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► **To cite this version:**

Stig Eriksen, Pauline Vos. Formal intentions in a new mathematics curriculum versus example tasks published before the standardized examinations -do they align?. Thirteenth Congress of the European Society for Research in Mathematics Education (CERME13), Alfréd Rényi Institute of Mathematics; Eötvös Loránd University of Budapest, Jul 2023, Budapest, Hungary. hal-04413504

HAL Id: hal-04413504

<https://hal.science/hal-04413504v1>

Submitted on 23 Jan 2024

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Formal intentions in a new mathematics curriculum versus example tasks published before the standardized examinations – do they align?

Stig Eriksen and Pauline Vos

University of Agder, Norway; stig.eriksen@uia.no

In 2020, a new Norwegian mathematics curriculum formally defined five competencies as pillars for mathematics learning, such as exploring, reasoning, representing, generalizing, or modelling. Shortly after the curriculum's launch, example tasks were published to show what type of tasks could come in the national standardized examinations. Within our theoretical framework, we interpret both the described competencies and the example tasks as resources in a discourse on an intended curriculum. We studied their alignment, namely, the extent to which the competencies were needed to solve the example tasks. We developed a scoring analysis with good inter-rater reliability. We found that the competencies were mainly needed for tasks for the theoretical stream and hardly for practical streams. Also, modelling was virtually absent. The first published example tasks communicated the ideals of the intended curriculum better than those published later.

Keywords: Curriculum reform, intended curriculum, national standardized examinations, mathematics curriculum, competency-oriented curriculum.

Introduction

In many countries, there are reforms in mathematics education with the aims to decrease teacher-centredness and the drill of mathematical rules and rather foster relations (1) among learners, (2) across mathematical constructs, and (3) between mathematics and the world outside school (Brady et al., 2015). However, various barriers hinder reform, such as teachers maintaining traditions and assessments not being adjusted to reforms (Fullan, 2014). In this paper, we present a study on the most recent mathematics curriculum reform in Norway and whether newly developed tasks for the national standardized examinations aligned with its intentions.

Norwegian mathematics education saw curriculum reforms in 1987, 1994/1997 and 2006. These developed from subject matter-oriented towards competence-oriented curricula (Ludvigsen et al., 2015). Nevertheless, evaluations showed that mathematics learning remained largely teacher-centred (Stovner & Klette, 2022), and that mathematical tasks in examinations primarily asked for technical work (Drüke-Noe & Kühn, 2017). In 2013, a committee tasked by the Ministry of Education evaluated the 2006 reform, studied curricula in Finland, Sweden, Denmark, and Scotland, and recommended to put more emphasis on competencies and to give more room to in-depth learning, creativity, interdisciplinarity, and using subject matter knowledge for societal and environmental issues (Ludvigsen et al., 2015). The committee's work shaped ideals for a competency-oriented curriculum (Niss & Højgaard, 2019) to be implemented in 2020. It was baptized *LK20* for 'Læreplanverket for kunnskapsløftet 2020' ('curriculum for knowledge advancement 2020'). In 2018, elaborated proposals for all subjects went through hearings with stakeholders, such as teacher associations and university mathematics departments, after which the final framework describing the intentions were published. Below, we first describe context and content of Mathematics within *LK20*.

Thereafter, we turn to our study on how curricular intentions were ‘translated’ into example tasks for the national standardized examinations.

Context of the study

In August 2020, the mathematics programs within LK20 were rolled out in Norwegian primary and secondary education. In the first implementation year, there was only one grade, which would have LK20-oriented examinations within a year. This was grade 11, the first year in non-compulsory education. For students, it marks a break from previous years, because they start at new schools. This grade 11 was the only grade for which *example tasks* were published in 2020.

In grade 11 students choose between general programs preparing them for higher education or vocational programs preparing for work. For mathematics, students can choose between two streams: a theoretical stream (T) or a practical stream (P). For instance, the T-mathematics has more calculus, whereas the P-program has more repeat of earlier content. The T- and P-mathematics streams are available in both the general and the vocational programs. This means that at the end of grade 11, students take examinations in one of four programs (1P, 1T, 1P-Y, or 1T-Y), whereby the Y-exams are for the vocational programs with contexts being tailored to vocations.

The formal documents in LK20 applied to grades 1-13, to all subjects, and to all programs and streams. The documents were structured in three parts. The first part applied to all subjects and grades describing, for example, *values*, such as cultural awareness, critical thinking, and respect for nature. The second part described for each subject general aims. The third part described content and competence levels in detail for each grade, program and stream separately.

For our study, we focused on the second part describing overarching, general aims for mathematics. We chose these, because they were the same for all grades, programs and streams, thus for each of the different examinations for 1P, 1T, 1P-Y, or 1T-Y. These overarching mathematical aims for grades 1 to 13 described that, for example, students were to learn to explore mathematically and solve problems, to understand and describe patterns and connections in society and nature, to develop a precise language for reasoning, critical thinking, and communication, to become competent problem solvers, and to work interdisciplinarily. These overarching mathematical aims were summarized in six *Core Elements*, of which five were competency-oriented: Exploration and Problem Solving, Modelling and Applications, Reasoning and Argumentation, Representation and Communication and Abstraction and Generalisation. The sixth Core Element, Mathematical Knowledge, linked the first five to subject matter knowledge. All Core Elements were elaborated; for example, Representation and Communication was elaborated as follows:

Representations in mathematics are ways of expressing mathematical concepts, relationships and problems. Representations can be concrete, contextual, visual, verbal and symbolic. Communication in mathematics means that students use mathematical language in conversations, argumentation and reasoning. Students shall have the opportunity to use mathematical representations in different contexts through their own experiences and in mathematical conversations. Students shall have the opportunity to explain and give reasons for the choice of representation form. Students must be able to switch between mathematical representations and everyday language and switch between different representations. (Utdanningsdirektoratet, 2020)

This description of Core Element Representation and Communication is written to fit the mathematics of any grade, program or stream. Also, the text explicates how this Core Element relates to others, with Argumentation and Reasoning explicitly mentioned. For our study, we took the five competency-oriented Core Elements and studied how they were to be assessed through the first published example tasks for the four different examinations in grade 11 (1P, 1T, 1P-Y, and 1T-Y). Our research question was: *to what extent do the example examination tasks align with the five competency-oriented Core Elements?*

Theoretical framework

In curriculum research, different curricular levels are distinguished (Porter, 2006). The *intended* curriculum expresses intentions, or goals, of what subject matter and competencies students should learn. These intentions should guide teachers, textbook authors and other stakeholders to implement the goals in classrooms with students. Within the intended curriculum, one can distinguish between the *ideal* curriculum and the *formal* curriculum:

The ideal reflects beliefs, opinions, and values of disciplinary and educational scholars, but most likely does not exist in reality. The formal curriculum refers to expectations for what should be taught and is represented in written statements (Remillard and Heck, 2014, p. 706).

Within LK20, the *ideal* curriculum was expressed in vision documents (e.g., Ludvigsen et al., 2015), and the *formal* curriculum was expressed, among others, in the Core Elements for mathematics (Utdanningsdirektoratet, 2020). We also perceive the *example examination tasks* as integral part of the *formal* curriculum, since these were published by the Ministry of Education and were meant to also guide the implementation of LK20's intentions.

The Core Elements and the example tasks are resources in *curricular discourses*, that is, in communication practices within certain socio-cultural structures, such as institutions, media, language use, or (hidden) agendas (Morgan & Sfard, 2016). For instance, an intended curriculum is expressed by an 'author' with a certain power, since it is the highest educational authority in a country. Fried and Amit (2016) wrote that authorities can support their communication through organising compulsory national examinations. Examinations are a different discursive practice, with, for example, a different language and document lay-out than those used in documents describing intentions. National standardized examinations can guide teachers to change their practices according to the new intentions. The driver to this mechanism is the phenomenon of 'teachers teaching to the test'. However, if tests are not aligned with the intentions, this mechanism can also be counterproductive to an intended curriculum.

In this paper, we use the term *alignment* for the degree to which curriculum goals and examination tasks match with each other. According to Porter (2006), "there are two ways in which the alignment can be less than perfect: content in the curriculum may not be assessed, and content assessed may not be in the curriculum" (p. 147). Research on curricular alignment has been carried out qualitatively (e.g., Berget, 2023), or through mixed methods, whereby tasks are coded by researchers in light of curriculum categories (e.g., Cunningham et al., 2017; Drüke-Noe & Kühn, 2017). Many studies find that curricular intentions are not fully aligned with tasks. From a discourse perspective, this makes sense since intentions and tasks are resources in different discourses. The goals are expressed in a

discourse between authorities and implementers of the goals (with students not directly being involved), whereas tasks are meant to be understood and carried out by students. However, in our study, the Core Elements and the example tasks were both part of *formal* curriculum, that is, they were both resources within the same discourse from the authorities to the implementers.

Methods

Our data consisted of six sets of example tasks; two of these were published in September 2020, and four sets of example tasks in January 2021. The first two sets held ten example tasks each, respectively for mathematics 1T and 1P. The later four sets held 13 example tasks each, again for 1T and 1P, but now also for the vocational programs 1T-Y and 1P-Y.

We analysed each task on the extent to which it addressed the five competency-oriented Core Elements. This would enable us to see how the sets of tasks covered the formal curriculum, to compare between tasks published at different moments (September 2020, January 2021), and to analyse how the communication from the Ministry to teachers and students evolved. Additionally, we compared between tasks for the theoretical and the practical streams (1T+1T-Y versus 1P+1P-Y), and between tasks for the general and the vocational programmes (1T+1P versus 1T-Y+1P-Y).

For studying alignment between tasks and the Core Elements, we needed a common denominator. The competency-oriented Core Elements hold descriptions of activities students must be able to carry out, and tasks ask students for an activity. For example, the formal description of Representations and Communication allowed us to extract four activity categories: (1) using mathematical language, (2) using mathematical representations, (3) justifying the choice for a certain representation, and (4) switching between representations. We then judged for each task whether the activities were needed to solve it, giving scores 0, 1 or 2 (not needed, could potentially be used, absolutely needed). In a similar way, we studied the other Core Elements, created categories, and scored the tasks one-by-one. This yielded for each task five scores, one for each Core Element, which were averaged across the tasks for each of the six sets of example tasks.

In the beginning of our analysis, we had to carefully pilot the categories. Each category gave rise to discussions about the interpretation of the categories. For example, for the four representation and communication categories above, we had to decide that reading a task text would not yield points in category (1) using mathematical language. Instead, this category was for translating everyday speech into mathematical language. We also decided that a Python program providing function values is a representation of a function. We illustrate our data analysis with one of the tasks (Figure 1).

Adil is taking part in an orienteering race. The posts give either 2 points or 5 points. He finds 13 posts and gets a total of 38 points. How many of his 13 posts give 2 points?

Figure 1: The Adil task

Analysing this task for Representation and Communication, we asked: does a student (1) need to use mathematical language to solve the problem? Students can use algebra ($x+y=13$, $2x+5y=38$) but find the answer more quickly by guessing the combinations. Therefore, we coded a 1, since mathematical language can potentially be used. To (2) use representations, number notation or algebra will somehow be needed, so we coded that 2. The task does not ask to (3) justify the choice of

representation, coded with 0. Regarding (4) switching between representations, the task text already offers two representations (numbers, verbal), potentially asks for one more (algebra), and switching between these is possible but not necessary, so we coded a 1. Thus, the Adil task scored on Representation and Communication: $(1+2+0+1)/4 = 1$ (in the range 0-2).

Core Element Modelling and Applications was also divided into four categories based on the curricular description. The task could be seen as *Connecting to daily life, work or society*, but likely also seen by students as just numbers in a pseudo-context. Hence, for this category the task scored a 1. The same went for *Mathematising – making a model*, a student may do this, but it was not needed to solve the task, also a score 1. The categories *Critical evaluation of model at hand* and *Applying the model to other situation* were not seen as parts of solving this task, and both scored a 0. That is, the Adil-task scored on Modelling and Applications: $(1+1+0+0)/4=0.5$. Figure 2 show that this is close to the average (0.475) of all the tasks in the set for 1P from September 2020. Both authors coded the tasks individually and then compared, discussed and increased a common understanding. We measured inter-rater reliability using Cohen's kappa yielding values -1 to 1 (>0.7 is considered good). In the last round of coding, our kappa was 0.82 and sufficient for reporting.

Results and discussion

We present our results using radar diagrams. The tasks were coded (0-2), codes were averaged over the sets, so all sets had six scores between 0 and 2. Figure 2 shows from left to right, the scores from the two sets of September 2020 (1T and 1P), from the two sets of January 2021 for the general program (1T / 1P), and from the two sets of January 2021 for the vocational program (1T-Y / 1P-Y).

We analyse scores clockwise starting from the top of the radar diagrams. Exploration and Problem solving had a high score from the tasks of September 2020, but apparently were less needed for tasks in the sets published later, and hardly in tasks for the vocational programs. Modelling and Applications received throughout low scores being hardly needed in any task. Reasoning and Argumentation received relatively good scores for both 1T sets (both dates), which means this was needed for solving tasks in the sets for 1T, but less in 1P and hardly in tasks for the vocational programs. Representation and Communication received relatively higher scores for 1T than for 1P, and higher scores for the September 2020 sets, which means that activities described by this core element were needed for the first set of example tasks, in particular for 1T, but less for tasks published later, and hardly for tasks for the vocational program. Abstraction and Generalisation received scores much higher in 1T than in 1P, and was most needed in the first set of tasks for 1T, and less elsewhere.

When comparing the scores on the sets of example tasks between September 2020 and January 2021, we look at the two diagrams on the left in Figure 2. Roughly speaking, all scores decreased, in particular those on Exploration and Problem solving, but not for Reasoning and Argumentation in 1T. Even the low score for Modelling and Applications decreased. This means that the sets from September 2020 better represented the three Core Elements EP, RC and AG than the January 2021 sets. In fact, Figure 2 can be perceived as a timeline of how the proposed examination tasks moved away from the competency-oriented Core Elements in LK20.

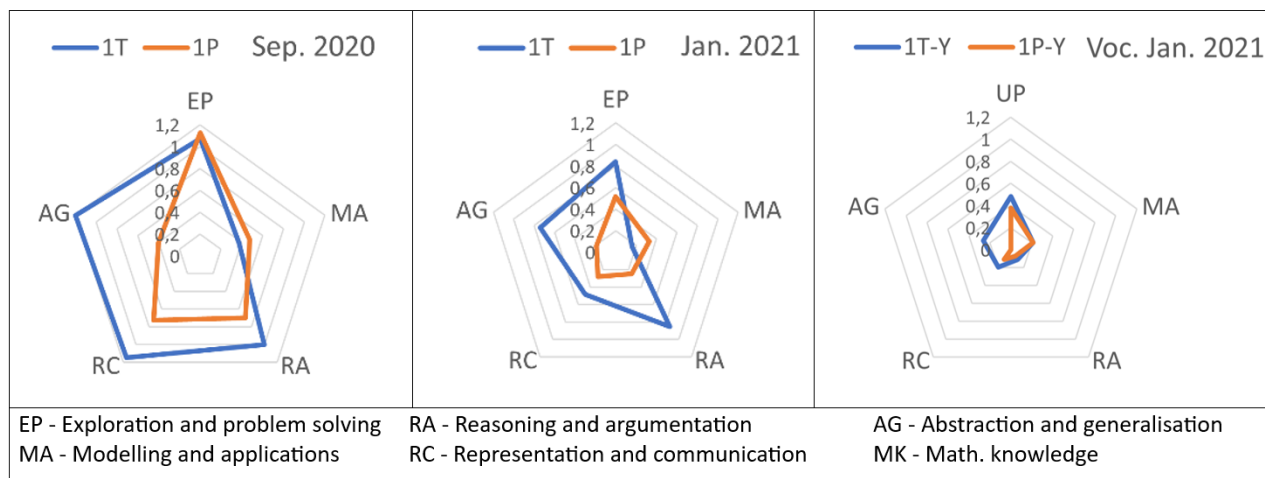


Figure 2: Scores of the sets of tasks to the six Core Elements

When comparing the scores of the sets of example tasks for the theoretical stream (1T and 1T-Y) and the practical stream (1P and 1P-Y), we compare the two radars within each diagram. In all three diagrams, the 1T-radar ‘surrounds’ the 1P-radar except for Modelling and Applications, and for Exploration and Problem solving in September 2020. Figure 2 shows that the sets of example tasks communicate to teachers and students that the theoretical stream would have more competency-oriented examinations, whereas these competencies are less important for the students choosing 1P or vocational programs. It strikes us that Modelling and Applications, which connects mathematics to practical contexts, was underrepresented there.

When comparing the scores of the sets of example tasks for the general program (1T and 1P) and the vocational program (1T-Y and 1P-Y), we look at the right-most diagram and see that all figures are very low making the diagram almost unreadable. It means that the five Core Elements were hardly represented in the sets for the vocational program, irrespective of whether this was for the theoretical stream (1T-Y) or the practical stream (1P-Y).

Conclusion and recommendations

Evaluations of the Norwegian 2006-curriculum showed that students were not learning mathematics through teaching approaches recommended in research (Ludvigsen et al., 2015). The ensuing *ideal, intended* curriculum, LK20, was developed thoroughly and comprehensively (Ludvigsen et al., 2015). The ideals were translated into a *formal intended* curriculum including five competency-oriented Core Elements for mathematics, including the activities exploring, problem solving, modelling, applying, reasoning, giving arguments, representing, communicating, abstracting and generalizing (Utdanningsdirektoratet, 2020). The activities were to be carried out by students, which marked a break from the tradition of teacher-centered demonstrations (Stovner & Klette, 2022). However, when LK20 was kicked-off at the start of the school year in August 2020, it still was quite unclear how the ideals would be assessed in the national standardized examinations (the assessed curriculum). Thus, it helped that the first sets of example tasks were published in September 2020 showing teachers and other stakeholders the types of tasks that were not seen in Norwegian examinations before. Yet, this was late, since teachers and textbook publishers generally prepare their resources before the start of a school year. This lateness of the first two sets of example tasks, and also the lack of tasks targeting

the vocational program in the first round of publishing, indicate that likely, the task design was carried out under time pressure, unlike the development of the *ideal* curriculum, which took years.

Our analysis showed that the earlier example tasks asked for activities described in the five Core Elements to quite an extent. In particular, this was the case for tasks for the theoretical stream 1T, which holds approximately a quarter of the student cohort. This sends an implicit message that the mathematical activities considered important in the intended curriculum are meant for the ‘better’ students. Without exploring, using representations and the other competencies, there mainly remains memorizing and working procedurally for the majority of students who struggle with mathematics and choose the practical stream (1P) or the vocational programs (1T-Y and 1P-Y). It entails curricular misalignment in two ways (Porter, 2006): competencies described in LK20 are not assessed, and content assessed is not in LK20’s intentions. Another discursive message in the example tasks was that Modelling and Applications were hardly needed for the tasks. This absence communicates to teachers, students and other stakeholders that pure mathematics should be emphasized in Norwegian mathematics education, which confirms Berget’s (2023) findings.

The curriculum discourse was actively followed by the first author who witnessed publicly expressed concerns from teachers, mathematicians, and others after the first sets of example tasks were published in September 2020. These reactions may have affected the task designers, but the process of task design was untransparent. Some changes in the curricula were formally communicated, such as the cutting of Python syntax and programming from 1P, yet a reduction in Core Elements was never announced. Our analysis of the later example tasks indicates that the decreased emphasis on the five competency-oriented Core Elements made the implemented curriculum diverge from the *formal intended* curriculum.

Returning to the research question *to what extent do the example examination tasks align with the five competency-oriented Core Elements?*, our answer is that these competencies were somewhat present in the first set of example tasks for the theoretical stream, but far less in the later sets, in particular for the practical stream and the vocational programs. In terms of curricular alignment, the *formal, intended* curriculum was diluted by the sets of example tasks, in particular those published later. However, we also note that it never was made clear how the Core Elements should be distributed across teaching, across classroom-oriented assessment, or across high-stakes examinations, and how this should be different across student groups. This is something we recommend future designers of an intended curriculum to do.

Our final recommendation is for task designers to be more transparent about the development of tasks for national standardized examinations and the connection to curricular intentions. If the example tasks of January 2021 set the tone for upcoming exams, and teachers ‘teach to the test’, the competency aims will be diluted, making intended and attained curriculum considerably misaligned.

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