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Realistic Mathematics Education: A Brief History of a Longstanding Reform Movement

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1. Introduction

Beginning in 1968, Realistic Mathematics Education (RME) has evolved into the main approach to mathematics education in the Netherlands. This paper describes how this fifty year reform came into being and developed further.

The development, the dissemination and implementation of the RME reform is a very complex process in wich ideas and thoughts gradually crystallized into principles for teaching mathematics. In this process, many change agents had a role, mostly in collaboration with each other or through supporting each other. It was a joint enterprise, without being uniform in course of action and in result. From the beginning on, people involved in the development of RME have placed different accents in what RME is or should be. Its development was clearly not a top-down process. There was no long-term governance by the state behind it that made this development possible and there was no stable continuous institutional backing. Institutions involved in the development of RME were sometimes abolished and later reopened again under a different constellation, but the work on RME continued. What was important for the reform process was the overall eductional infrastructure in the Netherlands in which research institutions, teacher education institutions, advisory centers for teachers, and centers for curriculum and test development, textbook publishers, the Ministry of Education and the School Inspectorate more or less worked together. The development of RME and its implementation was the work of many people. Due to their personal engagement, RME has become an established player in mathematics education, in its theory and practice and in its research and development. Moreover, this does not only apply at national level but also internationally (Van den Heuvel-Panhuizen, 2020).

In the next sections, we trail RME from its onset at the end of the 1960s to what it is nowadays. We go through this history with 10 year steps, each characterizing another phase of RME's development. In describing this development, we take the perspective of the RME reform in primary school mathematics.

2. A need for change: the emergence of RME reform at the end of the1960s

In the late 1950s, in many western countries a need was felt for "radical changes and improvements in the teaching of mathematics" (OEEC, 1961, p. 11). Important reasons for this were the increasing importance of mathematics and its applications for society and the availability of new insights on learning and teaching of mathematics. The need for reform in particular was addressed at the Royaumont conference in 1959. This conference eventually formed the starting point of the world-wide introduction of the New Math reform movement (e.g., Bjarnadóttir, 2014; Kilpatrick, 2012). In the Netherlands, however, under guidance of the "leading dissident" Freudenthal (Robitaille & Travers 2003, p. 1495), New Math would not gain a foothold. Instead, another direction was chosen, which led to RME.

Nevertheless, the Royaumont conference was not without consequences in the Netherlands. After the conference, in 1961, the Dutch government installed the CMLW (Commission Modernization Mathematics Curriculum). Freudenthal was initially a member of this commission and in 1969 he became its chair. The CMLW was appointed to investigate what reformed content and didactics were needed in the Netherlands (CMLW, 1961). Originally, the field of activity of this commission was secondary education only, but when, as part of the CMLW, the Wiskobas project was established in 1968, primary education also came into the picture. Wiskobas is an acronym for 'mathematics in primary school'. The inception of the Wiskobas project marks the starting point of the development of RME as an alternative for the then prevailing approach to arithmetic education in the Netherlands, which was rather mechanistic in nature. Characteristic of this approach was its focus on teaching fixed calculation procedures in a step-by-step manner with the teacher demonstrating for each step how to proceed. Real-world problems were only used for the application of previously learned calculation procedures, and little or no attention was paid to developing insight in the underlying mathematics of these procedures.

This mechanistic approach to mathematics education that is often refered to as 'traditional' is in sharp contrast with the ideas on mathematics education that existed at the end of the 19th and beginning of the 20th century. In these old times, serious appeals were made over the importance of insightful education, for heuristic methods with guided reinvention, making use of visualisations, and paying attention to mental arithmetic and practical applications (De Moor, 2009). In other words, RME did not come out of the blue, but was in a way prepared for by the ideas that pedagogues and mathematics didacticians already advocated decades earlier.

3. 1970 – 1980: Period of educational engineering

From 1971 on, the work of Wiskobas continued in the newly-founded IOWO (Institute for Development of Mathematics Education), of which Freudenthal was the first director. The ten years of this institute's existence can be seen as a period of educational engineering. Freudenthal saw himself and the workers at this institute as engineers. The work was all about 'making something' and, as is the case when practical work is done by engineers, this work may eventually also produce scientific residues (Freudenthal, 1987).

The IOWO period can rightly be called the delivery room of RME. Ideas on teaching mathematics developed during that time have served as models and worked examples for conceiving mathematics education for decades and can still be found in current mathematics textbooks (Van Zanten & Van den Heuvel-Panhuizen, in preparation). The IOWO products comprise a broad variety of materials: rich tasks, themes, lessons, teaching sequences, and complete programs for various topics within arithmetic, measurement and geometry, and meant for primary school, teacher education and professional development courses. There was an explosion of ideas on all aspects of mathematics education. Curriculum development, teacher education, and professional development were taken up with great enthusiasm by the Wiskobas team. The Special Issue of *Educational Studies in Mathematics* titled "Five Years IOWO"

(Freudenthal, Janssen, & Sweers, 1976) reflects the outburst of ideas in the initial period of the reform movement to achieve a new mathematics education. From the outset, the educational field was involved in all this design work. Also, every year, several conferences and courses for teacher educators, teachers, teacher advisors, researchers, inspectors and primary school teachers were organized. For teachers, though, the need for professional development was not always so pronounced. This implied that the implementation policy of Wiskobas was very thoughtful. The approach was not to come up with improvident changes in the teaching of mathematics, but first conduct small experiments in practice. These experiments created a huge amount of materials, with respect to both the content and the didactics. The focus was in particular on enlivening mathematics education by providing teachers and teacher educators with teaching ideas. To achieve this, Wiskobas bulletins were published and educational TV productions were used. Although the design activities were most prominent in the first years of RME, the underlying theory was also given attention. In 1973, Freudenthal published his groundbreaking “Mathematics As an Educational Task,” and in 1978, Treffers brought out his seminal work on the goals and approaches to mathematics education according to Wiskobas. Other important research work that started at the end of the 1970s entailed carrying out textbook analysis. Existing textbooks were commented on and critically examined from the perspective of the intended reform, which had a guiding function for the innovation. In 1981, the Wiskobas work came to an end. As a result of a decision of the government, the IOWO was disbanded, implying that its work was reallotted to a number of other institutions. This curtailed IOWO's original work considerably. From then on, curriculum work fell under the responsibility of the recently established SLO (the Netherlands Institute for Curriculum Development), while test design had to be done by Cito (the Netherlands Institute for Educational Measurement), and only a small group of people could continue with research work in a newly founded institute, OW&OC (Mathematics Education Research and Educational Computer Center), as the successor of IOWO.

4. 1980 – 1990: Period of research, theory development, and infrastructure

Remarkably, within the constellation of OW&OC, a lot of things from the IOWO time continued and contact between the people who were now spread out over different institutions remained as close as before. Characteristic of this period were the many research activities and the many national and international publications that resulted from it. For primary education, for example, this included the work of Adri Treffers (progressive schematization of algorithms), Leen Streefland (context and models for fractions), and Jan van den Brink (mathematical language and representations for early number). Also, a new boost to theory development was given by Freudenthal’s (1983) “Didactical Phenomenology of Mathematical Structures” and Treffers’ (1987) “Three Dimensions.”

In this period, an event of imperative importance for the survival and durability of the young renewal movement was the establishment of NVORWO (Netherlands Association for the Development of Mathematics Education) in 1982. Through this association the collaboration and the sharing of knowledge of people from different institutions could be continued in a more formal infrastructure. NVORWO fulfills the role of intermediary between politicians, researchers and developers on the one hand and on the other hand those directly involved in mathematics education: teachers, teacher educators, teacher advisors, mathematics coordinators, and teacher students. As an independent association, NVORWO had an important function in creating broad support for the innovation of mathematics education and gaining further acceptance in the education field. Like other steps in the Dutch reform movement, the initiative for such an association was a personal idea that was welcomed immediately by others, quickly leading to the establishment of this association, which still exists!

One of the first actions of NVORWO was to pave the way for a national plan for primary mathematics education to create more coherence in the widely varying content and approaches to teaching mathematics that had developed since the late 1970s. In 1984, a draft version of this plan was submitted for consultation to almost 300 experts in the field of primary school mathematics. It was proposed to give algorithmic digit-based calculation a less central position in favor of mental calculation, estimation and number sense, to aim more at applicability, and not to start with teaching students the most shortened forms of standard algorithms immediately, but begin with a notation using whole numbers. This plan received much acclaim. In general, there was almost unanimous agreement with the reform of mathematics education as proposed in the concept plan. Also a small group of surveyed parents agreed with this plan. In 1987, the findings resulted in the first blueprint for a national programme for mathematics education in primary school, the so-called 'Proeve publications' (e.g., Treffers, De Moor, & Feijs, 1989).

5. 1990 – 2000: Period of the further implementation of RME in curriculum documents and textbooks

In 1990, Freudenthal passed away, and in 1991, OW&OC was renamed the 'Freudenthal Institute'. The period before the turn of the century is further characterized by a scaling-up of the reform movement.

In the first place, the end of primary school goals as described in the Proeve publications were officially given approval by the government by taken them over as the national core goals for primary education (Ministry of Education, 1993). This legitimization meant a break with the past, implying that for the future curriculum it was the intention to give full attention to mental calculation and estimation, restrict operations with fractions to fractions in context situations, take account of insightful calculator use, and officially include geometry in the primary school program. This break with the past was even more significant for the general objectives that were formulated, which included being able to identify elementary mathematical relationships and patterns, to reflect on one's own mathematical activities, and to use and explain inquiry- based and reasoning strategies. In hindsight, however, the most remarkable part was that this change on the level of the curriculum happened without much discussion, and more or less followed along in the direction that had been taken earlier after the consultation of experts in 1984. Therefore, confirming this direction in the national core goals could be viewed as a silent revolution (Treffers & De Moor, 1994). A further implementation in curriculum documents was possible in the development of the TAL teaching-learning trajectories for primary mathematics education commissioned by the Ministry of Education (e.g., Van den Heuvel- Panhuizen, 2001).

The other form of scaling up that took place during these years was the further implementation of RME in textbooks. The Proeve publications with their descriptions of goals, examples of tasks and teaching methods served, together with an abundance of other publications, as beacons for textbook authors and test developers. Just as had been the case for the earlier Wiskobas products, copying from the Proeve publications was free. This resulted in a remarkable change in the nature of textbooks. From 1987 to 1997, the market share of RME-oriented textbooks increased from 15% to 75%, which, however, did not necessarily mean that the implementation of RME was applied to classroom practice as well. Empirial research on a large scale is not really available in that respect, but based on the experiences of teacher advisors and teacher educators who visited schools, it can be concluded that the teaching of mathematics did not change that much when the teachers moved to RME-oriented textbooks. In other words, it can be assumed that the innovation at the level of practice lagged behind the intentions of RME. To improve this situation, there was an urgent need for professional development. However, recurring attempts to have a government-funded national professional development program for teachers on mathematics education did not lead to the desired result.

An important point for any educational reform is the effect on student achievement. Although there was uncertainty about how teachers used the RME-oriented textbooks, the 1997 five-year PPON survey (the National Assessment of Educational Achievement) by Cito, showed that the reform movement and the accompanying new road that was taken for algorithmic digit-based calculation could be recognized in student performance. The scores on the scale for operations with multiplication and division were more than 10 percent points lower in 1997 than in 1987. There was a negative effect of almost half a standard deviation. The new goals formulated for education ten years before, had apparently led to giving algorithmic digit-based calculation a less central position in the mathematics lessons.

6. 2000 – 2010: Period of the omnipresence of RME and the emergent critique

The period covering the first decade of the millennium contained two quite contradictory developments. Up to halfway through this period there was still a steady growth in market share of RME-oriented textbooks which reached a 100% share around 2004 (see Figure 1).

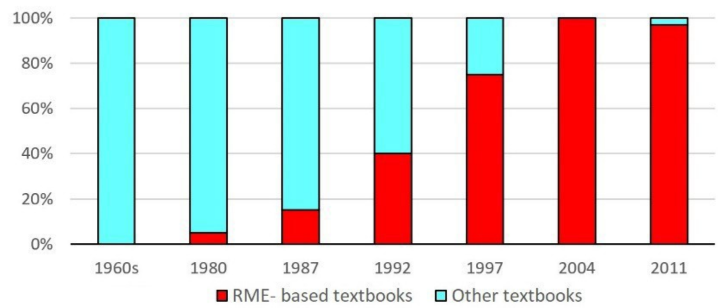

Figure 1. Market shares of RME-oriented and other textbooks over the years

Despite this omnipresence of RME in all sectors of the mathematics education field, including the teacher education programs, the situation regarding in-service professional development had not changed much. Despite repeated requests, a large-scale and national program for professional development did not come. As in the previous years, there were only small-scale initiatives set up by various institutions, sometimes supported by a minor grant from the Ministry of Education. There was no compulsory continuing professional development for teachers. Participating in professional development was on a voluntary basis and teachers could, and still can, choose themselves on which subject they wanted to follow in-service teacher education. It was therefore not a surprise that TIMSS showed the Netherlands at the bottom of the league table for teacher participation in professional development for mathematics education (see Mullis et al., 2008).

In the second half of this period, the educational climate changed remarkably (see Van den Heuvel-Panhuizen, 2010). This change was prompted by the results from the 2004 PPON survey. The results showed that student performance in number sense, mental calculation and estimation had substantially improved since 1987, but that achievements for written algorithmic calculation had decreased further. Again, this was to a certain degree in line with the performance profile opted for twenty years earlier. However, not everyone was satisfied with the results that came out now, all the more because the TIMSS results also showed that the mathematics performance of Dutch students was declining. All these findings evoked much protest that came particularly from a few mathematicians, who launched their critique of the RME reform on social media and in newspapers. They were against the reform and were in favor of returning to the approach to mathematics education of forty years ago. In short, what had been a silent revolution ended up a real revolt.

To calm down the fierce debate between supporters and opponents of the innovation and to put an end to these turbulent times, the Ministery of Education asked the highest academic body in the Netherlands, the Royal Netherlands Academy of Arts and Sciences (KNAW) to find out which approach to teaching mathematics is better: the RME approach or the traditional mechanistic manner of teaching (KNAW, 2009). The commission established by the KNAW did a review of empirical research conducted in the Netherlands and abroad in the previous twenty years. The conclusion was that no convincing empirical evidence was found for the claims on the effectiveness of traditional methods versus RME. With regard to pre- and in-service teacher education, the KNAW commission was more pronounced. In their eyes, the key to improving mathematics achievements is in the competence level of teachers, and therefore they criticized the serious erosion of professional development in the Netherlands.

7. 2010 – present: Period of undoing and revitalizing the reform

After the verdict of the KNAW commission, peace returned, and at least the worst of the 'math war' seemed to be over. For all those involved in the RME reform movement, it was a challenge to stay grounded in those turbulent times, but the reform process continues. Yet, it is clear that the uprising has left its mark on it. The market share of RME-oriented textbooks lost its 100% position. A few percent of the market share went to a new textbook series which acknowledged itself as the counterpart of RME. Also, there were significant changes to existing RME-oriented textbooks. This means that at the moment, although the KNAW commission found no evidence to better qualify one approach over the other, most publishers produced adapted new editions of textbooks showing features of the mechanistic approach of the past. This means that, again, more emphasis is put on written calculation, including digit-based algorithmic procedures. However, in most of these textbooks, the teaching-learning trajectory that is followed for calculation globally reflects the structure as described in the Proeve and TAL. Thus, they do not focus on blindly training of procedures but instead aim at understanding by starting with a phase of transparent whole-number-based written calculation. Put differently, the RME characteristics are upheld in most current textbooks. Nevertheless, publishers refrain – maybe for commercial reasons – from using the term 'realistic' for their new textbooks.

Apart from this movement back to a more mechanistic approach, instigated by the declining scores of students on procedural calculations, there has been another recent movement to the past. This is the movement toward the origins of RME with much attention on mathematical reasoning and problem solving. A few years ago, these higher-order competencies came to the fore again. A wake-up call for paying more attention to mathematical reasoning in primary school already was a small-scale study (Van den Heuvel-Panhuizen & Bodin, 2004) on solving non-routine puzzle-like problems. The results showed that even high-achieving students had difficulties with solving these problems. Further research revealed that Dutch mathematics textbooks, even though they were based on RME, hardly contained problems for mathematical reasoning (Kolovou, Van den Heuvel-Panhuizen, & Bakker, 2009). The focus was mainly on plain calculation problems. A recent replication of this textbook analysis study (Van Zanten & Van den Heuvel-Panhuizen, 2018) showed that the situation has not changed much. Moreover, solving mathematical problems and reasoning are no longer even mentioned in the most recent goals for primary mathematics education. Therefore, in 2015, the Beyond Flatland project was set up to investigate how the Dutch primary school mathematics curriculum can be made 'more mathematical' by including activities on mathematical reasoning and genuine problem solving. In line with the ideas of the Wiskobas team (1980), who forty years ago already argued in favor of including more 'advanced' mathematical content in primary school textbooks, in the Beyond Flatland project, lesson series have been developed for early algebra, probability, and reasoning with graphs. At the same time, this project offers a new arena to explore how in the vein of the RME tradition, the RME principles can be enriched with ideas from recent theories about learning, by incorporating insights of embodied cognition (grounding mathematical concepts in bodily experiences) and variation theory (acquiring understanding of key aspects of concepts by experiencing variation).

The newest development is that the Ministry of Education has recently commissioned a project team of teachers to rethink and revise the current mathematics curriculum to better equip students for their future personal and professional life. The plans that have came out by now, which are supported by NVORWO (2017), emphasize the importance of starting in primary school with mathematical problem solving through modelling and reasoning. Here again, the spirit of Wiskobas is recognizable.

In this paper, we have taken big steps through 50 years of primary school mathematics education reform in the Netherlands to show the long-standing process of developing and implementing RME, a process which is still continuing.

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