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THE IMPLEMENTED AND ATTAINED MATHEMATICS CURRICULUM: SOME RESULTS OF THE SECOND INTERNATIONAL MATHEMATICS STUDY IN THE NETHERLANDS

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Introduction

From November 1977 (till March 1983) the Netherlands participated in the Second International Mathematics Study (SIMS) of the International Association for the Evaluation of Educational Achievement (IEA). In this article a global description of this project and its results are presented. Attention will be especially focused on the relationship between the implemented and attained mathematics curriculum.

The SIMS is an IEA project. IEA is an international organization with about 40 member countries. Since the early sixties IEA has been involved in multinational research projects. At first, attention was focused on the study of the outcomes of education in several disciplines. In recent projects a wider range of educational research questions has been studied. Twelve countries took part in IEA's first project: the first mathematics project. The results of this study are reported internationally by Husén (1967).

In the period 1970-1975 the Six Subject Study was undertaken. This investigated reading comprehension, science, civics, English (as a foreign language), French (as a foreign language) and literature. The results of this study are reported in 9 volumes of the International Studies in Evaluation.

Background of the Second Mathematics Study

In the sixties important changes in mathematics education took place all over the world. Changing opinions about the content and the didactics of school mathematics were the starting point of a profound revision of the mathematics curricula (see e.g. Treffers, 1978). In many countries these developments stabilized in the beginning of the seventies. The second part of this decade is therefore a good period for a state-of-the-art study of mathematics in the schools.

The major aim of the project is to give a description of the relationships which exist between (a) the mathematics program (what is the content and the context of mathematics teaching?), (b) the affective and cognitive results of the students (what is the output of mathematics teaching?) and (c) the teaching-learning process (in what way is the output achieved?).

We can study the mathematics curriculum on three different levels. On the first level we have the intended curriculum, as specified in the official documents of a country. The second level is the curriculum as implemented within the schools and the classrooms. In the actual mathematics lessons the intended curriculum is given its concrete form. Here the time to be spent on the parts of the curriculum, the didactcs and the methods are determined. Finally, we have the attained curriculum: the (affective and cognitive) objectives the students have attained. In the study the content of each of these levels is described and the relationships between them are investigated. Each curriculum level is a special object of study in certain parts of the SIMS (see figure 1). In this figure is also indicated on which level data are collected.

	Study component	Object of study	Data from
I	Curriculum-analyses	Intended Curriculum	Countries (educational systems)
II	Classroom processes	Implemented Curriculum	School and Class
III	Outcomes	Attained Curriculum	Student

FIGURE 1: Schematic View of the Study

In the curriculum analysis part of the study, attention is paid to the content (i.e. the topics in school mathematics) and the context (e.g. school system, examination system) of the intended mathematics curriculum. In this paper we will not deal with these analyses; see Steiner (1980) for the first results.

The study of the teaching-learning processes within the classroom is (amongst others) directed to the description of the implemented curriculum, the methods used and the didactics applied in these methods. In the third part of the study the cognitive and the affective results of the students are assessed in relation to the intended and implemented curriculum and several other variables (e.g. hours spent on home work and gender).

Summary Design and Instruments

In the next sections only those data about the design of the study are mentioned which are necessary for a good understanding of the results presented later.

The Design of the Study

Twenty-one countries participated in the SIMS. The design of the study was a result of discussions between the participating countries. Each country could take part according to the complete international design or only in parts of the study.

The Netherlands decided on a limited participation in the SIMS, by restricting itself to one of the two internationally proposed populations. The international definition of this population (population A) is: all students in the grade level where the majority has reached the age of 13.00 - 13.11 by the middle of the school year. In the Netherlands this population was determined as the second year of secondary education (US-grade level 8). In the Dutch school system a number of different schooltypes can be distinguished at this grade level. First of all we can distinguish between school types which offer a general education and school types which offer elementary vocational education (LBO).

TABLE 1: School Types and Enrollment Percentage at Grade Level 8. (May 1981).

School Type	Enrollment % in level 8 (N=276.807)
Pre-university education (VWO)	11,2
Higher general education (HAVO)	9,5
Intermediate general education (MAVO)	33,2
Elementary technical education (LTO)	11,2
Elementary nautical education (LNO)	0,2
Elementary domestic science education	9,2
Elementary agricultural education (LLO)	2,2
Elementary trademan's education (LMO)	1,2
Elementary commercial education (LEAO)	2,7
Combination HAVO-VWO	4,4
Other combinations	14,0

In table 1 the major school types are listed accompanied by the percentage of grade level 8 students who are in these school types. VWO, HAVO and MAVO are different streams in general education, while LTO, LNO, LHNO, LLO, LMO, and LEAO are different streams within elementary vocational education (LBO). In general students have different courses in each school type from grade level 7 in the Netherlands. But exceptions are possible, which are expressed by the "combination-types" displayed in table 1. Within these schools choosing for a specific school course is postponed until at least after grade level 8. The combination HAVO-VWO is the most common combination.

One of the major goals of the Second Mathematics Study in the Netherlands was to compare the major school types with respect to implemented and attained curriculum. Because the mathematics courses in HAVO and VWO hardly differ at grade level 8 and because of the enrollment figures (see table 1) the population which was actually considered in SIMS consisted of all students in the second year of HAVO-VWO, MAVO, LTO and LHNO. Using a stratified random sample of classes from this population, the study was conducted in May 1981.

Table 2 contains the numbers of teachers and stuaents participating in SIMS. The willingness of schools, teachers and students to cooperate was very high: about 98% of the distributed instruments were completed and returned.

TABLE 2: Number of Participating Teachers (Equal to the Number of Schools) and the Number of Students.

	HAVO-VWO	MAVO	LTO	LHNO	Total
Teachers	60	70	57	49	236
Students	1515	1718	1276	991	5500

For statistical reasons it was decided to sample a larger number of schools (and so teachers and students) in two types of elementary vocational education, LTO and LHNO, than was needed for a sample proportional to size. The large numbers allow us to make precise estimations of variables for each of the school types in the project.

Instruments

The following test and questionnaires were used:

1. Cognitive tests
2. Student background questionnaires
3. Teacher questionnaire "Opportunity to Learn"
4. Teacher background questionnaires
5. School questionnaire

For this paper especially instruments 1 and 3 are of importance.

The cognitive tests consist of 176 five-choice items. Each student answered 74 of the 176 items, by taking a test of 40 items, which was the same for all students (core test), and one of the four 34 item tests, each of which was designed for a quarter of the students (rotated forms).

In the "Opportunity to Learn" questionnaire several questions were posed to investigate whether the subject matter, represented by the respective items, was taught to the students or not. In other words: did the students have an opportunity to learn the subject matter represented by that item? In the Netherlands, for each item teachers had to indicate in which of the following periods the subject matter concerned was or should be taught:

1. Primary school
2. 1st grade secondary school
3. 2nd grade secondary school: before Christmas
4. 2nd grade secondary school: after Christmas (but before the date of data collection)
5. 2nd grade secondary school: after the date of data collection
6. 3rd or higher grade secondary education
7. never

To eliminate from this rating the hidden estimation of the difficulty of the item for a particular class, the teacher was also asked to estimate (per item) the percentage of students in his/her class who should be able to answer the item correctly without guessing.

Results

The second Mathematics Study data bank contains data on various aspects of the mathematics curriculum, especially for the second year of secondary education in the Netherlands. These data can be used in several ways: they give base line information for the year 1981, as well as the possibility of several exploratory data analyses which could result in generating hypotheses for future research. In this chapter we restrict ourselves to presenting some data on the actually implemented and attained mathematics curriculum in Dutch classrooms.

Number of Weekly Lessons in Mathematics

The Ministry of Education in the Netherlands does not prescribe the number of lessons per week (of 50 minutes) in mathematics for the second year of secondary education. In fact there are only regulations on the total number of mathematics lessons during the total duration of a school type. E.g., in MAVO, which has a 4-year course, it is prescribed that the total number of weekly lessons of mathematics is at least 7. Schools are free in the way they spread these 7 or more lessons over the grade levels. For this reason it is interesting to describe the actual situation in grade level 8.

In Figure 2 we see that the number of weekly mathematics lessons varies between as well as within school types. Although the mode in all school types is 3 lessons per week, we see that the number of lessons slightly decreases from HAVO-VWO, MAVO, LTO to LHNO. The great variation between schools in LTO is striking.

Time Devoted to Mathematics Topics

As a consequence of the national examinations and their associated programs at the end of each school type and because of the use of the available mathematics textbooks, within a school type there is some uniformity in mathematics curricula in the Netherlands. On the other hand schools and teachers have much freedom to determine which mathematics topics will be taught at which time and with what emphasis in the mathematics classroom. Until now no systematically gathered information about the actual time devoted to mathematics topics has been available. To get an impression of the emphasis which is given to mathematics topics, teachers were asked to estimate the total number of hours during a year devoted to 14 mathematics topics. This kind of time estimation has some disadvantages. Firstly there is a possibility of overlap between the topics, and secondly, it is known that retrospective judgement of time allocation is not very reliable. But when we use these data only in relative, rather than in absolute, terms they are appropriate for descriptive purposes.

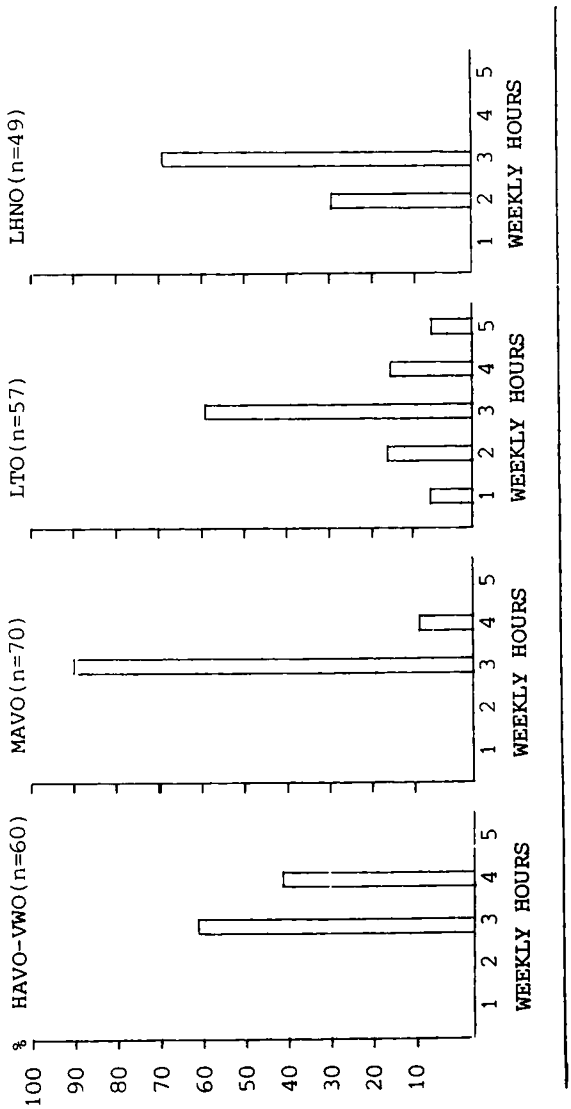
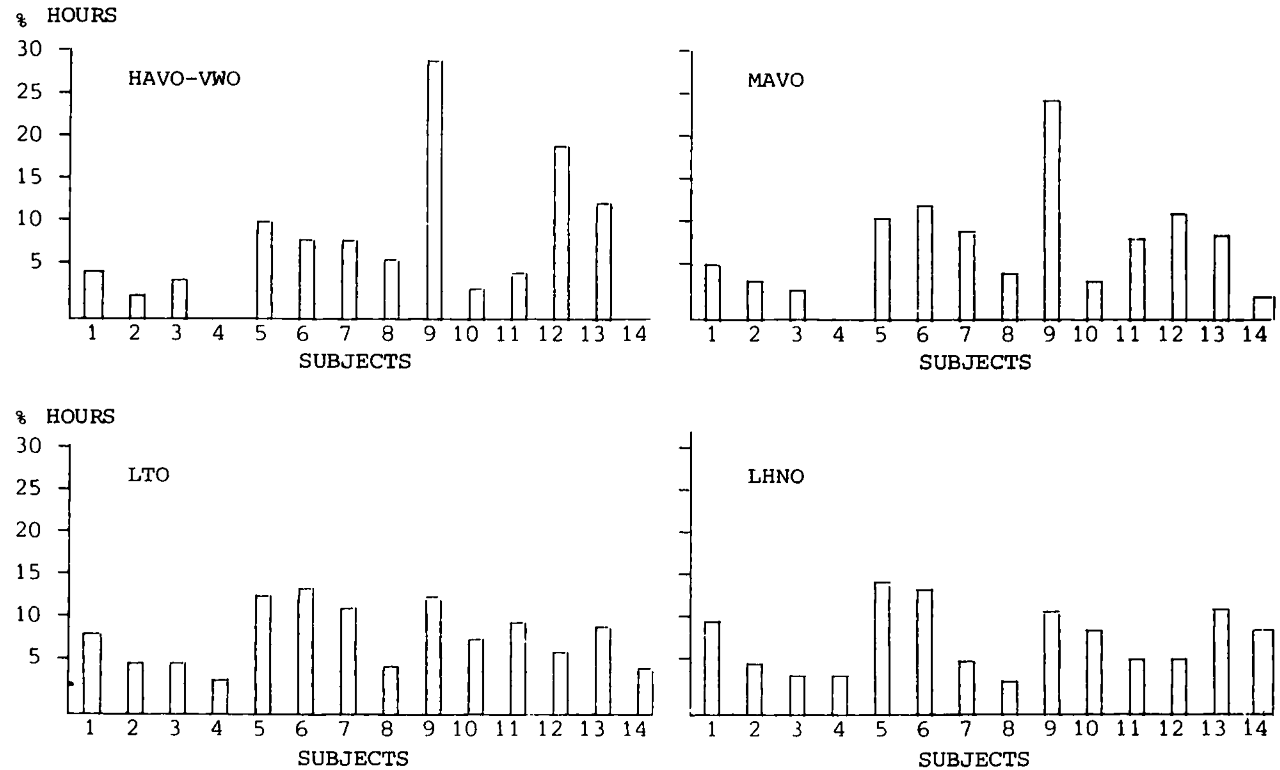


Figure 2. Population A- distribution of the number of weekly hours in each school type.



1. common fractions
2. decimal fractions
3. ratio and proportion
4. percent
5. measurements
6. geometry, plane figures
7. geometry, informal transformation
8. geometry, other topics
9. formulas and equations
10. integers
11. powers and exponents
12. rational and real numbers
13. sets
14. probability and statistics

Figure 3. Population A- relative allocation of hours for each mathematics subject in each school type.

Figure 3 shows some striking differences between the school types in the relative allocation of time to various mathematics topics.

In the general school types (HAVO-VWO and MAVO) there is much emphasis on formulas and equations. In elementary vocational education (LTO and LHNO) the time is spread over many topics in comparison with HAVO-VWO and MAVO. Furthermore, it becomes clear that the topics, probability and statistics, and percentage calculations have more emphasis in elementary vocational education than in general education.

The Implemented Curriculum

In analyzing the opportunity to learn data at the item level it becomes clear that within, and also between, the school types there is a large variation in teacher judgement of when mathematics subject matter is or was taught. The results of aggregating these data to the forty core test items are given in Figure 4.

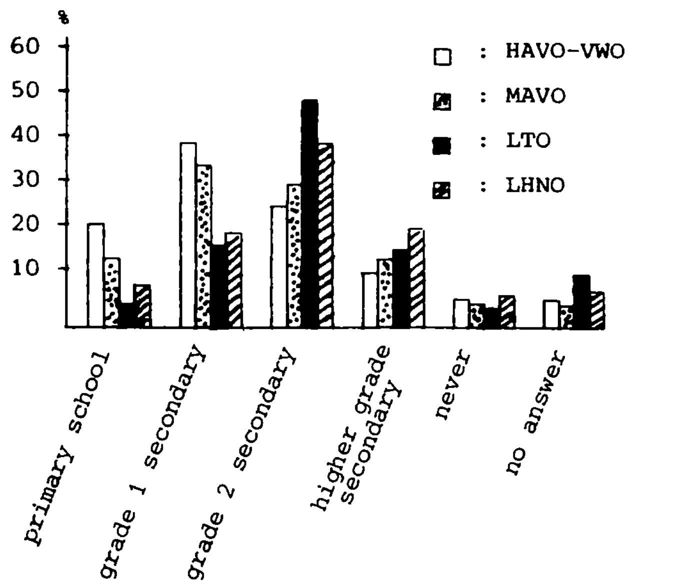


FIGURE 4: Percentages Answers (averaged over 40 core-items) from teachers to the question asking when the subject matter related to these items was taught to students in their class.

Notable in Figure 4 is that the cognitive items fit the Dutch mathematics curriculum fairly well, because the percentages in the categories "never" and "no response" are relatively low. Furthermore it is clear that in general education (HAVO-VWO and MAVO) mathematics subject matter is taught earlier than in elementary vocational education. Finally it is apparent that more teachers in general education believe that mathematics subject matter is taught in primary schools than do teachers in vocational education. This could mean that in vocational education quite a few primary school mathematics topics are repeated.

The Attained Curriculum (Knowledge of Students)

In Table 3 the results on the mathematics tests are summarized. Means of percentages correct are given for all items and for five subtests.

TABLE 3: Percentage Correct Answers for Subtests and Total Test in Each School Type.

SUBJECT	NUMBER ITEMS	HAVO-VWO (N=1486)	MAVO (N=1682)	LTO (N=1248)	LEHO (N=967)
Arithmetic (core)	11	82.%	63.%	48.%	36.%
Arithmetic (total)	19 à 21	80.	61.	47.	35.
Algebra (core)	9	86.	67.	46.	32.
Algebra (total)	19 à 18	79.	58.	40.	30.
Geometry (core)	11	77.	58.	48.	37.
Geometry (total)	19 à 21	74.	55.	45.	33.
Statistics (core)	4	91.	83.	69.	66.
Statistics (total)	7 à 8	85.	73.	61.	54.
Measurement (core)	5	80.	63.	53.	38.
Measurement (total)	9 à 10	79.	61.	54.	39.
Total (core+rotated)	74	78.	60.	47.	36.

It can be seen in the table that the total scores and the scores on all the subtests, decrease from HAVO-VWO, MAVO, LTO to LHNO. This clear trend is not surprising, because it is known that the general abilities of students decrease in the same order in these school types. Furthermore this could be explained by the differences in time devoted to mathematics in these school types, as was shown in Figure 2.

In the next section we will discuss in some detail the question of whether the actually implemented curriculum, as indicated by the Opportunity-to-Learn data, is related to the variation in the mathematics test scores. Before doing this some remarks will be made on the meaning of the opportunity to learn ratings.

Validity of Opportunity to Learn Ratings

In the Second Mathematics Study mathematics teachers made the following judgements concerning all 176 items:

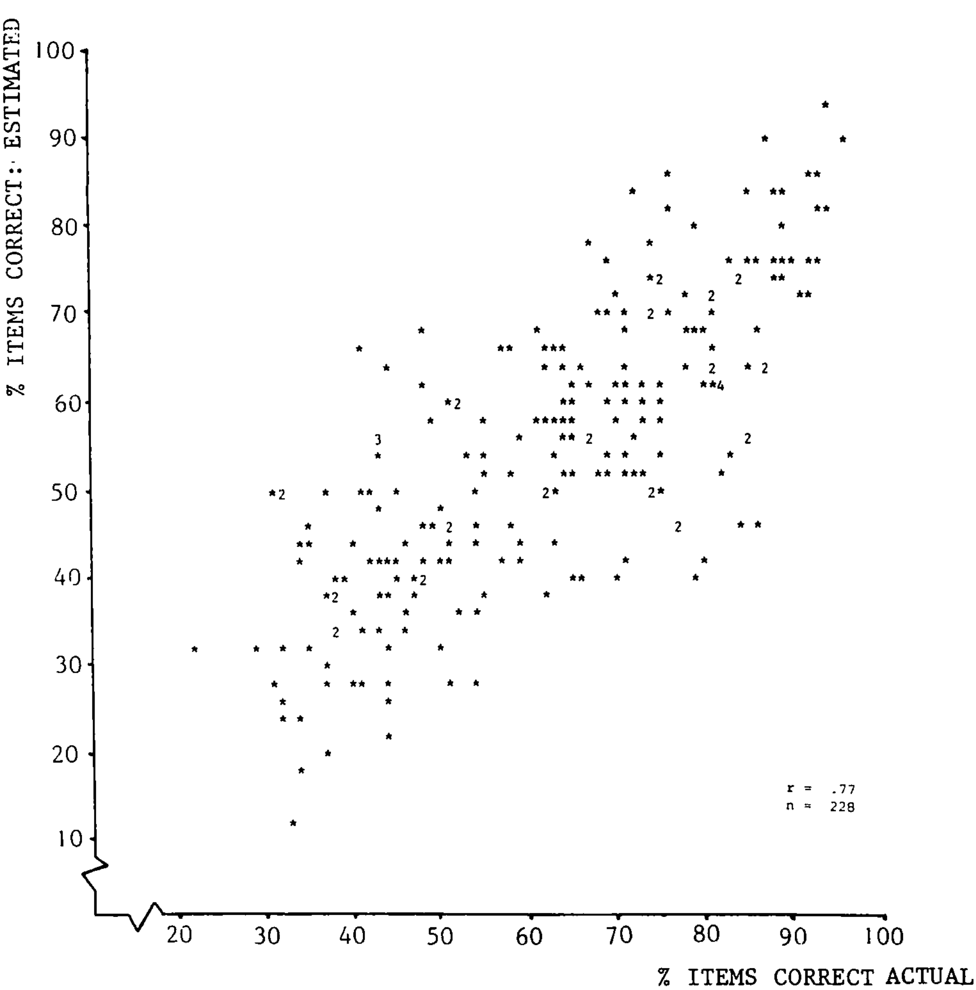


FIGURE 5: Scattergram of the Estimated and Actual Percentages Correct

1. Estimation of the percentage correct answers in the target class without guessing.

2. When is, or was, the mathematics necessary to answer the item correctly taught?

These judgements were made with respect to the mathematics class that was involved in the study. The results presented in the following are based on the forty items in the core-test. A first analysis of the opportunity to learn results makes it clear that the two teacher judgements were not mixed up: the percentage items in the core test, which according to the teacher were taught before the testing data, has a low correlation (r=.25) with the mean of the estimations of percentage correct over all core test items. But from this result we do not know what meaning can be ascribed to the judgements. As a first exploration in this field we put the following questions:

1. What is the relation between the estimated and the actual percentage correct answers?

2. What is the validity of the judgements of whether the subject matter has been taught?

Concerning the first question it appears that the correlation between the actual and the estimated percentages is fairly high (r=.77) in the total sample. Although Figure 5 shows that the variation in the columns is still considerable, we can nevertheless state that there is a strong relation in the <u>heterogeneous total population</u>. So we conclude that these are indications that the estimation of percentage correct is valid.

TABLE 4: Percentage OTL-Answers for Primary Education-items from the Core Test

		Item														
		K03	K07	K11	K14	K15	K17	K18	K20	K21	K24	K26	K30	K33	K35	K37
havo/vwo	PRIM	63	23	42	15	22	18	62	27	37	3	45	58	77	53	25
	GR.1 SEC.	15	10	13	48	10	50	20	60	8	8	10	2	15	27	27
	GR.2 SEC.	10	7	38	30	5	28	12	8	5	72	25	3	2	10	12
	HIGHER SEC.	2	40	3	0	50	0	0	0	33	10	17	5	2	2	5
	NEVER	5	17	0	0	12	2	2	2	12	0	0	27	2	0	25
	N.A.	5	3	3	7	2	2	5	3	5	7	3	5	3	8	7
mavo	PRIM	56	11	26	19	7	24	53	20	17	1	44	60	51	23	20
	GR.1 SEC.	26	10	33	41	7	43	26	41	9	16	9	7	24	46	46
	GR.2 SEC.	9	17	34	34	23	29	16	33	17	71	14	7	13	26	14
	HIGHER SEC.	4	56	3	0	54	0	1	0	46	7	27	3	4	0	3
	NEVER	3	3	0	0	1	0	0	3	4	1	1	17	1	3	13
	G.A.	3	3	4	6	7	4	4	3	7	3	4	6	6	3	4
lto	PRIM	32	2	9	5	2	11	16	12	5	2	9	39	9	19	4
	GR.1 SEC.	16	14	26	26	9	25	37	33	7	18	14	21	26	28	28
	GR.2 SEC.	35	39	49	61	39	58	39	47	44	65	42	16	40	44	51
	HIGHER SEC.	5	37	4	0	37	0	0	0	37	9	28	0	12	0	7
	NEVER	0	0	0	0	5	0	0	0	2	0	0	12	0	0	4
	N.A.	12	9	12	7	9	7	9	7	5	7	7	12	12	9	5
lhno	PRIM	41	0	12	6	4	14	20	24	4	2	6	35	18	16	16
	GR.1 SEC.	27	18	22	12	12	14	35	43	8	0	14	18	16	51	27
	GR.2 SEC.	24	53	31	78	53	65	31	12	43	20	39	16	31	24	37
	HIGHER SEC.	2	22	22	0	27	0	2	8	39	57	33	0	27	2	6
	NEVER	0	2	0	0	0	0	0	0	0	14	0	20	0	2	10
	N.A.	6	4	12	4	4	6	12	12	6	6	8	10	8	4	4

PRIM = Primary education; GR.1 SEC. = Grade 1 secondary education; GR.2 SEC. = Grade 2 secondary education; HIGHER SEC. = Higher grade levels secondary education; N.A. = No Answer.

Alexandra walked from Riverview to Bridgeport, which are 3.1 kilometers apart. During her walk she lost her watch, went back 1.7 kilometers to find it, and then continued in the original direction until she reached Bridgeport. How many kilometers had Alexandra walked altogether when she arrived at Bridgeport?

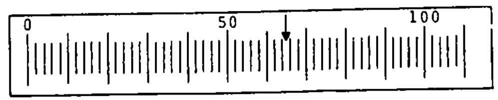
A. 1.4

B. 4.6

C. 6.5

D 8.2

E None of these



On the above scale the reading indicated by the arrow is between

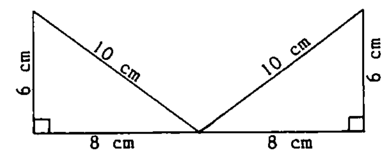
A 51 and 52

B 57 and 56

C 60 and 62

D 62 and 64

E 64 and 66



The total area of the top triangles is

A $6 \times 8\ cm^2$

B $\frac{6 \times 8}{2}\ cm^2$

C $\frac{10 \times 6}{2}\ cm^2$

D $\frac{10 \times 12}{2}\ cm^2$

$\frac{20 \times 12}{2}\ cm^2$

FIGURE 6: Some Examples of Items in the Core Test

To answer the second validity question we use the following method: We compare the judgements of teachers in the sample with the data from other sources. From two other sources data are available on the period in which the mathematics needed to answer the test-item was taught. First we have judgements from 4 experts from the National Institute for Educational Measurement (CITO). These experts judged independently which test-items dealt with subject matter taught in primary schools. The other source of information is an analysis of mathematics textbooks conducted by experienced mathematics teachers. These teachers judged when the subject matter asked for in the test items was treated in the most commonly used textbooks in every school type. The primary school items in the core test were identified as follows: Those items that the four experts unanimously judged primary school items. In Figure 6 some of these items are printed as an illustration, while in Table 4 the opportunity to learn results for all primary school items are given.

The rows in Table 4 show for each school type the OTL-answer-categories. The table shows that in considering the total sample the OTL-instrument cannot be used for the identification of primary school mathematics. For the percentage answers in the category "PRIM" are often low, whilst at the same time the percentage answers in the categories on secondary education are high. This might be realistic because many primary school topics in mathematics are repeated in secondary education. Looking at the shift of answers from the category PRIM in HAVO-VWO to the category secondary education in LHNO, this seems to be a plausible explanation, assuming that more repetition is necessary as fewer primary school goals are reached.

As far as the validity of the OTL-judgements is concerned, the following question might be asked: Do teachers really teach what they say they do? In this study we can only answer this question indirectly. Direct answers could be given by performing observational studies, something that was not possible during SIMS. However, an indirect answer can be given by means of the textbook the teacher uses. A committee of teachers was asked to rate when the subject matter in the mathematics textbook is taught. Each teacher was very familiar with the textbook they were asked to consider. Table 5 shows the number of raters for each textbook.

TABLE 5: Number of Raters for Each Textbook

		Number of Raters
HAVO-VWO :	Moderne Wiskunde	2
MAVO :	Getal & Ruimte	2
	Sigma	1
LTO :	Denken, Doen en Begrijpen	1
LHNO :	Passen & Meten	1

These ratings can be compared with the ratings of teachers in the sample who use the same textbook. The textbook "Passen & Meten" will be left out of consideration, because only 3 teachers in the sample used this textbook.

TABLE 6: Judgements for Each Core-Item of the Presence of Related Subject Matters in the Textbook (by Members of the Teacher Committee)

1 = present in the textbook
0 = not present in the textbook
- = cannot be judged

G&R: Getal & Ruimte, S: Sigma, MW: Modern Wiskunde,
DDB: Denken, Doen & Begrijpen.
STUD: Percentage teachers in the study with the same textbook judging that the subject matter was taught in secondary education.

Item	G&R	G&R STUD	S	S STUD	MW	MW STUD	MW	DDB	DDB STUD
1	1	100	1	1	100	1	100	1	1	100
2	1	37.5	0	0	9	1	100	1	0	23,8
3	0	12.5	-	-	18	-	47,3	1	0	52,4
4	1	100	1	1	100	1	100	1	0	52,4
5	1	100	1	1	100	1	94,6	1	1	76,2
6	1	89	1	1	64	1	94,6	1	1	76,2
7	0	37,5	0	0	9.1	0	21,1	0	0	61,9
8	1	62.5	1	0	36,4	1	97	1	1	81,8
9	1	100	1	1	100	1	100	1	0	28,6
10	1	100	1	1	100	1	100	1	0	52,4
11	1	87.5	1	0	9.1	1	78,4	1	0	33,3
12	1	87.5	1	1	90,9	1	94,7	1	1	57,1
13	1	100	1	0	18,2	1	93,8	1	1	81
14	1	100	1	1	100	1	82,2	1	1	95,3
15	0	47,5	0	0	9.1	0	15,8	0	0	28,6
16	1	100	1	1	100	1	100	1	1	89,5
17	1	100	1	1	81,8	0	73,7	0	1	94,2
18	1	37,5	-	1	63,6	0	47,4	0	0	52,4
19	1	25	1	0	0	0	52,6	0	0	14,3
20	1	100	1	1	81,8	0	63,1	0	1	66,6
21	0	50	0	0	9,1	0	5,3	0	0	19,1
22	1	100	1	1	100	1	100	1	1	81
23	1	100	1	1	100	1	84,3	1	1	47,6
24	1	87,5	-	1	81,8	1	89,4	1	1	95,2
25	1	87,5	0	0	46,4	1	73,7	1	0	33,3
26	1	75	1	0	18,2	0	42,3	0	0	23,8
27	0	25	0	0	36,4	0	21,1	0	0	28,6
28	1	100	1	1	90,9	1	100	1	1	90,5
29	1	100	1	1	100	1	89,4	1	1	61,9
30	0	0	0	0	9,1	0	0	0	0	14,4
31	0	37,5	0	0	9,1	0	15,8	1	0	19
32	0	62,5	1	0	0	1	36,9	1	0	13,8
33	0	50	-	0	36,4	0	15,8	0	0	23,8
34	1	75	1	0	81,8	1	100	1	0	23,8
35	0	75	-	1	81,8	1	57,9	1	0	66,7
36	1	87,5	1	1	81,8	1	87,5	1	0	33.3
37	1	87,5	1	0	74,7	1	52,7	1	1	71,5
38	1	100	1	1	100	1	100	1	1	85,7
39	1	75	0	0	0	1	47,4	1	0	14,3
40	1	100	1	1	81,8	1	79	1	1	100

Table 6 shows how the committee of teachers rated for each textbook the occurrence of the subject matter necessary for answering a core-item before testing date.

Table 6 shows that the relation is fairly strong. Generally speaking, one can conclude that items for which there is no subject matter in the textbook are also less frequently taught. The contrary is also true. This shows that information from two different sources converges. The correlation between these two sources is .79. Our conclusion from the preceding is that there are indications that the OTL-instrument is valid for the identification of the implemented curriculum in the first two years of secondary education. This means that the goal of measuring "Opportunity to Learn" is to a reasonable degree, realised. Again it should be stressed that the instrument in this form is not suitable for the identification of primary school mathematics. According to our impression primary school mathematics can be identified in as far as it is not repeated in secondary education.

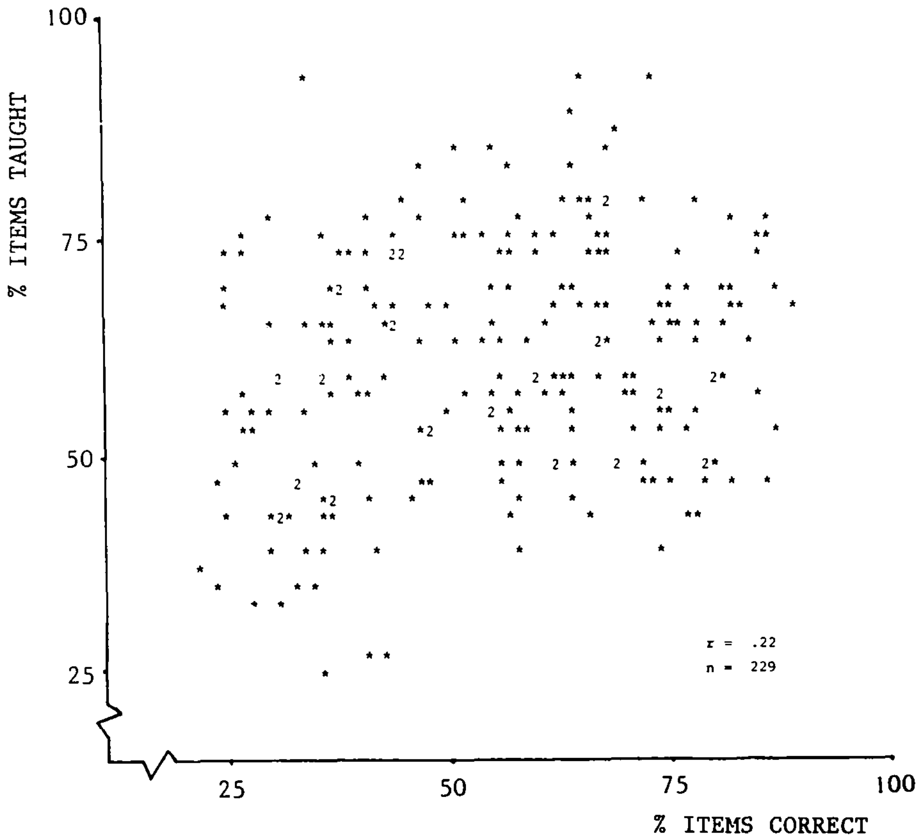


FIGURE 7: Scattergram of the Percentage Items Taught Versus the Percentage Correctly Answered in Each Class

Relation of Opportunity to Learn with Test-Scores

It seems reasonable to assume that along with other factors the presentation or non-presentation of subject matter will exert a strong influence on the knowledge of students. Students who are confronted with relevant subject matter in the classroom should - ceteris paribus - perform better than students who were not given the opportunity to learn the subject matter. In this section we will present a first analysis related to this topic.

First of all we investigated the relation between the amount of subject matter taught and the test-scores of students. Figure 7 shows the scattergram of these data. The conclusion is clear: There is no substantial relation, although the observed correlation is, due to a high N, statistically significant.

Figure 7 shows that the measure of Opportunity to Learn used in this study seems to be a bad predictor of student performance. This is a strange result because it would mean that presenting the subject matter has no effect.

There are some possible explanations which should be investigated further. One possible explanation is the level of aggregation of data (i.e. total test-score), because analysis on the item-level show that for several items (app. 20%) reasonable effects occur. This means that in such cases classes in which the subject matter is taught achieve much better than classes in which the subject matter is not taught.

Some effects are however negative, which shows that forgetting could also play a role. Another intervening factor is that the test-items were not explicitly constructed to measure OTL, so they probably do not optimally discriminate schools which implemented certain subject matter from schools which did not.

Summary and Discussion

In the preceding paragraphs a description was given of the mathematics curricula in four different school types in the Netherlands, based on empirical data from the Second International Mathematics Study. It was shown that there are big differences in the students' mathematical knowledge within and between school types. In order to interpret these differences, amongst others, data on the actual implemented curriculum content are needed. The actual implemented curriculum content was measured by letting teachers make opportunity to learn ratings for each of the 176 cognitive test-items. The results of these ratings show at first sight a certain face validity, which was confirmed by comparing the ratings with an external criterion.

For the total sample the p-values as predicted by the teachers correlate high with the observed p-values. However, it is remarkable that the degree to which the corresponding mathematics content has been taught hardly correlates with the observed scores. The general conclusion in connection with these findings is that the test scores are not influenced by whether or not the content matter has been taught. The question which immediately arises is: Does teaching have no effect? A tentative answer to this question might be: No, as far as the teaching considered has been done over a relatively long period of time (in this case two years): and as far as effects are measured in terms of total test scores on an item pool constructed according to classical principles.

From this study there are some possible explanations for the reported results. One possible explanation for the low correlation between content and performance measures might be that, as a consequence of considering a relatively long period of time, the effect of forgetting plays an important role. One might hypothesize that this effect occurs especially with items which measure actual math-knowledge and to a much lesser degree with items which measure general mathematical abilities.

A second explanation might be that those items were selected for the test, which have maximal discrimination related to total test scores. In this IEA study maximal correlation with Opportunity to Learn was not a criterion at the construction of the cognitive tests. A consequence of this strategy might be that the cognitive tests measure much more general mathematical knowledge and hence are not sensitive to variation in specific content taught.

Both explanations need to be investigated further in secondary analyses of the data and in new studies. The availability of comparable data from a larger number of countries will lead to generalizable conclusions on the quality and usefulness of the opportunity to learn instrument, which at first sight can be a useful tool in the first stage of curriculum implementation research, because potentially weak areas can be identified in a sophisticated empirical way.

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