Exams in calculations/mathematics in Norway 1946–2017 – content and form

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Mathematics has been a constant part of Norwegian primary schooling. This impression of constancy is misleading, however. In the period from 1946 to 2017, the subject 'regning' (calculations) had its name changed to mathematics and has gone through a long series of reforms. The goals of the subject have changed with each reform.

Based on content analyses of a selection of school leaving exams, we will describe how the content of mathematics has changed over time. As the demands on pupils' language have increased, so have the demands on their ability to use different tools and handle different task formats and information presented in different ways. In summary, the knowledge and skills that pupils need to complete the exams today are very different from the skills they needed in 1946.

Keywords: Mathematics Education, history, exit examinations, language.

Background

Mathematics as a school subject has been evolving over time, and this development can be studied through the examination of curriculum documents, exams and other sources. In this paper, we will study the school subject in Norway through its exams. While this is interesting in itself, we also hope that this study may be built upon to study trends in different countries.

In 1889, 'folkeskolen' ('folk school') was established by law in Norway. Pupils would enter school at age 7 and finish at age 14. There was a difference between the urban schools (byskoler) with 40 weeks of schooling per year and the rural schools with mostly 12 weeks per year at the program's inception (Thune, 2017). In 1890, the first 'normal plan' for folkeskolen was put forward; it was revised in 1922/25.[1]

The law was again revised in 1936 (with new 'normal plans' in 1939). At this time, most children aged 7–14 did attend school. In 1959, a common law for both urban and rural areas was introduced, making schooling compulsory for everyone for 7 years. It even became possible to expand compulsory schooling to 9 years (this was to be decided locally). A new curriculum for the trials with 9-year schooling was published in 1960. By law, in 1969, school was extended to 9 years for everyone. It was extended to 10 years in 1997. New curriculum documents went into effect in 1974 (M74), 1987 (M87), 1997 (L97) and again in 2006 (LK06) (Thune, 2017). The next curriculum document is expected to go into effect in 2020.

The subject was called 'regning' (calculation) until 1959 but was renamed 'matematikk' (mathematics) in the curriculum documents from 1960 onwards. The different curricula had

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[1] The normal plan for rural areas was revised in 1922, the one for urban areas in 1925.

different focuses, but Table 1 suggests a clear trend: new subjects have regularly been included, but rarely have subjects been removed. The subject ‘datalære’ (computer technology) was first a subject on its own in the 1987 curriculum, and computer technology has remained part of the curriculum in some form (although not in the original form with the intention of working on algorithms). However, according to the preliminary versions of the 2020 curriculum, it seems that it will be coming back.

	1939	1974	1987	1997	2006
Numbers and calculation	x	X	x	x	x
Geometry	x	X	x	x	x
Measurement	x	X	x	x	x
Algebra and equations		X	x	x	x
Functions		X	x	x	x
Application: private economy		X	x	x	x
Problem solving			x	x	x
Statistics			x	x	x
Probability and combinatorics				x	x
IT (‘Datalære’)			x		

Table 1: Subjects in the curriculum documents

Such a classification can never convey the full scope of the curriculum documents; there will be nuances in which parts of these subjects are included and how they are described. For instance, in the 1997 curriculum documents, the history of mathematics was explicitly included in the description of what pupils should learn, but not as a subject on its own.

By 1939, the plan stressed the active pupil, in the sense that the pupils should ‘do as much independent work as possible’ (Mosvold, 2002, p. 12, our translation). This was adhered to in the 1960 plan. In a temporary plan in 1971, this idea was gone, and the plan was based on the New Math and on teaching the correct definitions and rules. However, by 1974, heavy criticism led to the return to the concept of the active pupil, and most of the New Math ideas were removed (Mosvold, 2002). Throughout the 1987, 1997 and 2006 documents, the focus on active pupils has remained important, even though the latest curriculum documents have been more concerned with teachers’ autonomy in choosing their own teaching methods.

Theory and earlier research

The development and implementation of curriculum happens on several levels: societal, institutional and instructional (Goodlad, 1979). The development of the exam in Norway is currently done on the institutional level by an ‘eksamensnemnd’ (‘exam committee’) appointed by the directorate of education. The exam and the results are important for the pupils, and the results on the school level are published and influence the standing of the schools in the community. Exams play an important part in what pupils and teachers do – what is tested influences what is considered important (Au, 2007; Niss & Jensen, 2002; Wideen, O'Shea, Pye, & Ivany, 1997). Teachers also use earlier exams in their teaching (Andresen, Fossum, Rogstad, & Smestad, 2017). Therefore, exams are an important object of study used to investigate the implementations of the curriculum over time.

In an evaluation of the 2017 exam (Andresen et al., 2017), comparisons with the 2009 exam show that, even in such a short time, there are important developments in terms of the content tested and the language, illustrations, question formats and so on.

Andresen et al. (2017) include a summary of international research on language traits that make mathematics tasks difficult to understand. These traits can exist on the word level (long words, infrequent words etc.), on the sentence level (for instance, long noun clauses) and on the text level (such as lack of connection between sentences). They can make tasks more difficult on their own or when combined with other traits, but difficult language can also be partially offset by helpful illustrations.

Our research question is this: How has the content and form of primary school exams in calculations/mathematics in Norway changed in the period from 1946–2017?

The choice of the particular period to study is governed by the availability of full sets of exams. We would like to stress that we do not study the difficulty of the exams, as the difficulty depends on the content of the education that has been presented. Neither will this article include an analysis of the contexts used in the tasks.

Method

To answer the research question, we performed content analysis of the selected exams. The analyses considered several different aspects of the exams: the subjects, the answer formats, the language and the illustrations. In the analyses of language, the same method and operationalization are used as in the evaluation of the 2017 exam (Andresen et al., 2017).[2] This means that we analyse language features that are known to contribute to making understanding mathematics tasks more difficult: the number of words, long words (>6 letters), compound words and general academic words.[3] In the analyses of illustrations, we are inspired by Van Den Heuvel-Panhuizen (2005) and the different roles illustrations can have, but we use a simpler categorization: illustrations that are necessary to solve the task, illustrations that are helpful and illustrations that are simply decorative.

The choice of exams has been somewhat convenience-based, as not all exams are easily available in complete versions suitable for the different analyses we plan to do. Also, we have chosen exams from different time periods. For this paper, we include the exams from 1946, 1960, 1979, 1985, 1995, 2006 and 2017.

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[2] Indeed, some of the results of the analyses of the 2017 exam have been used here directly.

[3] According to Academic Wordlist: http://www.tekstlab.uio.no:4000/

The 1946 and 1960 exams were made locally, and the ones we include are from Oslo, the capital of Norway, for the entire period. The remainder of the exams are national.

Year	School	Grade	Hours
1946	Oslo Folkeskole	7th	4h
1960	Oslo Folkeskole	7th	4h
1979	Grunnskolen	9th	5h
1985	Grunnskolen	9th	5h
1995	Grunnskolen	9th	5h
2006	Grunnskolen	10th	5h
2017	Grunnskolen	10th	5h

Table 2: Exams chosen for analysis

In some of the exams, there are tasks that not everyone is supposed to do in the same way. The 1946 exam included one task that girls could choose not to do, as they had less teaching than boys. We have included that task in our analyses. The 1985 exam was in two parts: part 1 was to be done without a calculator, but part 2 came in two versions, one for use with a calculator and one without. We have analysed the version where the calculator was allowed. In 2006, there was a considerable number of tasks (62), of which pupils were supposed to choose only some (39). While we have analysed all 62 tasks in tables and graphs, here we include only numbers based on 39 tasks.[4] In 1960, 1979, 1995 and 2017, every pupil was supposed to do all the tasks included in the exam. It is an interesting finding on its own that the scope of choices has varied so much through the years.

For most of the exams, it was not apparent whether all subtasks counted the same towards the result. Therefore, in these analyses, we use unweighted counts of the subtasks.

Results and discussion

The analysis of the content of the tasks is in accordance with the general goals of the curricula. While numbers and calculations were part of all sub-questions in the 1960 exam, today they comprise about half of the tasks (Figure 1). There appear to be two reasons for this: partly because new topics are included in the curriculum and partly because the tasks seem to be ‘purer’, in that there are more examples of tasks that test only one topic.

In addition, the answer formats have also become more diverse. In 1946 and in 1960, all exam tasks were answered with a short calculation and an answer (called ‘open’ here). In 2017, 24% of the tasks were multiple-choice items. In addition, some tasks are to be answered using a spreadsheet,

[4] To be precise, we calculate the average of the numbers that would be right if the students always chose the first available option and the numbers if the students always chose the last available option.

some using a graphing program (Geogebra, for instance) and some (17%) were to be answered with the answer only (Figure 2).

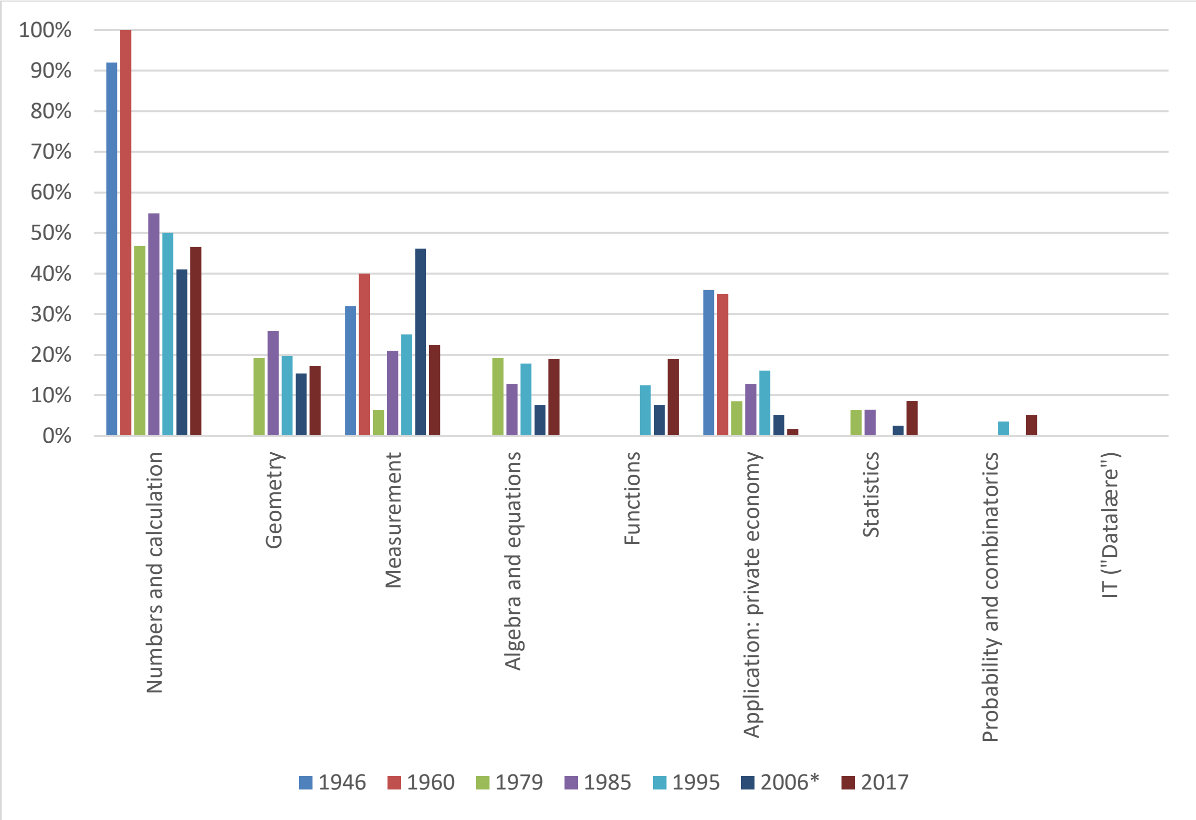

Figure 1: Percentage of tasks testing different topics, 1946–2017

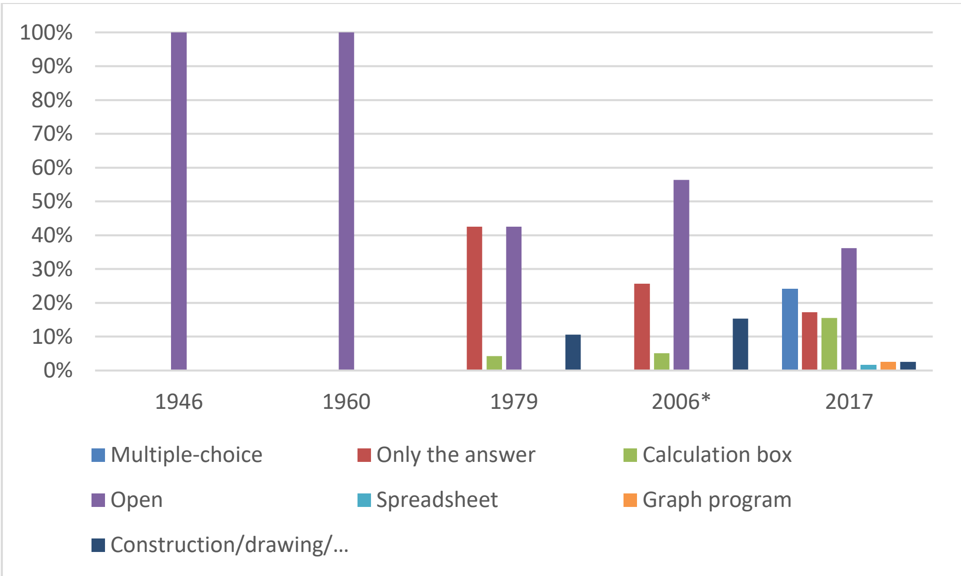

Figure 2: Answer formats in exams

The tools that pupils have available and are supposed to master have changed through the years. In 1946, the pupils probably had no other tools than pen or pencil and paper. In 2017, pupils are supposed to use graphing software (such as Geogebra) and spreadsheets in addition to more traditional tools, such as calculators, compasses and rulers. Today, computer algebra systems (CAS) are also allowed.

Table 3 shows the number of sentences and the number of words in the exams. The amount of language has varied, with a decrease from 1946 to 1960. However, the main tendency is that the amount of language has been increasing since 1960 and that it was higher in 2017 than in any other year in our sample.

	1946	1960	1979	1985	1995	2006	2017
Number of sentences	95	62	63	113	143	111	158
Number of words	756	464	456	896	945	924	1240

Table 3: Number of sentences and words in the exams

In this table, the number of sentences and words that the pupils in 2006 were exposed to is understated. If we suppose that many pupils read all 62 tasks in order to choose which 39 to do, they would have to read 164 sentences with a total of 1,434 words, making the 2006 exam the most voluminous of all of these exams. Additionally, there was a 539-word information booklet which the pupils were supposed to have read in advance of the test.

More challenging than simply evaluating the number of words is trying to say something concrete about how the language has changed. In analyses of language traits that make tasks difficult to read, long words, compound words and general academic words are of interest.

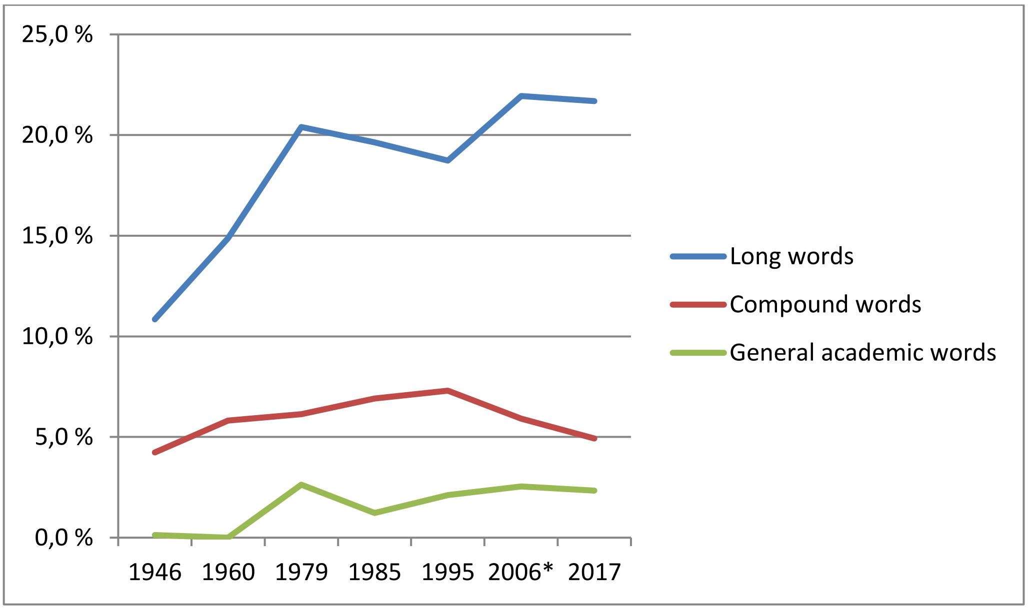

Figure 3: The ratio of long words, compound words and general academic words in exams

In Figure 3, we see a clear tendency throughout the period of a higher proportion of long words and general academic words, while there has been no significant increase in the number of compound words. The general academic words are noteworthy – examples of these are 'describe', 'function', 'example' and 'explanation'. While pupils in 1946 were mostly asked to do something (calculate, usually), in 2017, they were asked to compare, describe and explain, which may be more demanding.

In addition to pupils having to deal with more tools and a more academic language, the exams are also visually different: there is a large number of illustrations in modern tasks. We look at which illustrations are necessary to solve the task, which are helpful, and which are only decorative.

	1946	1960	1979	1985	1995	2006	2017
Necessary	0	0	2 (2)	4 (3)	8 (8)	14 (13)	17 (15)
Helpful	0	0	2 (1)	0	0	3	7 (1)
Decorative	0	0	0	0	0	10	9

Table 4: Illustrations in exams: necessary, helpful or decorative. In parenthesis are the numbers of illustrations that are explicitly mentioned in the text of the task

Table 4 shows that, in our material, illustrations were not included until 1979, and at that time only as illustrations that were necessary or helpful to solve the task. In the 21st century, there have also been more illustrations that are simply decorative, and even illustrations that are necessary to solve the task are not necessarily mentioned explicitly in the text. Even though illustrations can make the tasks easier to understand, at the same time, they make more demands on the pupils – in 2017 there were 33 illustrations, and for each, the pupils had to decide if they needed to use them to solve the tasks.

While it is important to consider that the 1946 and 1960 exams were for 14-year-olds, while the rest of the tests are for 16-year-olds, most of the development noted seems to have been independent of that change.

Conclusion

The overall picture is complex. Thematically, mathematics as a subject has become more diverse. While the exams in ‘folkeskolen’ consisted mainly of calculations, often involving measuring units and everyday economics, today they involve more topics. However, at the same time, the connections among different topics seem to be included less often – fewer tasks now include more subjects at once.

More tasks are multiple-choice, making it possible to get through more tasks in the same amount of time. Also, there is a need for speed because in the five hours allotted, pupils must demonstrate their skills with more tools than previously, including spreadsheet and graphing software and CAS.

The demands on the pupils’ language skills have also increased. The number of words has increased, and the proportion of long words and general academic words has increased as well. There are far more illustrations than before, and the illustrations serve several different functions.

Consequently, although we cannot say whether the difficulty level of the mathematics has increased or decreased, the complexity of the exams – a greater variety of topics, answer formats, tools and greater language difficulty – means that there are many more factors that pupils must deal with than previously. At the same time, the number of questions has increased substantially, meaning that the students have far less time to consider each sub-question while handling the different complexities. Thus, speed is implicitly seen as an important value in mathematics, and while this is rarely questioned by teachers, it is often questioned by mathematics education researchers.

In conclusion, such an analysis of exams may give a clear picture of the development of mathematics as a school subject which can complement the results of curriculum analyses. To the extent that exams do not develop in the same direction as the curriculum documents, it is an open question as to whose concept of mathematics will prevail. International comparative studies would be an interesting next step to see how trends in exams are similar or different across borders.

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