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Competencies and curricula: Danish experiences with a two-dimensional approach

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Curricula around the world make more and more use of goals trying to capture different kind of processes for the students to master. In Denmark, these ambitions have most recently been described in terms of subject specific competencies. However, bringing such ambitions into the actual teaching practices has proved challenging. KOMPIS was a longitudinal project aimed at developing and examining ways of dealing with some of these challenges in lower secondary Danish classrooms in collaboration with teachers. In this paper, we present aspects relevant to mathematics curricula. As a key point of this analysis, we present a two-dimensional content model derived from KOMPIS that proved useful in supporting competence-based curriculum development and teacher planning. We argue that curriculum descriptions of competency objectives need to be clear and distinct as well as independent of subject matter to be operational.

Keywords: Competence, mathematical competencies, the KOMPIS project, two-dimensional content framework.

Introduction

KOMPIS is an acronym for KOmpetenceMål i PraksIS, which is Danish for "Competency Goals in Practice". It was a longitudinal research and development project conducted in the years 2009-2012. The project was based on collaboration between teachers, teacher educators and researchers working to implement competency-oriented teaching in mathematics, science and Danish language classes for grades 7-9. A number of these model and concepts were subsequently incorporated into the national curriculum (Undervisningsministeriet, 2014).

In this paper, we focus on the curricular aspects of the KOMPIS project within mathematics by analyzing the following question: *How can we describe curriculum in a way that enables teachers to structure their planning in a manner that focusses on competency development?* Firstly, the background for KOMPIS is briefly described. Secondly, we describe the two-dimensional content model for mathematics education that was developed for and challenged by the experimental teaching conducted during the KOMPIS project. Finally, we describe the experiences regarding planning and organizing of teaching and the conclusions drawn from these experiences regarding curriculum development.

Background

In Denmark, as well as in many other countries, competencies are used more and more to describe curriculum goals. Internationally this is partly due to the initiation of what has since been called the Bologna process, aimed at making transfer of educational merits between countries of the EU easier

(European Ministry of Education, 1999). To accomplish this a unified description of educational standards was needed, and it was decided to describe these standards in terms of competencies.

Alongside this political process, there has been theoretical and practical development of competencies as an educational concept. One of the most significant developments was the appointment of a workgroup called Description and Selection of Competencies (DeSeCo). In their final report, they formulated a well-conceived and holistic definition of the term and presented their recommendations for "key competencies for the good life and the well-functioning society" (Rychen & Salganik, 2003).

Syllabusitis

Analytically, another educational approach to the concept of competence can arise from asking the question (cf. Blomhøj & Jensen, 2007, pp. 46-47, which this and the next section is based on): What constitutes a subject, e.g. mathematics? "Mathematics is the subject dealing with numbers, geometry, functions, calculations, etc." is not a rare type of answer.

What, then, does it mean to master a subject? With reference to the above, it is tempting to identify mastering mathematics with proficiency in mathematical subject matter. However, this belief if transformed into educational practice is severely debilitating for students' ability to make reason of the subjects and to apply them in future contexts. The debilitating effect is potentially severe enough that the phenomena has been given a name that evokes images of a disease, namely syllabusitis (Jensen, 1995; Lewis, 1972). A curriculum infected by syllabusitis tends to focus only on the ability to reproduce subject matter and therefore fails to set an appropriate level of ambition and puts the teachers in a position where they struggle to cover the prescribed subject matter.

The KOM project, competency and mathematical competencies

The issue of syllabusitis was one of the main issues to be addressed by the Danish so-called KOM project, running from 2000-2002. The core of the project was to identify, explicitly formulate and exemplify a set of mathematical competencies as independent dimensions in the spanning of mathematical competence (see Figure 1) (Niss & Højgaard (to appear) provides a presentation and analysis of the project and an English translation of the original report).

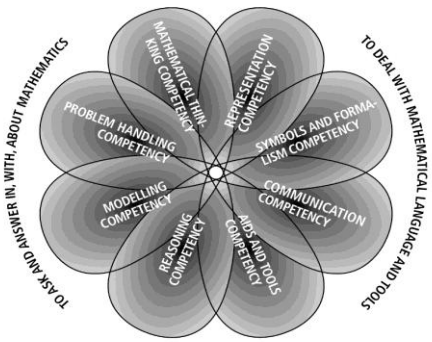

Figure 1: A visual representation – the "KOM flower" – of the eight mathematical competencies presented and exemplified in the KOM report (Niss & Højgaard, to appear)

Such a set of mathematical competencies has the potential of replacing the syllabus as the focus of attention when working with the development of mathematics education, simply because it offers a vocabulary for a focused discussion of what it means to master mathematics (Jensen, 2007). Often when a syllabus attracts all the attention in a developmental process, it is because the traditional specificity of the syllabus makes us feel comfortable in the discussion.

The definition of the term "competence" in the KOM report (Niss & Jensen, 2002, p. 43) was semantically identical to the one we use: Competence is someone's insightful readiness to act in response to the challenges of a given situation (cf. Blomhøj & Jensen, 2003). In definite form, a mathematical competency is consequently defined as someone's insightful readiness to act in response to a certain kind of mathematical challenge of a given situation.

The initial KOMPIS analysis

Following the approach of the KOM project, the endeavour to incorporate subject specific descriptions of competencies in mathematics curricula should primarily be guided by an attempt to fight syllabusitis. In this perspective, it was important to focus on the interplay between subject specific competencies and the subject matter traditionally described in the syllabus.

A two-dimensional content model

In the KOM report the proposal for such an interplay is to separate subject specific competencies and subject matter areas as two independent dimensions of content (Niss & Højgaard, to appear). Subsequent research and development work prior to the KOMPIS project (Jensen, 2007) supported the importance of such an approach to curriculum development, and added the general hypothesis that a goal oriented (yearly) planning is supported by a curriculum that is systematically developed for enhancement of transparency, offering itself as a thinking tool for the teachers. The model in Figure 2 was a proposal for such a transparent representation of the core of the by then (2009) newly revised National Standards for mathematics (Undervisningsministeriet, 2009).

In a curricular perspective, the defining point of such two-dimensional content models is that the subject specific competencies can function as "the missing link" between the overarching purpose of an education and a concrete syllabus, by pointing out what types of challenges the students must be able to act in relation to.

Subject matter area / Competency	Numbers and algebra	Geometry	Statistics and probability
Math. thinking comp.			
Math. problem handling comp.			
Math. modelling comp.			
Math. reasoning comp.			
Math. representation comp.			
Math. symbols and form. comp.			
Math. communication comp.			
Math. aids and tools comp.			

Figure 2: A two-dimensional model for description of the content of grade K-9 mathematics teaching (Højgaard et al., 2010, p. 15)

The KOMPIS project and the methodological approach chosen here

The experimental teaching included 16 teachers from four schools together with three university researchers and three teacher educators split into three subject groups—math, science and Danish. The groups had three-hour meetings at alternating schools once every month to discuss the teachers' experience and reflections regarding their competency-based lesson plans and the teaching they tried out between meetings. Furthermore, all participants met (including representatives from the municipality) twice a year for full-day seminars to exchange experiences across subjects.

Our participation in this longitudinal experimental process gave us access to knowledge and ideas from the different participants, and to follow the developmental processes among the teachers on an ethnographic basis. In this paper we report on our analysis of how the two-dimensional content framing influenced two aspects of these processes; planning and organization of teaching.

Hence, the "implementation element" of the paper in the sense described by Century & Cassata (2016) is the two-dimensional model displayed in Figure 2, used as a tool for helping teachers to plan and organize a teaching focused on the development of certain mathematical competencies.

KOMPIS experiences regarding planning and organization of teaching

The common distinction between planning and organization of teaching is useful for describing some of the results of the KOMPIS project. Following Larsen (1969) we consider planning of teaching as the process of making decisions regarding the content of the teaching, whereas organization of teaching deals with selecting appropriate (relative to the content and the learning ambitions associated with it) teaching methods and making decisions regarding the course of the teaching.

Planning competency-oriented teaching

In this sense of the phrase, planning of teaching inevitably boils down to an endeavor with one dominating dimension: Time. Since time is a scarce resource when teaching takes place within a formal educational system like compulsory schooling, it is of little surprise that the two-dimensional content model in figure 2 acted as a systematically induced challenge to the planning of the teaching. One of the consequences of this approach is that it makes didactical considerations necessary when planning from a two-dimensional content structure to a one-dimensional yearly teaching plan. Planning of competency-oriented teaching is ideally about creating a connection between the two dimensions in such a way that the work with a given subject matter area can be explained and motivated by development of competencies, which make the students able to handle new types of situations or known situations in a more competent way. This often requires more prolonged and successive teaching time making it necessary to plan teaching in modules wherein the students get to build a chosen competency.

This approach can be modelled by dividing the year up into modules and deciding early on which areas of subject matter, competencies or combination of the two to focus on, cf. the modelling of this approach in figure 3. This model can function as a planning and reflection tool for teachers as

well as a model that teachers can use when they discuss what the objectives of a given teaching session is with colleagues and students (Højgaard, 2010).

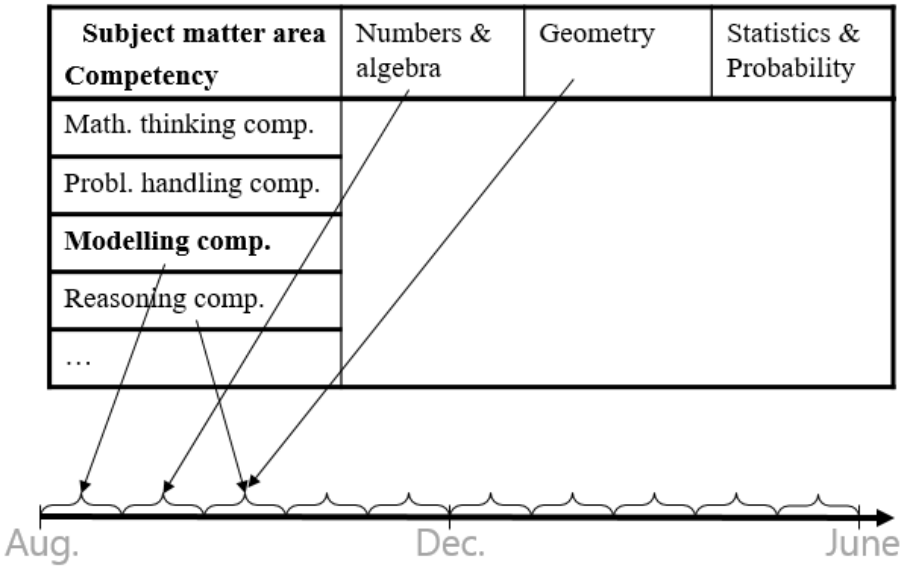

Figure 3: The two-dimensional model used as a tool for planning of teaching by creating modules of some weeks in duration, each appointed with explicitly stated learning objectives consisting of subject specific competencies and/or objectives related to specific subject matter

Hence, an important part of implementing competency objectives in teaching turned out to be linked to planning for extended periods of time, where students and teachers could focus on a few selected competency objectives. KOMPIS was designed to ensure that teachers included such periods in their yearly planning from year two of the project. When the mathematics teachers involved were interviewed subsequently, they assessed the explicit use of the model in figure 3 as a planning tool as both challenging, constructive and meaningful. Challenging because the representation of the competencies as a separate dimension in the model forced them to be explicit about their ways of thinking and working with this new kind of objectives. Constructive because the model turned out to be a comprehensible thinking tool when planning their teaching, not least by explicating the role of the competencies in their answer to the fundamental planning question posed above: When are the students to learn what? Meaningful because they experienced the mathematical competencies as a way of making some of their more fundamental ambitions as mathematics teachers explicit.

Organizing competency-oriented teaching

Following the planning approach by dividing the year up into modules, the dominant organizational approach used by the teachers in the KOMPIS project was project work where the students could concentrate on a selected competency objective. In the mathematics group, Tomas followed one teacher closely. She deliberately and explicitly organized the project work modules with the following general characteristics:

a) The teacher decided on a given mathematical competency objective to focus on for the project period.

Six projects were oriented towards the mathematical modelling competency and two towards mathematical reasoning competency.

b) Approximately, one week was spent on helping students develop an understanding of the given competency objective.
An example of this was that in the first project focusing on mathematical reasoning, where the teacher let the students spend the first week gaining different experiences with mathematical reasoning by alternating between short tasks that required students to use mathematical reasoning and group discussions about their reflections. This led to the development of a model that presented the students ideas about central elements involved in mathematical reasoning (Sølberg, Bundsgaard, & Højgaard, 2015).

c) Once the class had reached a common understanding of the given competency, each project group was required to come up with relevant problems involving the given competency. They then spent the rest of the allotted time—most often two weeks—working on problems through which they developed the given mathematical competency.
For example, one group of students chose to work on the mathematical reasoning involved in solving and producing Sudokus, while another group worked on developing simple mathematical proofs.

The process ensured that students and teacher reached a mutual understanding of a competency objective before the students were challenged to find ways of developing it. Such an approach turned out to be supported by choosing one and only one competency as the guiding learning objective for each project work. From this perspective, the important attribute of the two-dimensional content model is the separation of competencies and subject matter areas, so it is for the teacher to decide whether the learning objectives for a given module should come from a mathematical competency, a mathematical concept or a combination of the two. In previous one-dimensional Danish curricula a mixing of the two types of learning objectives were the dominant approach chosen.

Another advantage of employing a set structure was that the students became familiar with the template. After the first couple of projects, they did not need as much instruction during the project work and gradually gained significant ownership of the process.

Curricular perspectives

Applying a teachers' perspective on curriculum, there are at least two important perspectives regarding the use of competency objectives to be derived from KOMPIS. *Firstly*, the project confirmed that teachers require help in formulating learning objectives to be able to plan teaching explicitly aimed at building student competence. To formulate such more specific learning objectives, however, there is a need for *clear and distinct* competency descriptions in the curriculum. At the same time, to avoid syllabusitis it is necessary to be able to distinguish between competencies and subject matter as two independent dimensions of content descriptions. The model in figure 2 demonstrates how this could be achieved for mathematics, and we propose that similar two-dimensional models of content could be generated for other subjects.

Secondly, being able to formulate competency-oriented learning objectives can help teachers plan their school year in a way that allows them to maintain focus on a *few key subject specific competencies* and thereby create the necessary conditions for sustained development of both teacher and student competencies. In addition, being able to focus on a few learning objectives at a time enables the students to better understand the meaning behind the learning objectives which in turn enables the students to pursue them more independently.

Final remarks

One of the goals behind the KOMPIS project was to experiment with curriculum development from a teacher's perspective. We wanted to engage teachers in developing an approach to competency-oriented teaching that was not only meaningful but also practical for teaching. To make a long story short, our experience from this longitudinal study is twofold (Højgaard, 2012): Firstly, one of the main advantages of using a two-dimensionally structured competency perspective is that it inherently fosters reflections among teachers about the essence of the competencies involved. Secondly, such reflections promote the implementation of the more ambitious kind of work processes that mathematics education aims for as long as the teachers involved (as has been the case in the KOMPIS project) get the necessary time and support to learn how to use the two-dimensional structure as a developmental tool. Hence, KOMPIS indicates that there is significant promise from a teachers' perspective in applying the two-dimensional model presented here for mathematics teaching.

The experiences from KOMPIS have come to influence the subsequent national curriculum revisions. The two-dimensional model has been incorporated into the current curriculum for mathematics (Undervisningsministeriet, 2014), and at the time of writing (2018) it is being revised to emphasize this approach even more. Thus, Danish mathematics teachers are now officially encouraged to use the two-dimensional model in planning their teaching.

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