THE POWER OF MATHEMATICS EDUCATION IN THE 18TH CENTURY

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In the Dutch Republic in the 18th century mathematics was considered very important for many professions. However there were hardly any national or regional educational institutes which provided mathematics education. Three orphanages in different towns received a large inheritance under condition that they provided education for technical and artistic professions. The Foundations which were established had a curriculum in which mathematics was the main subject. The influence of several curriculum components and some external curriculum factors are recognisable in documents and archival data. This is illustrated by the history of one student.

THE *FUNDATIE VAN RENSWOUDE*

During the 18th century in the Dutch Republic mathematics was considered very important for professions such as navigation, architecture, the technical weapons, shipbuilding, water management and also fine arts (Van Maanen, 2006). However there was a serious shortage of mathematically trained professionals. The main reason for this was the absence of national or regional institutions which offered mathematics education (Beckers, 2005; Boekholt & Booy, 1987). The example of the Dutch Engineering School at Leiden University in the 17th century (Krüger, 2010) had resulted in lectures in Dutch language on fortification, navigation and architecture at a few institutes for higher education. But they occurred only intermittently and were not for those on a low income. Professional education was mainly left to individuals, the quality varied and the fees could be high. The Dutch adopted a religious form of Enlightenment; they believed in progress through mathematics and science, which also revealed God's work. Many saw the value of education, also for poor people; initiatives of wealthy individuals, of learned societies and of local government became more common in the Dutch Republic during the 18th century (Dodde, 1991; Roberts, 2010, Smid, 1997). An early example of such an initiative is the legacy of Maria Duyst van Voorhout, baroness of Renswoude: in 1754 three orphanages, in Utrecht, Delft and The Hague, each inherited about 500 000 Dutch guilders (HUA 771, inv. 3). The main condition was that the money should be used to select talented orphan boys, at least 15 years old and teach them separately from the other orphans in:

> Mathematics, Drawing or Painting Art, Sculpture or Stone Cutting, practices in building dykes to protect our Country against floods or similar Liberal Arts….

It seems that Mathematics was meant as a profession, but also as the main subject taught: all the professions mentioned used mathematics in some way. Some of the

other conditions were that the capital should be administered by an independent administrator and that the governors of the three orphanages should meet at least once a year (HUA 771, inv. 1). As a result, in 1756 three Foundations were established, each called *Fundatie van Renswoude* (in full: Foundation of the Baroness of Renswoude), with communal rules, the General Regulations (HUA 771, inv. 5). The archives of the Foundation in Utrecht are well preserved, they provide much information about the intended and implemented curriculum. A question one may ask is:

Which factors influenced the curriculum of this Foundation?

The main subject in all three Foundations was mathematics or rather mathematical sciences. When one analyses the available information on the curriculum many curriculum components, which are distinguished in present day research, are recognisable. In this paper I will discuss some of these components, but also some other factors which were of notable influence on the curriculum of the Foundation in Utrecht. This will be illustrated by the history of one of their students, Dirk Kuijper.

CURRICULUM RESEARCH

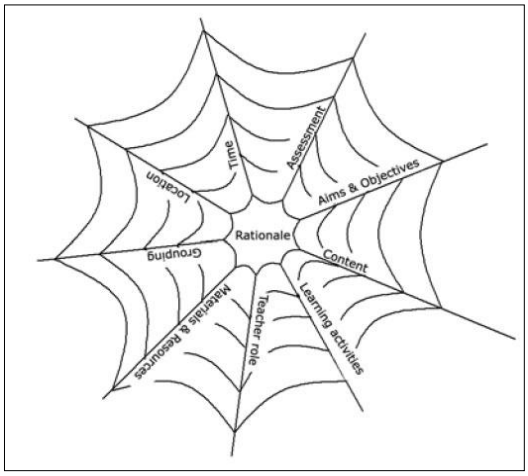

Fig. 1: Spiderweb model

A useful model to describe curriculum and its components is the spiderweb model used by Van den Akker (2003). Characteristics of the spiderweb model, which has ten components, are the visibility and influence of these components in the intended and/or implemented curriculum and the interconnections between the various components. If one component changes this effects some or all of the others and each component may be influenced by others (fig. 1). In this paper I add the component Harmonisation, as this is mentioned explicitly in all documents of the intended curriculum. For instance, the governors of the three Foundations were to discuss the state of affairs and progress in the three institutes regularly. Harmonisation influenced the choice of the mathematics teacher in Utrecht, the content of the mathematics curriculum, the choice of some learning materials etc. See table 1 for an overview of 11 curriculum components.

Rationale	Why are they learning?
Aims & Objectives	Toward which goals are they learning?
Content	What are they learning?
Learning activities	Through which activities are they learning?
Teacher role	In which way does the teacher facilitate the learning?
Learning materials	With what materials are they learning?
Grouping	With which students are they learning?
Location	Where are they learning?

Time	When and for how long are they learning?
Assessment	How far has their learning progressed?
Harmonisation	Is the learning coherent with the larger curriculum?

Table 1: Components of the curriculum, based on Van den Akker (2003)

There are other factors which are influential, but a major difference with the curriculum components in table 1 is that the influence is mainly one-way. I call them external factors. Some examples are in table 2. 'Transition' refers to the preparation of students for the next stage of their life, after completing the curriculum.

Students	Who are learning?
Finance	Which financial means are available to facilitate learning?
Transition	In which way is the start of students in the next stage facilitated?

Table 2: External factors

The influence of curriculum components (table 1) and external factors (table 2) are to some extent illustrated by the history of student Dirk Kuijper.

DIRK KUIJPER (1766 – 1830) AND THE *FUNDATIE VAN RENSWOUDE* [1]

Fig. 2 Dirk Kuijper

Dirk came into the care of the town orphanage on 3 May 1769, when he was about three years old. Thirty years earlier, his prospects would have been rather bleak. However, since 1756 the Foundation, of which the big house was situated next to the orphanage, was to select some talented boys to educate them for a technical or artistic profession. As at the start, in 1756, only some of the boys of the right age (15 – 18 years old) could read a little and none could do arithmetic, the governors had appointed a carefully chosen teacher to teach the eligible boys reading, writing and arithmetic. This was the preparatory school and in 1773 Dirk was one of the 22 boys in the preparatory school, with ages ranging from 5 – 15 years old (HUA 771, inv. 37).

The mathematics instructor (mathematics teacher) of the Foundation, Laurens Praalder, was the main teacher and also the supervisor of the Foundation school. He visited the preparatory school at least once a week to watch progress and to discuss with the teacher the potential of each boy. Once a year the governors asked his advice on which boys should do an admission exam to assess if they qualified for entrance into the Foundation. On 28 April 1779 Dirk was one of four boys who was allowed to take the exam, which consisted mainly of arithmetic. On 11 June 1779 the board of governors admitted Dirk, 13 years old and one other boy, who was 12 at the time. The average age on admission was 15 years.

Mathematical education

The education process in the Foundation was structured into three phases. During the first phase, which lasted about two years, teaching would be in small groups and the program was the same for all the students. After about two years, depending on the progress of the individual student, a profession would be chosen. In most cases the

Fig. 3 Large lecture room

student would start in a part time apprenticeship with a work master, while continuing theory lessons in the Foundation in the evenings and during some afternoons. The third and last phase would usually consist of a fulltime apprenticeship, preferably in some other part of the country or abroad. During the first two years Dirk would have about 32 hours of lessons per week, of which at least 20 were taught by the mathematics teacher. Drawing lessons, by the drawing master, took eight hours and the remaining hours were spent on writing, French language and religion. Outside teaching hours there was homework to do, mathematical exercises, drawings to finish, etc. Lessons took place in the large lecture room (fig. 3), homework was made in the dining room, under supervision. In both rooms books and writing materials were available; the mathematics teacher also liked to do practical exercises with the students, preferably based on measurements in the environment (Krüger, 2012). In spring 1781 Dirk had been nearly two years in the Foundation, he had made sufficient progress to choose a profession and start an apprenticeship. Governor Eyck, who always was very concerned about the students, reported in the governors meeting that Dirk would like to become an instrument maker. However at the time there was no suitable instrument maker in Utrecht willing to take on an apprentice. So the governors decided that Dirk should stay with the mathematics instructor and study mathematical subjects as a general preparation for technical professions. Dirk was to study with Praalder for four more years.

In February 1785, after 5½ years in the Foundation, Dirk had studied the following mathematical subjects: Arithmetic (whole, rational, irrational and decimal numbers, calculating roots and powers of numbers), Geometry (at least Euclid I - VI), Algebra, including linear and second degree equations and series, the theory and practice of Surveying, including trigonometry and the use of logarithms, Civil and Military Architecture, Mechanics and Geography.

The importance of social and cultural education

Mathematical subjects were very important, but not sufficient to succeed. Dirk also learnt to draw, both technical and artistic drawing, French language and how to write properly. Students would need these skills in most of the professions for which the Foundation provided education. They also needed the skills to maintain a position on a middle class level of society. So like all students Dirk learnt proper table manners, how to read a newspaper, how to behave in company and similar skills.

Specialisation

The mathematics instructor also advised the governors on a choice of profession for the students. In the course of 1784 Laurens Praalder suggested that Dirk might

become an army engineer. That was unusual for the Foundation in Utrecht, no student had yet been allowed to choose that profession. Perhaps the fact that the Director-General of the Fortifications, Carel Diederik Du Moulin, some of the governors and the secretary-administrator of the Foundation had become members of the Provincial Utrecht Society (PUG) had something to do with this new possibility of career choice for the students. PUG, a scientific Society, was established in 1773 by Laurens Praalder and Van Haeften and attracted a good number of members (Van Haeften, 1781). Du Moulin was very much in favour of mathematical instruction for officers in the army. On 1 December 1784 the governors decided that Praalder should contact Du Moulin to enquire if he would be willing to take on a student of the Foundation. At the meeting of the governors on 26 January 1785 they heard that Du Moulin would be happy to take two students. Unfortunately Dirk was ill at the time, but on Wednesday 9 February there was an extra meeting to discuss a letter of major-engineer Kupfer, who supervised improvements of the Grebbe defence works. The major expressed his hope that Dirk would soon be well, he described the work Dirk would have to do, mainly surveying and the instruments Dirk would need, surveying tools. The doctor declared that Dirk was well again and the mathematics teacher declared that Dirk was competent to execute the work described by the major. So the governors decided that Dirk should leave the next Saturday, with a warm coat, field maps, a suitcase with the necessary clothes and linen, a good quality surveyor's chain, a surveyor's level and an astrolabe. Dirk was to write every eight days to report on the spending of the pocket money he received and on his whereabouts.

Apprenticeship and politics

During 1985 Dirk worked as an apprentice-engineer for the army. Some of his letters are kept in the archives (HUA 771, inv. 38); he wrote on the work he was doing and where he was staying. Major Kupfer wrote a letter on 21 September 1785, towards the end of Dirk's first year, in which he was very positive; he mentioned his diligence, good behaviour and skills. Kupfer proposed to employ Dirk in the army, in that way he could earn some income as well. The governors decided to decline this offer. The Foundation was responsible for her students until they could earn an income which allowed them to be independent and they considered Dirk too young to be left on his own. On 28 December 1785 Dirk was back in the Foundation home as the army had its winter stop. Dirk continued to study theory of military engineering. In the spring of 1786 Dirk worked under guidance of captain Ulrich Huguenin, who also appreciated Dirk very much and who in the years to follow would be important for his career. Huguenin had studied mathematics while in the army and had also taught mathematics at a private school for artillery officers. Like Du Moulin he considered knowledge of mathematical sciences very important. Dirk also started to learn German during that year, on his own request. Possibly Huguenin had advised him on this to enable him to study the German military literature. Huguenin was in the artillery, so this meant for Dirk a change from military engineering to artillery. Huguenin also proposed to let Dirk enrol in the army. But by now the political

situation had changed, in October 1786 the patriots had come to power in Utrecht. As a consequence the governors of the Foundation were either patriots or neutral, as most Orangist governors were replaced by patriots. The army in principle supported the Orangists, so the governors could not allow a student of the Foundation to fight in the army against their patriotic comrades. Dirk was not allowed to continue with his work for the artillery, he remained in the Foundation; during 1787 he supervised defence works and enlarged a map of Utrecht, on order of governor Eyck, an active and popular patriot. In September 1787 the Prussian troops intervened, the Patriots lost power and a number of them, like governor Eyck, went into exile for some years. Most patriotic governors were replaced by Orangists, so a military career became again a possibility for Dirk. In December 1787 governor Kien told the meeting that he recently had met captain Huguenin who had expressed his regrets that Dirk Kuijper had not returned into the army. The governors decided at once to invite Huguenin for a dinner and to tell Dirk about the good opinion captain Huguenin had expressed. Soon after it was decided that Dirk should train as an artillerist, but in accordance with the regulations he remained a student of the Foundation for the time being. That meant that the Foundation paid for most of his cost of living and study.

The start of a career

On 27 February 1788 Dirk left for The Hague. As was common in the army he moved around frequently and was often short of money, as life in these army towns was expensive. Early in March he bought *Anfangsgründe der Artillerie*, by K.A. Struensee, on advice of captain Huguenin; which meant he had by now sufficient command of German language to study German textbooks (fig. 4). He also wrote that he hoped to be taken on as cadet-bombardier on 25 March, which would mean that he earned *f*2,- a week, about 40% of the amount he needed for board and living. From then on his career went well. Huguenin had been right about the possibilities for Dirk in the artillery, though the financial rewards were small at first. In 1788, possibly under pressure of the political situation, the stadtholder agreed to establish three Artillery Schools. In May 1789 when Dirk was in Breda, with Huguenin, he was promoted to lieutenant-to-be. Soon afterwards Dirk also became a junior teacher at the new Artillery School in Breda, with Huguenin as Director. He still had to study hard to be able to fulfil for the demands of his teaching position, the Foundation paid his bills of a German bookseller. In August 1790 he became lieutenant and tutor at the Artillery School, which enabled him to become independent. He was dismissed

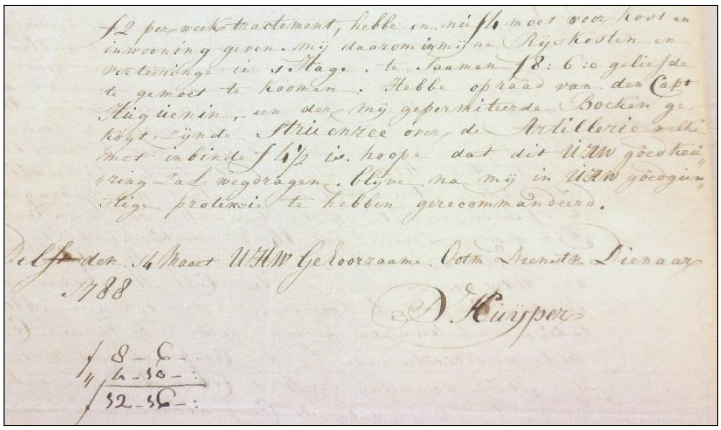

Fig. 4 Letter by Dirk Kuijper, 14-3-1788

with honour from the Foundation. In December 1790 he married a wealthy orphaned young lady, ms Stuerman, from Baarle Nassau. In 1795 he became director of the Artillery School in Groningen. In that position he in his turn admitted and taught some students of the Foundation.

Learning materials

Learning materials were considered very important by teachers and governors. They consisted of students notes, many books and also instruments, such as surveying tools, compasses, drawing utensils and gauging rods. Laurens Praalder wrote his own teaching texts to use during the first and part of the second phase (Krüger, 2012). The students made extensive notes, during the first phase they may have used books during homework time. In phase two and three they needed more specialized books for their future profession. While the Foundation was quite willing to pay for books for their students, on average only 3,6% of the yearly expenditure was spent on learning materials (Table 4). The cost for Dirks books was above the average. Information about these come from an inventory Dirk made in January 1787, from his letters and from the invoices of the booksellers (HUA 771, inv. 38, inv. 90, inv, 103, inv. 129, inv. 130).

On 24 January 1787 Dirk possessed some mathematics books all students used, on algebra and *Euclid* in the edition of Warius. He had *Werkdadige Meetkonst* by Morgenster & Knoop, a leading book on trigonometry and surveying (Van Maanen, 2006), which was used by many, but not all of the students. Dirk also possessed at that time five books on military architecture; one in the style of the Dutch military architect Menno van Coehoorn, which used mainly geometry; one in the style of the French military architect Sebastian le Pretre de Vauban, published in 1784, in which book algebra was combined with geometry. These books represented different points of view on military architecture and also different mathematical approaches. He possessed a French grammar and a German-Dutch dictionary. During 1786 and 1787, during the period of the patriots, the governors bought three books of B.F. de Belidor (*Sciences des ingenieur, Le bombardier francois* and *Nouveau cours de mathématique à l'usage de l'artillerie*). This suggests that Dirk's command of French was at least sufficient to study from these more specialised books. In 1788 Dirk bought *Anfangsgründe der Artillerie*, by K.A. Struensee, see fig. 4. In 1789 in Breda he purchased *Magazin für Ingenieur und Artilleristen*, 11 volumes, by A. Böhm; *Lehrbegriff der gesamten Mathematik*, 8 volumes, by W.J.G. Karsten and *Mémoires d'artillerie : contenant L'artillerie nouvelle* by H.O. Scheel. So from 1787 on he used more specialised military literature, which was written in French or German. But he also bought the eight volumes of a general mathematics publication in German. This extensive work by Karsten is still available in print.

Finance [2]

Finance is rarely a topic in research on mathematics curricula. However, the financial means available were very important in the 18th century, as they are today. The amount of money at the start of the Foundation was a factor which permitted the building of a home suitable for physical care and for education. The financial situation also made possible to engage good quality teachers who were well-paid. At least as important was financial management, which in Utrecht became more professional from about 1771. From 1772 – 1809 on average the yearly income and expenditure of the Foundation were in balance, both slightly more than *f* 15000 (HUA 771, inv. 89 – 92). In 1810 the income was severely reduced, due to French regulations (Table 3).

	1772 – 1809, average	**1810**
Income	*f* 15909	*f* 6938
Expenditure	*f* 15378	*f* 11660

Table 3 Average income and expenditure of the *Fundatie van Renswoude* in Utrecht.

Between 1772 and 1787 there are sufficient data to estimate the relative expenditure of some entries and their range (HUA 771, inv. 89, 90). See table 4.

	Average of total	minimum	maximum
Household and clothing	30,6 %	*f* 4011	*f* 5506
Salaries	24,9 %	*f* 3686	*f* 4202
Workmasters	6,5 %	*f* 250	*f* 1705
Learning materials	3,6 %	*f* 226	*f* 1076
Pocket money etc.	2,7 %	*f* 188	*f* 806
Gift at dismissal	4,7 %	*f* 54	*f* 2695
Students abroad	4,1 %	*f* 0	*f* 2494

Table 4 Yearly expenditure 1772 - 1787

During this period costs of household and clothing were on average 30,6% of the total expenditure; salaries of teachers and personnel were on average nearly 25% of total expenditure. The salary of the mathematics teacher was by far the highest, *f*1500. The costs of work masters fluctuated, but over the years the relative cost increased, from about 1,5% to about 10% of the total expenditure. Learning materials included paper, writing utensils, books and some instruments, the cost fluctuated, but there is no trend visible. A student who became independent and thus was dismissed, usually received equipment and money to assist him in the start of his career. The remainder of the expenditure, ca 22% of total cost, was for maintenance of the building, interest, administration, costs of meetings, etc.

Dirk Kuijper paid on board and lodging on average *f* 5 per week. He received some income from the army: about *f* 2:10 per week. The additional funding by the Foundation also was *f* 2:10 each week. The Foundation also paid for travelling costs, books and clothes. In January 1789, when he got promoted and had to make extra costs, he received an additional *f* 250. On his promotion to lieutenant and his appointment as a tutor at the Artillery School, in August 1790, his salary became *f* 49 every six weeks, which was sufficient to become independent. He was dismissed from the Foundation on his own request and received *f* 350 as the remainder of his dismissal gift.

DISCUSSION

In the curriculum of the *Fundatie van Renswoude* in Utrecht the curriculum components (table 1) and external factors (table 2) are clearly recognisable, perhaps with the exception of grouping. In Utrecht, but also in Delft the selected boys were cared for and educated in a location close by but separate from the orphanage. As a result it became possible to give these students not only a sound mathematical education, but also a social and cultural education, thus facilitating the transition to their future profession and position in society. This is illustrated by the history of Dirk Kuijper. There are no indications that this student was exceptionally gifted, but he did well in mathematics, he was willing to work hard and to learn an extra language. He would very probably have remained a labourer all his life if the Foundation had not only offered him the opportunity to learn mathematics quite well, but also to learn languages and social skills. To start with he studied the mathematics every student had to: arithmetic, Euclidian geometry and some algebra. While he was taught by Laurens Praalder he also learnt surveying theory and practice, military architecture and mechanics. This made a career as an engineer in the army a possibility. During 1785 – 1786 the Foudation bought several books on military architecture and engineering for him. Mainly in Dutch but at least one book in French. From 1787 on there are only invoices on French and German mathematical publications for Dirk, specialist books on artillery and military engineering, but also general mathematics publications. Dirk made good use of the French lessons and the German he learned to become more accomplished in the mathematics he needed and in this way enhanced his chances to make a good career. Also very important was the financial support by the Foundation until he could earn an independent living in his profession. In the 17th century the Dutch Engineering School at Leiden University had similar aims as the *Fundatie van Renswoude*, though restricted to the training of surveyors and military engineers (Krüger 2010). Most of the curriculum components and some external curriculum factors are recognisable in the curriculum of the Engineering School as well. It might be worthwhile to compare these and other curricula with respect to these components and factors and the possible influence they may have on the success of a curriculum.

NOTES

1. Sources: Hua 771, inv. 11, inv. 12 (resolutions of meetings of governors), Langenbach (1991), unless otherwise stated.

2. A guilder (*f*) was 20 pennies, so *f* 2:10 is two guilders and 10 pennies, or two and a half guilders.

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