# Mathematics Standards and Curricula under the Influence of Digital Affordances

## Different Notions, Meanings and Roles in Different Parts of the World

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# Introduction

When it comes to education, the **world** is more **diverse** and **complex** than we tend to think.

- This also pertains to terms such as **”standards”**, **”curriculum”, ”guidelines”,** and **”syllabus”**.

- These terms have very **different meanings** in different countries, and the entities referred to have very **different roles** across countries.

# What can we learn from diversity and complexity?

- Things that **vary** across contexts and conditions **can be changed**! Things that remain **constant** across contexts and conditions are **hard to change**! The insight into **what is variable** and **what is constant** makes us **sharper** and **wiser.**

- **Understanding** the ways in which our **own situation differs** from that of others **sheds light on the specifics** of our situation.

- We can get **inspiration** for our own endeavours by paying attention to **other(s') approaches and solutions.**

# The notion of curriculum

The notion and reality of curriculum **varies greatly** across countries.

- ”The curriculum can be seen as an amalgam of goals, content, instruction, assessment and materials.” [colours added] (Kilpatrick, 1994)

- ”…we use the term curriculum broadly to include mathematics curriculum materials and textbooks, curriculum goals as intended by teachers, and the curriculum that is enacted in the classroom.” [colours added] (Stein et al., 2007)

**I propose a general definition:**

**With respect to a given educational setting, a curriculum is a vector** with six entries:

- **Goals** (overarching purpose, desirable learning outcomes, specific objectives/aims)
- **Content** (topic areas, concepts, theories, results, methods, techniques, procedures)
- **Materials** (instructional materials and resources, including textbooks, artefacts and IT-systems)

- **Forms of teaching** (tasks, activities and modes of operation of the teacher)

- **Student activities** (activities of and tasks and assignments for students)

- **Assessment** (goals, modes, forms and instruments of formative or summative assessment)

I call the **agency** (or **individual**) that **defines** a certain curriculum the **curriculum authority** for that curriculum

- A curriculum authority **may leave some of the six entries empty**.

What do we mean by **"standards"** (not a universally used term, though)?

**To meanings**:

*** A mandatory curriculum** for a politico-administrative unit (say a country), defined by an overriding curriculum authority. Typically emphasis on **goals**, **content**, and (summative) **assessment**.

*** A recommended curriculum** (e.g. the NCTM Standards), defined by any sort of curriculum authority. Typically includes all or most of the entries - **goals**, **content**, **(materials)**, **forms of teaching**, **student activities**, **assessment**

For **a given educational setting**, two **key issues** are:

- **Who are the curriculum authorities** in function?
- **What are the relationships between the different authorities** and between their curricula?

**Example**: **Denmark** (roughly similar in Finland, Norway and Sweden).

The **primary curriculum authority** is the **government** (the ministry of education). For a given educational setting (say high school), their curriculum is of the following form (specified **in writing**):

- **Goals**: **Explicit**, yet somewhat terse and of an overarching nature
- **Content**: **Pretty substantial**, but specified at a general level. Strong emphasis on ***CAS and graphing calculators***
- **Materials**: **Empty**
- **Forms of teaching**: **Almost empty**; a few guidelines.

- **Student activities**: Some requirements concerning student tasks, otherwise **almost empty**

- **Assessment**: **Pretty substantial** as to summative assessment: National written exams set by the ministry – **never** multiple choice. Focus on ***CAS and graphing calculators***. Also guidelines for oral exams. Empty as regards formative assessment.

**Symbolically**:

(**Goals; Content; Materials; Forms of teaching; Student activities; Assessment**) = **(m, M, 0, ε, ε, M)**

(m = manifest, M = very manifest, 0 = empty, ε = very little)

In Denmark, the official **ministerial curricula are mandatory** but leave, nevertheless, a fair degree of **leeway and freedom** to the **teacher**.

So, **within the boundary conditions of the ministerial curriculum**, the individual teacher defines his/her own curriculum –typically **enacted** rather than written):

The **teacher's (additional) curriculum**:

(the teacher being the (subordinate) curriculum authority)

- **Goals**: Typically **implicit**
- **Content**: **Limited** to specifications of, and amendments to, the content of the ministerial curriculum
- **Materials**: **Substantial** - selected or constructed by the teacher(s)

- **Forms of teaching**: **Substantial** - almost completely in the hands of the teacher (modulo a few boundary conditions)

- **Student activities**: **Substantial** - almost completely in the hands of the teacher (modulo a few boundary conditions)

- **Assessment**: **Substantial** – completely in the hands of the teacher, except for the final national exams.

**Symbolically**:

(**Goals**; **Content**; **Materials**; **Forms of teaching**; **Student activities**; **Assessment**) = **(ε; m; M; M; M; M)**

(m = manifest, M = very manifest, ε = very little)

Within the same educational context, even within the same school, **different teachers define (very) different curricula**.

- At the **high school level**: **two official categories** of curriculum authorities - the **ministry of education**, and the **individual teacher.** (The ministry recognises the International Baccalaureate.)

- At the **primary and lower secondary level**: **three official categories** of curriculum authorities, one between the **ministry of education** and the **individual teacher**: The **municipality** (the local government) – in principle rather than in practice, though.

In **Denmark**:

## No private curriculum authorities

- Danish **textbooks** might be seen as specifying **a rudimentary curriculum**, heavily focusing on **content**, possibly supplemented with certain proposed student activities and assessment tasks.

- However, the other components - goals, (other) materials, forms of teaching, student activities in general, and assessment in general - are **largely absent**, unlike in the USA.

In most **European** countries, the national or provincial **government** (via the ministry of education) **is the primary curriculum authority**, to which other curriculum authorities are subordinate. Similarly, there are hardly any private/commercial curriculum authorities. The same is true of many East Asian countries (e.g. Japan, Singapore, S. Korea).

An **exception**: In **Germany**, the state ministers have formed "a national coalition of the willing" to agree on ***Bildungsstandards,*** à la the CCSS initiative in the US.

The room for and role of **the teacher's curriculum**, however, varies considerably across countries, ranging from relatively little to extensive curricular freedom.

# Dilemmas and balances

- **Goals** (overarching purpose, desirable learning outcomes, specific objectives/aims)

In the **past**: often implicit, or very terse and very general.

**Today**, **four kinds** of **goals**:

- Building ”static” mathematical **knowledge**
- Developing ”dynamic” mathematical **competencies** (capabilities / proficiencies) with students
- Developing **procedural skills**
- Fostering **attitudes**, **emotions**, or **beliefs**

Very **different**, but **not contradictory**

Significant **issue**

Do the goals involve **aspects beyond mathematics itself**, for example

- The ability to **put mathematics to use** in extra-mathematical contexts and situations?
- Using mathematics as a vehicle for developing **general ICT familiarity and proficiency**?
- Using mathematics as a vehicle for developing **general intellectual or emotional traits**?

- **Content** (topic areas, concepts, theories, results, methods, techniques, procedures)

**Classically**, content lists have constituted the core of a mathematics curriculum

**Different categories** of **content**, such as

- Internal mathematical **subject matter**
- Mathematics as it manifests itself within **other subjects or practice areas**
- Mathematical **processes** perceived as objects
- **Historical**, **philosophical** or **sociological aspects** of mathematics
- **ICT systems and tools**

- **Materials** (instructional materials and resources, including textbooks, artefacts and ICT systems)

In the **past**, not considered part of the curriculum proper. **Classically**, focus on textbooks and physical tools.

**Today**, **several kinds** of **materials**

- **Texts**
- **Manipulatives**
- **Physical instruments** and **artefacts**, including **games**
- **ICT systems**, hard and soft, including computers, CAS and graphing calculators, cell phones, the internet
- **Interactive media**

Materials tend to be **increasingly integrated**

- **Assessment** (goals, modes, forms and instruments of formative or summative assessment)

**Classically**, assessment = testing

**Today**, a **multi-faceted array** of assessment modes and instruments, in order to provide for the need for assessing **a wide spectrum of mathematical competencies**, in a variety of different contexts - no ”one size fits all”

**WYAWYG =**

**What You Assess is What You Get!**

# Digital affordances

Research provides ample **evidence** that **the very same digital technology** can give rise to **”miracles”** as well as to **”disasters”** in mathematics education.

**No ICT system is, in itself, good or bad for mathematics education.**

The outcome **crucially depends** on the **role** and **place** of the technology in the entire curriculum, and on the **specific relationships** between that component and other curricular components.

Two significantly **distinct purposes** of involving digital technologies in **mathematics education**

Closely related to the **goals of mathematics education:**

- Digital technologies may **enhance mathematical capacities**

- Digital technologies may **replace mathematical competencies**

How can ICT **enhance** mathematical capacities?

- Generating **experiences of phenomena** which are difficult to obtain
- Creating **spaces of exploration** in which things can be investigated through manipulation and variation
- Creating static and dymanic **images** of objects, phenomena and processes which are difficult to capture and grasp
- Creating **connections between different representations** of a mathematical entity
- Solving inaccessible or hard **computational problems**

- Performing rule-based **symbolic manipulations**
- Supporting the production of **mathematical texts**
- Creating platforms for individualised **training and assessment**

**Etc. Etc.**

**BUT presupposes that the user understands the fundamentals of what is going on.**

# What ICT **cannot do!**

- **Replace creation of meaning** and **understanding** of mathematical **concepts**
- **Replace reasoning and sound judgment**
- **Replace problem solving competency**
- **Replace symbols- and formalism competency**, including the ability to compute
- **Construct, interprete** or **validate mathematical models**
- **Replace** the **work** needed **to understand what, how** and **why in mathematics**

- Digital affordances contribute to creating **miracles**,

when ICT is part of a didactically and pedagogically **thougtfully designed teaching-learning sequence in mathematics**,

- in which its **specific purpose and role in capacity enhancement** is clear and articulate,
- in which the **division of labour** mongst other components is explicit and well-founded,
- and in which the teacher is fully aware of **what ICT can and is expected to contribute** in the context at issue.

- ICT contributes to creating **disasters**,

When its **purpose**, **role**, and **relationships** with other components in the teaching-learning sequence in **mathematics education** is not clearly and carefully thought out,

- when what is happening is **haphazard**,
- when the ICT system itself is allowed to **carry students and teachers away** – e.g. because its mastery takes excessive time
- in short, when **mathematics education 'cannot afford digital affordances'**

# Conclusion

**The notions, properties and roles of mathematics curricula around the world are multi-faceted and present us with tough challenges, not the least so in a world of digital affordances.**

**We can learn a lot from each other if we pay due attention to what is variable and what is constant in mathematics curricula in different countries.**

**Thank you so much for your kind attention!**