Chapter 11
Ensuring Usability—Reflections on a Dutch Mathematics Reform Project for Students Aged 12–16

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Change in education is easy to propose, hard to implement, and extraordinarily difficult to sustain.
Hargreaves and Fink (2006, p. 1)

Abstract In this chapter, I look back at the implementation of W12-16, a major reform of mathematics education in the lower grades of general secondary education and pre-vocational secondary education in the Netherlands including all students aged 12–16. The nationwide implementation of W12-16 started in 1990 and envisioned a major change in what and how mathematics was taught and learned. The content was broadened from algebra and geometry to algebra, geometry and measurement, numeracy, and data processing and statistics. The learning trajectories and the instruction theory were based on the ideas of Realistic Mathematics Education (RME): the primary processes used in the classroom were to be guided re-invention and problem solving. 'Ensuring usability' in the title of this chapter refers to the aim of the content being useful and understandable for all students, but also to the involvement of all relevant stakeholders in the implementation project, including teachers, students, parents, editors, curriculum and assessment developers, teacher educators, publishers, media and policy makers. Finally, I reflect on the current state of affairs more than 20 years after the nationwide introduction. The main questions to be asked are: Have the goals been reached? Was the implementation successful?

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11.1 Vision

11.1.1 Radical Innovation

The W12-16[1] reform of mathematics education in the lower grades of general secondary education and pre-vocational secondary education in the 1980s and 1990s was widely seen as a radical innovation in mathematics education. The reform affected all elements of mathematics education in secondary schools: a new and broader curriculum, alternative ways to approach students, fostering students to develop more and other skills such as problem solving, and using different assessments such as contextual and open-ended problems.

The realisation of such a change was only possible with broad support. In the 1980s and 1990s, there was in the Netherlands a great deal of agreement between teachers, mathematics education developers from the Freudenthal Institute (the former IOWO[2]), mathematics educators from the SLO,[3] the staff of APS,[4] and teacher educators from various teacher education institutions.

Through and with these leading institutions, publishers, other teacher educators, teacher unions, educational support agencies, researchers and developers in mathematics education worked together to change mathematics education. Furthermore, a great many of these people were involved in writing mathematics textbooks. This broad collaboration also made it possible to offer in-service training on a large scale. And last but not least, there was support, although limited, to this mathematics education reform movement from professional mathematicians; because of the eminent stature of Hans Freudenthal.

This broad engagement was also visible in the two teams that were the driving forces in the development and implementation of W12-16 reform. First, the W12-16 team started as a development and design team with members of various institutions. Later, this team was transformed into the SW12-16[5] team, a broad implementation team with dozens of teachers and mathematics educators as team members, working together to implement the new curriculum.

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[1]Wiskunde 12-16 (Mathematics 12-16).

[2]Instituut voor de Ontwikkeling van het Wiskunde Onderwijs (Institute for the Development of Mathematics Education).

[3]Netherlands Institute for Curriculum Development.

[4]National Centre for School Improvement.

[5]Samenwerkingsgroep Wiskunde 12-16 (Collaborative working group Mathematics 12-16).

11.1.2 Pioneering

For most members of the W12-16 team, innovation in mathematics education began well before their participation in the team. Some members were looking for opportunities to innovate teaching methods, while others had an affinity with at-risk students and acted from a background of special needs education. Other team members were mostly interested in the professional development and empowering of mathematics teachers. Yet some other members were working on promoting mathematics for girls. All team members had one thing in common; they were looking for a setting in which all students could be inspired by mathematics, motivated by the content and the approach, and be actively engaged in mathematics. The team members were the pioneers who advanced the initial developments.

In some sense, the work of the W12-16 team was an extension of the mathematics education development that was already taking place in the Netherlands. At the same time, W12-16 was the focal point through which all the initiatives came together and were moulded in a coherent vision. From the beginning of the 1970s, at the IOWO people had been working on the design of Realistic Mathematics Education (RME) in which students are given practical problems from everyday life or other sources which can be experienced as real by the students. By solving these problems and reflecting on them with mathematics teachers, students construct their own set of mathematical concepts. In RME this is called 'guided reinvention' (Gravemeijer, 1994, 2004). In the first instance, the IOWO staff focused on primary education and primary school teacher education. As a follow up, a number of booklets on particular mathematical domains were developed for lower secondary education using the same approach. The influence of this material was limited because the content of the examinations changed little, if at all. Because of this, teachers and mathematics textbook authors were hesitant to use these booklets in their teaching programmes.

More substantial for the development of the W12-16 team's vision was a change in upper levels of secondary education resulting from the HEWET[6] and HAWEX[7] projects, which introduced a new mathematics curriculum. The influence of the HEWET project (1978–1985) was the most substantial because it concerned, amongst other things, the development and introduction of a new curriculum for pre-university secondary education. Mathematics A was intended for students pursuing a university education in the social sciences; the contents were considered a kind of 'forerunner' of mathematical literacy (De Lange, 1987; OECD, 1999), including functional mathematics, contextual problem solving, and statistics and probability. Mathematics B was meant for students pursuing a university education in the natural sciences and contained more technical mathematics with a strong calculus

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[6]Herverkaveling Wiskunde I en II (Re-allotment Mathematics I and II); the HEWET project resulted in Mathematics A and Mathematics B, a new mathematics curriculum for the upper grades (age 16–18) of VWO, the pre-university level of secondary education.

[7]HAVO Wiskunde Experimenten (HAVO mathematics experiments); the HAWEX project resulted in Mathematics A and Mathematics B for the upper grades of HAVO, general secondary education which qualifies for higher professional education.

approach, including functions, graphs, and advanced calculus. In addition to the calculus domain, the curriculum of Mathematics B included a domain of geometry in which mathematical proofs were reintroduced in the curriculum as an example of the scientific mathematical method.

At this stage, the developments in primary education had also progressed. In the beginning of the 1990s about 40% of primary schools used a RME textbook series (Van den Heuvel-Panhuizen, 2010).

So, for both age ranges, the 4–12-year-old students and the 16–18-year-old students, the mathematics curricula were changing. One last gap remained: lower general and pre-vocational secondary education. In 1987 a committee was set up to review the mathematics curriculum for students in these tracks in the age range of 12–16 years.

11.1.3   The Educational and Societal Context of the Change

The experiences with a new curriculum in primary education and the upper levels of general secondary education fed the vision of the W12-16 team. However, it was not only developments in mathematics education which left their mark. While the W12-16 team was at work, more general educational changes took place and influenced the development of the team's vision. The direction and size of the educational change in W12-16 were determined to a large extent by the social context in which the plans were developed. In the 1980s and 1990s, in which the W12-16 and SW12-16 teams operated, there were several developments that affected classroom norms, educational policies and curriculum development. In this particular time frame, there was a focus on equity in education: schools organised students in heterogeneous classes; there was a general need for basic education for all, and consequently for mathematics for all; and last, but certainly not least, to prevent the waste of enormous human potential in mathematics, there was a focus on the mathematical competence of girls. In the Netherlands, compared with surrounding countries, girls were underrepresented in technology sectors of education and were underachieving in secondary education because many were choosing tracks with either no mathematics or easier mathematics.

Moreover, at that time, there was also increasingly widespread use of calculators in society, though this had not yet spread to schools. And, to complete the picture of this period of time, it is important to note that it was prior to the common use of the internet and the World Wide Web.

11.1.4   The Dutch School System

The Dutch school system has a few very distinct features, which also influenced the implementation of the new program (Fig. 11.1).
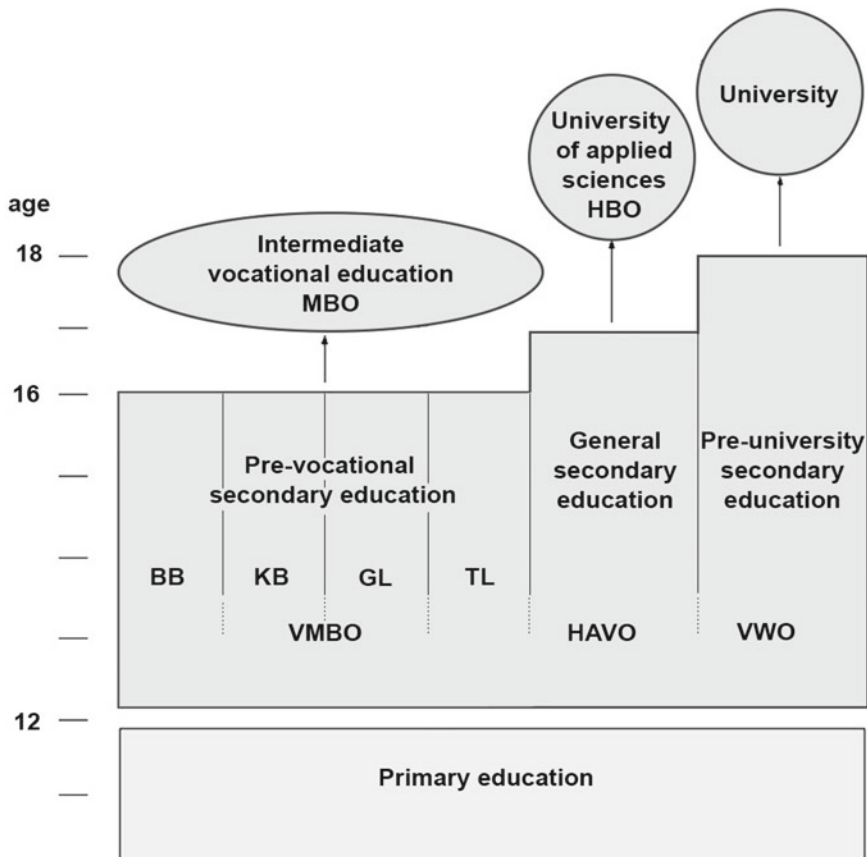
Fig. 11.1 The Dutch school system

Early streaming and a focus on vocational education from a very young age are typical features of the Dutch school system. Although it is internationally recognised that such early streaming limits the full developmental potential of the student population (OECD, 2013), discussing a change to this has been a no-go area in Dutch politics for decades. Reducing streaming is seen in Dutch politics as aiming at egalitarian and uniform education, instead of aiming at differentiated education, that is, dealing with differences in the classroom. The strong and early focus on vocational education could indeed have a benefit for many students, as they can engage in meaningful and job-related activities early in their education. But at the same time, it can lead to a sharp divide between vocational and general education. Preventing a two-tiered education structure, and in the long run a two-tiered society, was and is a serious educational challenge for the Netherlands. The aim of the W12-16 team was to make mathematics education meaningful for all students, regardless of level, gender, ethnicity or educational stream, preferably in an inclusive educational setting.

To summarise, developments in both mathematics education and society worked together to create a vision of mathematics for all students that targeted usability and inspiring and meaningful mathematical content.

11.2   The Content of the New Curriculum

11.2.1   RME—The Vision in a Nutshell

The Dutch approach to mathematics education has become known as 'Realistic Mathematics Education' (Gravemeijer & Terwel, 2000; Van den Heuvel-Panhuizen, 2000; Van den Heuvel-Panhuizen & Drijvers, 2014). The present form of RME has been mostly determined by Freudenthal's (1973) view on mathematics education and was further developed by the staff of the Freudenthal Institute at Utrecht University. Freudenthal viewed mathematics as an educational task that, for it to be of human value, should be connected to reality, remain within children's experience, and be relevant to society. In his view, teaching mathematics is much more than a transfer of knowledge to be absorbed by students. Freudenthal stressed the idea of learning and doing mathematics as a human activity; it should give students a guided opportunity to re-invent mathematics by actively doing it. This means that the focal point of mathematics education should not be on mathematics as a closed system but on the activity and on the process of mathematisation (Freudenthal, 1980).

11.2.2   RME in Secondary Education

In secondary education, mathematical concepts become more sophisticated and formal than in primary education. In many mathematics curricula all over the world (Hodgen, Pepper, Sturman, & Ruddock, 2010a, b) formal mathematics is used as both a goal and an organisational principle for the curriculum, as reflected in names of content domains such as 'algebra' and 'geometry', which are basically domain names from the early eighteenth century. In such mathematics curricula, contextual problems are most commonly used for knowledge application tasks at the end of a learning sequence, as a kind of add on. In the mathematics curriculum for lower secondary education, which is the curriculum being reflected on in this chapter, a broader scope was chosen in this reform: 'algebra' became 'functions, formulas and relations'; 'geometry' became 'geometry and measurement'; 'numeracy' was added with a focus on mathematical literacy; and 'data processing and statistics' were addressed. In this way, the organisational principle for the curriculum shifted towards a categorisation in topics related to the world around us and how mathematics plays a role in it, rather than a categorisation of mathematical concepts.

In RME, context problems also have another function than mere application of mathematics. They are typically used in the exploration and development of new mathematical concepts. In RME, context problems play a role in each new learning trajectory directly from the beginning. Learning trajectories start with the presentation of a problematic situation that is experientially real to the student. The contextual problems are intended to foster a re-invention process that enables students to become involved in problem solving and modelling processes and at the same time provides them with grips for more formal mathematics. In RME, context problems can function as anchoring points for the students to re-invent mathematics themselves. Moreover, guided re-invention and emergent modelling offer ways to address the generally perceived dilemma of how to bridge the gap between informal knowledge and formal mathematics.

11.2.3 Examples from Final Examinations

Curriculum changes are documented in formal curricula describing the skills and knowledge goals to be taught. For teachers, however, the most common way to communicate curriculum changes is through discussing exemplary tasks in final examinations and comparing 'old' tasks with 'new' tasks.

The tasks in Figs. 11.2 and 11.3 are from a mathematics final examination for pre-vocational secondary education. Figure 11.2 shows tasks from the examination in 1995, which are typical for the old curriculum, while the tasks in Fig. 11.3 are from the examination in 1996, which are typical for the new curriculum.

The differences between the final examination tasks of the old and the new curriculum are striking. First, the starting point for tasks in the final examination of 1996 involves problems from the real world, sometimes accompanied by pictures or diagrams. This approach contrasts considerably with the formal mathematical approach used previously. Second, the focus has shifted from making calculations at a formal level to mathematical problem solving and modelling. Third, multiple choice questions are abandoned to keep students in a problem-solving mind-set as long as possible. And finally, the mathematics is personalised in the sense that actual people are introduced in the tasks and, while the question may not be directly relatable to the life experience of the students, it is at least imaginable for them.

11.2.4 The Change in Content

Until 1992 the mathematics curriculum for lower secondary education was based on the classical mathematical subjects of geometry and algebra. In algebra, the focus was on algebraic manipulation, solving equations, and linear and quadratic functions and their graphs. In the domain of geometry, the focus was on plane geometry—measuring angles, Pythagoras, and goniometry—with a strong calculational approach. In

For which values of *x* the following inequality is true?

$-3(x - 2) \geq 3(x + 3)$

a. $x \leq -2\frac{1}{2}$

b. $x \leq -2$

c. $x \leq -\frac{5}{6}$

d. $x \leq -\frac{1}{2}$

e. $x \geq -2$

f. $x \geq -\frac{1}{2}$

For which values of x the following inequality is true?

$\frac{1}{2}x^2 - 5x - 3 < 0$

a. $\{x \mid 5 - \sqrt{19} < x < 5 + \sqrt{19}\}$

b. $\{x \mid 5 - \sqrt{31} < x < 5 + \sqrt{31}\}$

c. $\{x \mid -5 - \sqrt{31} < x < -5 + \sqrt{31}\}$

d. $\{x \mid x < 5 - \sqrt{19} \lor x > 5 + \sqrt{19}\}$

e. $\{x \mid x < 5 - \sqrt{31} \lor x > 5 + \sqrt{31}\}$

f. $\{x \mid x < -5 - \sqrt{31} \lor x > -5 + \sqrt{31}\}$

Fig. 11.2 Tasks from the final examination Wiskunde VMBO GT 1995 (pre-vocational secondary education, upper track, mathematics, old curriculum) (translated from Dutch by the author)

the new programme, there was a new approach to algebra and geometry and the scope was broadened to include numeracy and statistics. Furthermore, a new curriculum domain of integrated mathematical activities was added. The aim of this addition was for the students to intertwine the different content strands in a more thematic approach.

11.2.4.1 A New Approach to Algebra

The focus within the algebra domain shifted from algebraic and computational manipulation to reasoning on the relationships between variables and to flexibility in switching between four different types of representations of relations: graphs, tables, verbal representations of situations, and formulas. Other characteristics of the new algebra approach were:

Postal rates in Europe

Sending a letter to someone outside the Netherlands is more expensive than within the Netherlands. A list of PTT rates for 1996 for posting within Europe are given below.

Europe (incl. Turkey)	Letters, Cards, Printed matter and small parcels			
	Letters	Cards	Printed matter and small parcels	
	by air	by air	by air	by train, boat or car
0 – 20 gram	ƒ 1,-	ƒ 1,-	ƒ 1,-	ƒ 1,-
20 – 50 gram	ƒ 1,80		ƒ 1,60	ƒ 1,45
50 – 100 gram	ƒ 2,60		ƒ 2,40	ƒ 2,10
100 – 250 gram	ƒ 5,-		ƒ 3,75	ƒ 3,35
250 – 500 gram	ƒ 9,50		ƒ 7,-	ƒ 5,75
500 – 1 kg	ƒ 16,-		ƒ 9,50	ƒ 9,-
1 – 2 kg	ƒ 24,-		ƒ 15,-	ƒ 12,-

A part of the graph for the PTT rates for sending *letters* by air in Europe is drawn in the appendix to questions 15, 16, 17 and 18.
You can have your letters, folders and suchlike sent by the company QSV.
The graph for the QSV rates is also drawn in the appendix.
QSV charges the same rate for printed matter as for letters.

a. Draw the part of the graph for sending letters from 0 to 100 g by PTT.

b. Karel wants to send a letter weighing 130 g to Glasgow.
What is the difference in price between sending the letter by PTT and sending it by QSV?

c. Lianne wants to send 5 folders (printed matter) to the same address in Ankara (by airmail). She can send them all in separate envelopes. She can also send two or more in one envelope. Furthermore, Lia can choose between PTT and QSV. One folder weighs 50 g. One envelope weighs 10 g.
Work out the cheapest way to send them. Write down your calculations.

Fig. 11.3 Tasks from the final examination Wiskunde VMBO GT 1996 (pre-vocational secondary education, upper track, mathematics, new curriculum) (translated from Dutch by the author)

– Dealing with diversity in the representations of relationships between variables instead of focusing on uniformity and formal conventions.
– More focus on interpretation of representations of relationships between variables than on manipulation skills.
– More focus on broad techniques like translating representations of relationships between variables than on specialised techniques like using the abc-formula to solve quadratic equations.
– More focus on a concentric curriculum with a gradual increase in complexity rather than a linear curriculum.

With these characteristics, the new curriculum aimed for a more usable, practical, and meaningful interpretation of algebra. For mathematics in the upper levels of secondary education, it was also seen as possible to design a usable calculus course

based on these fundamental principles; see, for example, Gravemeijer and Doorman (1999).

11.2.4.2 A New Approach to Geometry

In the curriculum domain of geometry, the focus shifted away from two-dimensional plane geometry with a strong calculational approach and towards two- and three-dimensional geometry with a focus on so-called 'vision geometry'. This geometry is based on seeing, observing, perceiving, representing and explaining spatial objects and spatial phenomena, in which the idea of vision lines and intervisibility plays an important role.

Geometry for primary schools was developed from similar ideas prevalent in the 1970s and 1980s, primarily informed by everyday geometric phenomena. Emphasis was placed on 'observing, doing, thinking and seeing', as Goffree (1977) described the Wiskobas[8] geometry concept.

The approach could almost be seen as a revival of the ideas of Tatiana Ehrenfest-Afanassjewa, who in 1931 published her *Übungensammlung zu einer Geometrische Propädeuse* (Ehrenfest-Afanassjewa, 1931) in which she substantiated her thinking on geometry based on everyday experiences from a practical point of view. This book contains a collection of problems of an entirely different nature than the traditional geometrical problems around constructions and proofs. It presents everyday geometrical phenomena that could be examined by 10-year-olds or even younger. Accordingly, these problems served to stimulate children's intuitive notions of geometric concepts and properties, thus forming a basis for later formal and systematic work. In the secondary education geometry programme these ideas were continued. So, geometry moved to more usable geometry, with strong links to the surrounding reality. For an extensive overview of specific developments in geometry education, see De Moor (1999).

11.2.4.3 Numeracy as a New Domain for Secondary Education

Within the domain of numeracy, the focus in W12-16 was on mathematical literacy. The functional use of basic mathematics (and arithmetic) was the key element. The aim was to contribute to the basic competences of students in dealing with everyday quantitative situations or problems. The focus on operations with numbers was reduced, and the focus on problem solving and modelling was intensified. This was an approach comparable with the approaches in PISA (mathematical literacy), and PIAAC[9] (numeracy) which were also emerging in the 1990s. Because of the practical nature of the numeracy envisioned, much attention was given to proportional reasoning, estimating, dealing with measurement, and using the calculator.

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[8]Wiskunde op de Basisschool (Mathematics in Primary School).

[9]Programme for the International Assessment of Adult Competencies.

11.2.4.4 Data Handling and Statistics

The new curriculum domain of data handling and statistics was focused on the ways data are collected, visualised and used in decision making. It could be considered as a kind of forerunner of dealing with big data. It contrasted with what was common in this domain. In the pre-1996 programme some statistics was mentioned, again with a strong calculational approach, for example, how to calculate mean and standard deviation and how to produce histograms and circle diagrams.

In the W12-16 curriculum, data handling and statistics was treated as mature and serious components of the mathematics curriculum. They were seen as increasingly important aspects of the mathematical competences students needed in their future lives. The focus also shifted from calculations to interpreting the large amount of numbers and data that is ubiquitous and used more and more in communication between people. This vision was quite new and innovative at the time of the change. As mentioned before, in those years, internet or the World Wide Web were not yet available.

11.2.5 From Mathematics for a Few to Mathematics for All

One of the pedagogical and didactical consequences of seeing mathematics as a human activity (Freudenthal, 1973, 1980) was that it allowed the engagement of every student, not only those who are cognitively privileged or with a strong inclination to mathematical thinking. Mathematics as a human activity is an inclusive philosophy for teaching, learning and doing mathematics.

In W12-16, there was a strong belief that every student should be involved in mathematics on an appropriate level. The change from more specialised topics to a broader view of mathematics and the shift to a broader range of topics was one way of making mathematics more accessible to all. This broader scope followed a worldwide tendency in mathematics education towards more usability. Whereas until the 1970s mathematics curricula were defined as subsets of the mathematical knowledge structure, from the 1980s on there was a global focus on the usability of mathematics, and therefore curriculum elements were sought which had visible applications, including arithmetic, proportions, measurement, data collection and chance. This was a fundamental change in designing curricula, because it made aspects of the real world the basis for the categorisation scheme rather than the logical structure of the mathematical domains (Kilpatrick, 1996; Niss, 1996).

11.3   Implementation

11.3.1   Implementation Theories

From literature on educational change there are many theories and studies that detail the conditions necessary to make curriculum change successful (Hargreaves, Lieberman, Fullan, & Hopkins, 1998). Nevertheless, there are also many reports that describe curriculum changes that have failed. In a most cynical way, implementation of new curricula worldwide is sometimes summarised as the 'fiasco pattern'. If the target group for the curriculum change is set at 100%, after a few years these outcomes are most common: 70% have heard of it, 50% actually saw it, 30% have read it and have the documentation, 15% use it, 5% use it according to the intention of the change and 0–3% use it and attain the intended effect on the learners.

However, the particular changes in mathematics education described in this chapter have reached maturity over a period of 25 years and have proven to be quite sustainable. The curriculum over this period did not stay completely unaltered, but it still contains some clearly recognisable elements of the original ideas and intended outcomes.

In the following sections this particular implementation of mathematics education is analysed from the perspective of theories of educational change. The purpose of this analysis is to reconstruct which elements of the implementation strategy had a positive effect on the sustainability of the change. A reference is made to the frameworks of Miles and Fullan, which undeniably already in the 1990s inspired and influenced the implementation of the new mathematics curriculum. Fullan (1982), Fullan and Stiegelbauer (1991), and Miles, Ekholm and Vandenberghe (1987) identified three broad phases in the change process: initiation, implementation and continuation. Most of these ideas even go back to the writings of Pierce and Delbecq (1977) on organisational change. The phases can be visualised as in Fig. 11.4, which is based on the work of Miles et al. (1987).

For each phase, the relevant factors from literature are highlighted and it is shown how these factors were addressed in substantial change in the mathematics curriculum in the Netherlands realised through W12-16 and SW12-16.
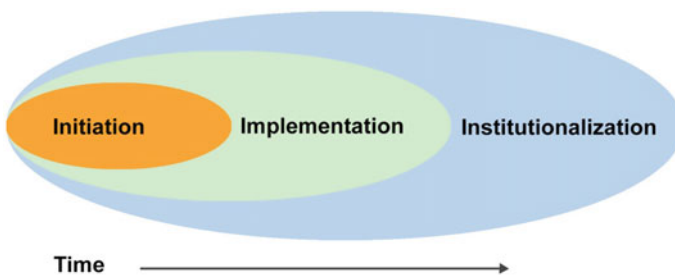
Fig. 11.4   The three overlapping phases of the change process (based on Miles et al., 1987)

11.3.2 Initiation Phase

According to the aforementioned frameworks of Miles and Fullan, the factors that affect the initiation phases include:

– Existence and quality of innovations
– Access to innovations
– Advocacy from central administration
– Teacher advocacy
– External change agents.

The quality of the innovation that resulted from W12-16 was to a great extent positively influenced by the thinking power of Hans Freudenthal. His thoughts about mathematics as an educational task (Freudenthal, 1973) influenced literally all the mathematics educators in the Netherlands and many mathematics educators abroad in the 1980s and 1990s. Access to the innovation for other schools was made possible through the publication of experimental lesson materials, through conducting a large number of information meetings, and through the two major Dutch journals on mathematics education which published monthly on aspects of the new curriculum. The Ministry of Education supported the reform and made funds available for pilot schools and development of experimental teaching materials. For the envisioned change a change in the formal, legislated, curriculum was also necessary. The Ministry of Education made that possible by changing the formal curriculum and the final examinations for pre-vocational secondary education (in the examination year 1996) with broad support from parliament. Moreover, the Ministry of Education commissioned and funded a committee to start with pilot schools. Through the work with pilot schools a group of mathematics teachers was created that acted as advocates for the reform. These so-called 'advocate teachers' also had an important role in the in-service teacher education activities. Most pre-service mathematics educators were also involved in the reform movement. Important external 'agents of change' were the in-service and pre-service teacher education institutions, the publishers, and the education inspectorate, who all supported the chosen vision.

The elements of this successful initiation were planned and documented in the W12-16 report *Operatie Acceptatie*[10] and involved a series of activities focusing on establishment of acceptance with all key stakeholders. At a conference in October 1989, which was attended by mathematics teachers and mathematics educators this idea arose. Members of the W12-16 team and the largest in-service teacher education institution APS were very much aware of the need to work carefully on creating support for the quite radical innovation. In Table 11.1 the most important activities of the initiation phase of W12-16 and SW12-16 are shown.

At the conference in October 1989, the first plans for an implementation strategy were formulated. In a series of follow-up consultations and meetings with a great number of stakeholders the contours for the implementation strategy were developed

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[10]Operation Acceptance.

Table 11.1 Summary of activities in the initiation phase of W12-16 and SW12-16

School year	Activities by W12-16	Activities by SW12-16
1987–1988	• Start W12-16 • Three development schools developed mathematics booklets	
1988–1989	• Development of mathematics booklets	
1989–1990	• Development of mathematics booklets • First draft of new mathematics curriculum • First pilot final examinations • Start of 'Operation acceptance'	
1990–1991	• Preliminary version of new mathematics textbooks • Regional information and information meetings • Second draft curriculum • Second pilot final examination	• Start SW12-16 • Start at 10 new pilot schools in the first year of secondary education • Introduction plan • Regional information and publicity meetings
1991–1992	• Regional information and publicity days • New curriculum • New mathematics textbooks • Background book for teachers: *Mathematics 12–16* • Third pilot final examination • End W12-16	• Pilot schools in the second year of secondary education • Regional information and publicity days

further. This strategy was taken over by the Minister of Education as is expressed by his statement:

> I request that special attention be paid to mathematics. The activities of the Commissie Ontwikkeling Wiskundeonderwijs[11] (COW) will be completed in the first half of 1992. On 1 August of that year, recommendations for a new examination syllabus for lower vocational education (LBO) and junior general secondary education (MAVO) shall be available, amongst other things. I intend to transform these recommendations into a definitive syllabus as soon as possible. With this in mind, I ask you now to carry out all the preparations in 1991 and to prepare the way for introduction as far as possible in order to enable a rapid introduction of the new examination syllabus. In order to promote a good connection, with regard to content, between development and support, I would ask that you also set up and carry out the above in consultation with the commission. (quoted by Kok, Meeder, Pouw, & Staal, 1999, p. 22) (translated from Dutch by the author)

The transition of initiation to implementation was marked by the mandate that was given by the Ministry of Education to set up a new commission. It marked the birth of the implementation team SW12-16.

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[11]Committee Developing Mathematics Education.

11.3.3 Implementation Phase

Fullan and Stiegelbauer (1991) identified three major factors which affect implementation: characteristics of change, local characteristics, and external factors. As summed up in Table 11.2, they identified different stakeholders at local, federal and governmental levels. They also identified characterisations of change for each stakeholder and the issues that each stakeholder should consider before committing to a change effort or rejecting it.

Although school leaders as well as policy makers supported the implementation of W12-16, mathematics education was often seen as troublesome with respect to the attained performance levels of the students and their motivation. Moreover, the formal and selective approach of the formal mathematics curricula were seen as opposite to an education that aimed for more equity, better motivation, and providing useful content for all students and not only for mathematically gifted students. To inform all involved as much as possible, the envisioned change was laid out extensively in pilot materials, new examinations and in courses for professional development of teachers. On all levels stakeholders were informed and they were all at least benevolent to the change.

During the implementation process the systematic effort to involve all stakeholders remained one of the key elements. One of the lessons learned from earlier curricular reforms was that forgetting one or more stakeholders will lead to major resistance, not just from the forgotten stakeholders, but from others as well. Strengthening ownership on all levels by involving stakeholders was seen to be of major importance. There were many stakeholders within this implementation, including teachers, school leaders, ministry officials, testing agencies, teacher educators, parents, publishers, policy makers and the media. A continuous and extensive dialogue through a series of meetings was a crucial aspect of involving these stakeholders.

In addition, in the implementation phase a strong need was felt to create and show good practices by 'regular' teachers in 'regular' schools. After an intensive tour of schools the SW12-16 team and APS agreed to experimentally introduce the programme in ten pilot schools and follow the progress with great care.

Table 11.2 Characteristics of change, local factors, and external factors

Characteristics of change	Local factors	External factors
• Need for change • Clarity about goals and needs • Complexity: the extent of change required for those responsible for implementation • Quality and practicality of the programme	• The school district • Community Board • Principal • Teacher	• Government and other agencies

11.3.4   Continuation and Institutionalisation

Continuation of an innovation is strongly dependent on the institutionalisation of key tenets of the innovation. Continuation depends on whether or not:

– The change is embedded/built into the structure (through policy/budget/timetable)
– The change has generated a critical mass of school leaders and teachers who are skilled and committed to the change
– The change has established procedures for continuing assistance.

In the case of W12-16 the combination of incorporating the changes in final examinations, in the major mathematics textbook series, and the incorporation in the teacher education programmes, both for in-service teacher education and for pre-service teacher education, was key to the implementation and the sustainability of the change. The networks of textbook authors, mathematics educators, and test designers overlapped heavily and made a relatively uniform interpretation of the new curriculum come to blossom. According to the implementation literature mentioned before, these kinds of complex changes in education take at least 20–30 years to come to full crystallisation. After 25 years one can analyse whether the change has reached the stage of institutionalisation.

   The next and final section discusses what results can be seen 25 years after the initiation of this mathematics education reform.

11.4   Reflection

11.4.1   How Sustainable Is the New Situation?

The changes in the mathematics curriculum since 1992 have been most sustainable and successful within the pre-vocational secondary education track of the Dutch education system. The programme has been running in this track for more than twenty years without any problems in classrooms or debates on the content. In the last twenty years, we can say that the students following this pre-vocational track did more mathematics with more usability, with better results, and with higher motivation than students in any other period in the history of mass education.

   As a serious indication of sustainability, the mathematics textbook series and the final examinations still reflect the essential tenets of the original vision. Figure 11.5 shows a task from the 2015 final examination for the pre-vocational intermediate track (VMBO-KB).

   As is shown in this examination task, most characteristics of the envisioned changes are still visible: based in reality, open-ended questions, and meaningful problems. At the same time, however, the change is still very vulnerable. In the last ten years, with the rise of social media, the persistent idea that children are performing poorly at mathematics and that this can be remedied with simple training and

A baby can be breastfed or bottle-fed. This task is about a baby who gets bottle-feeding.
To determine the required amount of feed per 24 hours for a baby under the age of 6 months, one uses a rule of thumb:
"A baby requires 150 ml bottle-feeding per kg bodyweight."
For example, a baby of 4 kg requires 4 × 150 = 600 ml bottle-feeding per 24 hours.

a. After a few weeks a baby weighs two times more than at birth.
The mother says her baby requires now 2 times more bottle-feeding
Calculate whether the mother is right by using the rule of thumb.
Write down your calculations.

b. Baby Luke weighs 3.8 kg at birth. Luke is given bottle-feeding every 3 hours, even at night.
Calculate how much ml bottle-feeding Luke needs a time. Write down your calculations.

c. Bottle-feeding can be made by yourself by mixing milk powder with water.
The milk powder container shows the data below.

number of level scoops + water	3 level scoops + 90 ml water	4 level scoops + 120 ml water	5 level scoops + 150 ml water	6 level scoops + 180 ml water
quantity of bottle feeding	100 ml	135 ml	165 ml	200 ml

The milk powder container shows more information:
Content 900 grams and 1 level scoop is 4.5 grams.
If Luke is three months old, he gets five times per day a 165 ml bottle.
Calculate how many days a full milk powder container will last. Write down your calculations.

Fig. 11.5 Exemplary task from final examination Wiskunde VMBO KB 2015 (pre-vocational secondary education, middle track, mathematics) (translated from Dutch by the author)

rote learning is still very much alive. See Van den Heuvel-Panhuizen (2010) for a report on this debate. In recent years, in the (social) media a framing can be witnessed that the educational change in the 1990s is to blame for the alleged low level of mathematics of today's students. This is in spite of results provided by international comparison studies like TIMSS, PISA and PIAAC, which consistently find the Netherlands performing quite high. But as is common in (social) media framings of education, assertions om low performance in mathematics are persistent and mainly fact free. This has led to a demand for rote learning, and a ban on the use of ICT-based mathematical tools. In the pre-vocational track of secondary education these demands did not have much effect yet because the curriculum proved itself to be useful for these students and their teachers support the practical and common-sense approach to mathematics.

In the higher tracks of secondary education, however, especially on tracks leading to university, there has been a recurring debate on the alleged low level of mathematics performances in the Netherlands since the late 1990s and the early 2000s, especially in regard to procedural skills. In the debate, we see many references to a 'backward utopia'. It is alleged that sometime in the past all students of all ability levels were able to execute all standardised procedural number and algebraic operations correctly

and fluently. This backward utopia, which arguably did never exist, has influenced the current mathematics curricula of lower and upper secondary general education through a re-incorporation of rote learning of algebraic skills. But more importantly, the discussion paralysed to some extent the further development of the didactical ideas introduced in the early 1990s and made it harder for teachers and prospective teachers to develop the skills necessary to make a more inquiry-based and guided re-invention-based mathematics education come to full blossom.

11.4.2   The Way Forwards

We have witnessed that the type of discussion in the media as described above has taken place in many countries over recent decades and will most likely pop up with every new generation of teachers, educators, mathematicians, and policy makers. If, for example, the now popular criteria of Hattie (2009, 2015) had been used to evaluate the work of the SW12-16 team the positive findings described in this chapter would never have been noticed. Luckily, a group of mathematics educators who had a critical mass in the Dutch educational infrastructure believed that mathematics education should be for all and envisioned a mathematics education that ensured usability.

In 2016, in the Netherlands a campaign entitled Onsonderwijs2032[12] is being launched for a curriculum reconsideration in the coming years. Its title reasons that students who enter education today will enter the workforce in 2032. In this campaign three major functions of education are emphasised. The Dutch philosopher and educator Biesta (2010, 2013), amongst others, strongly advocates a renewed focus on these functions: qualification, socialisation and subjectification. Biesta pleads for a greater focus on subjectification as the opposite of socialisation and calls for the uniqueness of each individual human being to be acknowledged. In the advice report for Onsonderwijs2032 (Platform Onderwijs2032, 2016) the goals are presented in a less philosophical way. The report emphasises the relevance of (1) development of knowledge and skills, (2) equipment for future society, and (3) personal development.

In this perspective, RME is more than ever a relevant approach to mathematics education and matches more general developments in education. There is a tendency worldwide to involve all students in mathematics, and RME can offer relevant content as well as an approach that contributes to the aspiration for all students to be involved in mathematics. RME is in that regard still one of the most widely known instruction theories for mathematics education. The broadened scope and the focus on mathematics as a human activity are also relevant in today's world because of the new focus in education on personalised learning and on students creating their own personal learning trajectories.

In the Netherlands, most mathematics educators ignore the current superficial framing in the media and continue designing and developing meaningful mathematics

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[12]Our education 2032.

education alongside international partners that share a vision for ensuring inspiring, meaningful and sensible mathematics education for all students. Good practices in RME can function as examples for the new tendencies in (mathematics) education in the decades to come.

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