The student teachers themselves believe that working with MILE enables them to apply and further explore the knowledge that they already have. A number of them demonstrated a budding appreciation for theory. Continued study should reveal whether the signals they display actually point to integrated knowledge of theory and practice, or, in other words, practical knowledge.

References

Boekaerts, M. & P.R.Simons (1993). *Leren en instructie.* Assen: Dekker & Van de Vegt.

Brink, F.J. van den (1989). *Realistisch rekenonderwijs aan jonge kinderen. (dissertatie) [Realistic arithmetic instruction for young children (dissertation)].* Utrecht: Vakgroep OW&OC, Universiteit Utrecht.

Dolk, M., Faes, W., Goffree, F., Hermsen, H. & W. Oonk. (1996). *A Multimedial Interactive Learning Environment for (Future) Primary School Teachers with Content for Primary Mathematics Teachers Education Programs.* Utrecht: MILE series, publication 1, Freudenthal Institute/NVORWO.

Eerde, D. van (1996). Kwantiwijzer. *Diagnostiek in reken-wiskundeonderwijs (dissertatie).[Diagnostics in Mathematics Education (dissertation)].* Tilburg: Zwijsen.

Elbaz, F. (1983). *Teacher thinking: A study of practical knowledge.* London: Croom Helm.

Glaser, B. G. & A.L. Strauss (1967). *The discovery of Grounded Theory. Strategies*

for Qualitative Research. Chicago: Aldine Publishing Company.
Goffree, F. (1979). *Leren onderwijzen met Wiskobas (Dissertatie). [Learning to teach With Wiskobas (Dissertation)'].* Utrecht: Institute for Development in Mathematics Education.
Goffree, F. (1982, 1983, 1984, 1994). *Wiskunde & Didactiek, deel 1, 2, 3 ['Mathematics & Didactics, vol. 1, 2, 3].* Groningen: Wolters-Noordhoff.
Goffree, F. & M. Dolk. (Eds.) (1995). *Standards for primary mathematics teacher education.* Utrecht: NVORWO/SLO (translation of a portion of Goffree, F. & M. Dolk (red.) (1995). Proeve van een nationaal programma voor rekenen-wiskunde & didactiek op de pabo).
Goffree, F & W.Oonk (1999). Teacher Education around the World. Educating Primary School Mathematics Teachers in the Netherlands: Back to the Classroom. In: *Journal of Mathematics Teacher Education, Vol.2 No.2: 207-214.*
Goffree, F & W. Oonk (2001). Digitizing real practice for teacher education programmes: The MILE approach. In: *Lin, F. & T.J. Cooney. Making sense of Mathematics Teacher Education.* Dordrecht: Kluwer Academic Publishers.
Glasersfeld, E. von (1995). *Radical Constructivism. A way of Knowing and Learning.* London, Washington, D.C.: The Falmer Press.
Gravemeijer, K. (1994). *Developing Realistic Mathematics Education (dissertation).* Utrecht: Freudenthal Institute.
Gudmundsdottir, S. (1995). The narrative nature of pedagogical content knowledge. In: *McEwan, H. & K. Egan, (Eds.), Narrative in teaching, learning, and research. (24-38).* New York: Teachers College, Columbia University.
Hiele, P.M. van (1973). *Begrip en inzicht.* Purmerend: Muusses.
Lampert, M. & D. Loewenberg Ball (1998). *Teaching. Multimedia and Mathematics. Investigations of real practice.* New York: Teachers College Press.
Lowyck, J. & N. Verloop (red.) (1995). *Onderwijskunde. Een kennisbasis voor professionals.* Groningen, Wolters-Noordhoff.
Maso, I & A. Smaling (1998). *Kwalitatief onderzoek: praktijk en theorie.* Amsterdam: Boom.
Oonk, W. (1999). *Pioniers in MILE. Een exploratief onderzoek.* MILE series, no. 9. Utrecht: Freudenthal Institute.
Schön, D. (1983). *The Reflective Practitioner.* Basic Books, New York.
Simons, P.R.J. (1999). Transfer of learning: paradoxes for learners. In: *International Journal of Educational research. Vol. 31, No. 7, p. 577-589.*
Treffers, A. & E. De Moor (1989, 1990). *Proeve van een nationaal programma voor het reken-wiskundeonderwijs op de basisschool, deel 1 en 2.* Tilburg: Zwijsen.
Van den Heuvel-Panhuizen, M. & K. Buys & A. Treffers (Eds.) (1998, 2000). *Tussendoelen Annex Leerlijnen (TAL).* Utrecht: Freudenthal Institute.
Verloop, N. (1991). *Praktijkkennis van docenten als deel van de onderwijskundige kennisbasis.* Oratie Rijks Universiteit Leiden.