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A preliminary comparison of Chinese and German state mandated curricula for mathematics education (years 1 to 6)

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The paper presents a preliminary analysis of official state-mandated curriculum documents for compulsory school mathematics education in China and Germany with a focus on years one to six. Both documents were issued in the context of relatively recent reform initiatives. In the context of these reforms some have observed an international harmonization of curriculum goals via the educational discourse disseminated by the OECD. This trend motivates the comparison. The preliminary comparison presented in this paper is part of a larger upcoming project that investigates how curriculum objectives are interpreted by actors at different levels of governance in systems with differing policies for controlling curriculum implementation. As a starting point for investigating the discretionary space granted to schools and teachers in their micro-curricular planning, the comparison presented here identifies the level of detail in the content standards.

Keywords: Mathematics curriculum, curriculum research, cross cultural studies, educational goals.

China and Germany – comparing the incomparable?

In China, after an incipient period in the 1950s where Soviet mathematics education was investigated and “sinocised” through translating and adapting Soviet textbooks (Ye, 2018), subsequent explorations of other systems appear much more diverse and critical. At a national forum convened by the Ministry of Education of the P.R.C. in 1959, investigations of Eastern European curriculum reforms were initiated; in the 1960s comparisons included the German Democratic Republic, the Soviet Union as well as the United States and Japan. In the late 1970s and the 1980s, the People’s Education Press investigated textbooks from Germany (along with some from England, France, Japan and the United States) in order to look at the structuring of mathematical knowledge and arrangement of topics (Xu, 2013). Some dimensions of the recent Chinese curriculum reform were originally initiated by investigations of trends in mathematics education in a range of countries, including Germany, Hong Kong, the United States and Taiwan in the 2000s (Lv & Cao, 2018; Ye, 2018).

In the context of incipient reforms in the 1950s, classroom pedagogy in some regions in northern China was found to draw on a five-step formal sequencing model for instruction (preparing; prompting; making comparisons; summarizing; applying) developed by the German philosopher Friedrich Herbart (who held Emmanuel Kant’s chair in Königsberg) and his followers; the model was imported during the New Culture Movement. According to Ruan and Zheng (2012) this sequencing of instruction is still seen in many classrooms in China at the beginning of the 21st century.

Over the last decade the Chinese mathematics curriculum has been subjected to continuous reforms. Some shift in focus is according to Zhang (2018, p. 480) motivated by the needs created in an era of

“knowledge-based economies and information-based societies, the fierce international competition and challenges”, which require a capability for “knowledge innovation and scientific innovation, to be able to collect, sort and express information using mathematical methods, establish models, solve problems, and create value for society.” The resulting revised compulsory mathematics curriculum standards (issued in 2011; implemented in autumn 2012) stress the importance of mathematical thinking and problem solving, including problems in real-world settings, in addition to the traditional emphasis on developing basic mathematical knowledge and skills (Wang et al., 2018). Further, aspects of what often is associated with allegedly ‘Western’ pedagogies, including ‘student-centered’ activities such as experimenting and conjecturing, argumentation and discussion have found their way into official Chinese recommendations for curriculum implementation (Li & Li, 2018). The changes in China also entailed a de-centralizing of educational administration and textbook production in order to allow for more diversity (Cai & Nie, 2007). In comparison to the previous policy for controlling curriculum implementation via textbooks, this entails a shift towards proposing the use of a range of resources, only harmonized by the national standards, which consequently (compared with the old syllabus) expanded in scope and depth (Xu, 2013; Wang et al., 2018).

In Germany, the unexpectedly low national performance in the OECD’s PISA as well in the IEA’s TIMSS-tests at the turn of the millennium stimulated a major debate on the quality of schooling and resulted in a new focus in educational policy. The Federal Ministry of Education and Research (BMBF) inter alia justified the need for developing outcome-oriented national educational standards by comparisons with some more successful education systems in the PISA-ranking. As a matter of fact, the selected comparator countries not only had adopted national curriculum standards, but also engaged in regular external evaluations of student achievement-outcomes. As Ertl (2006) points out, this new attempt of curriculum alignment across the Länder of the Federal Republic of Germany was conceptually different from earlier approaches of the Standing Conference of the Ministers of Education and Cultural Affairs (KMK) to reaching agreement on shared national standards since the late 1990s. The initiative not only aimed at modernizing and homogenizing local curricula, but also at alignment of educational aims and assessment. According to an expertise commissioned by the BMBF, the new national curriculum should describe competencies at a level of detail that not only affords conversion into learning tasks for students but in principle also into test items so that it becomes “possible to check whether the desired competencies have actually been acquired.” And further, “This will determine the extent to which the education system has fulfilled its mandate (educational monitoring), and schools will receive feedback on the results of their work (school evaluation)” (Klieme et al., 2003, p. 10, transl. EJ). At the same time the expertise recommended that standards should determine competency outcomes (instead of listing topics to be covered) and so leave sufficient freedom for schools and teachers for micro-curricular planning.

The resulting national curriculum document bears some similarities with the US National Council of Teachers of Mathematics (NCTM, 2000) standards in its descriptions of general (topic- and context-independent) processes and the structuring of mathematical topics in broader areas. All Länder have agreed to use the national standards as a basis for developing new local curricula as well as in teacher education. In parallel they also founded institutes responsible for the control and

the improvement of the quality of schooling. These institutes not only employ assessment for educational monitoring and school evaluation, but also aim at developing teachers' professional practices by exemplary operationalization of the curriculum standards in the form of assessment tasks (Blum et al., 2006).

The above sketch of diverse reform movements, in the context of which the Chinese and German mathematics curriculum documents have been produced, suggests that the texts under scrutiny represent hybrids of a range of pedagogic discourses from antecedent national curricula and other educational policy texts, international curricula as well as national recontextualisations of policy texts produced by supra-national institutions. The stated curriculum objectives in both systems reflect international mathematics education discourses that frame the outcomes as not only relevant for developing disciplinary knowledge, but stress applications ('mathematical literacy', 'practical mathematics', 'numeracy') (Jablonka, 2015). Consequently, these curricula can be expected to share some objectives and so have sufficient in common to make an investigation of their differences meaningful. Further, while in both systems there are centralized education regulations, there are differences in modes of governance that shape the decisions of actors (schools, teachers, textbook writers etc.). The production of textbooks in the two systems certainly recontextualises official pedagogic discourse in different spheres, with more or less intersections with the economic field.

Goals and methodology

In addition to other curriculum control instruments, such as officially sanctioned textbooks, external assessments, school inspections and other measures of evaluation, an investigation of curriculum documents provides a starting point for investigating how much interpretive action is granted to teachers. Depending on the level of detail in prescriptions of curriculum standards, teachers might perceive greater or lesser freedom to decide upon what content to bring into focus and how to adapt their instructional strategies in line with their school ethos, their professional identities, and personal values. In turn, such curriculum adaptations might either mitigate or (unintentionally) reinforce unequal access to mathematical knowledge: on the one hand, access to the generative principles and styles of mathematical reasoning that underpin disciplinary knowledge, and on the other, to more skill-based forms (e.g., Dowling, 1998; Jablonka & Gellert, 2012). This concern has been raised in the context of curriculum reforms in both systems: in China particularly with respect to increasing social inequality (Cai & Nie, 2011); in Germany with a focus on the challenges for teachers in finding ways to address the needs of heterogeneous groups of students (Siller & Roth, 2016).

Based on the general research interest stated above, this preliminary comparison explores at which level of detail the prescriptions operate and which forms of mathematical knowledge and skills they privilege. It is part of a larger upcoming project that investigates how curriculum objectives are interpreted by actors at different levels of governance in systems with differing policies for controlling curriculum implementation. The larger project will investigate the articulation of curriculum objectives at three levels, which are commonly conceptualized as macro-, meso- and micro-levels, and will include case studies of classroom practice. While conceptualising the relation

between these levels as “recontextualisation” of pedagogic discourses (Bernstein, 1996), in the project this is not interpreted as constituting a hierarchical relation.

The focus of the comparison are the state mandated curricula for mathematics education for years 1 to 6. For Germany, the recently issued common mathematics curriculum standards for Berlin and Brandenburg (Senatsverwaltung für [...], 2015; henceforth the “G-BBM”) has been chosen as an example. The document has been developed in order to align the local with the statewide standards. In the two Länder primary school comprises 6 grades (instead of the usual four). The Chinese national curriculum standards for compulsory mathematics education (Ministry of Education P. R. C., 2012; henceforth the “C-NCM”) are grouped into three stages, grades 1-3, grades 4-6, and grades 7-9. Only the first two stages are of interest for the comparison. The G-BBM is for grades 1-10. It is structured in levels A-H within topics. For years 1-6, “as a rule” the levels A-D are to be reached and so these have been chosen for the comparison. One shared feature of the two documents is the coherent structuring of the mathematical topics beyond grade six, which affords useful comparison.

The most obvious challenge of this comparison is language. The Chinese document was subjected to a machine translation into English as well as into German. In some instances, these versions complemented each other and lead to improvements. The draft was further edited with the aid of an online German-Chinese dictionary. In many cases only knowledge of school mathematics helped to edit the translation. In addition, a semi-official English translation of an early trial-version has been consulted along with translations of key concepts in publications authored by insiders. Still, there remained quite some nonsensical portions of text.

Both the C-NCM and the G-BBM contain sections with mathematical topics (entitled “Content Standards” and “Topics and Content”, respectively). These sections contain short statements with some thematic coherence under one or two levels of headings and subheadings with names for school mathematical areas and specific topics. In the texts, these statements are clearly separated by lay-out (paragraph spacing, arrangement in table cells, numbering). For the analysis, each visually separated portion of text has been counted as one statement. While simply counting statements admittedly does not provide deep insights about the authority relations established by the state-author with the teacher-reader, this simple comparison of content standards might reveal differences to be explored further.

A difference that emerged when reading the content statements concerns the “discursive saturation” of the suggested student activity; the notion here is used in the sense of Dowling (2009). While interpreting the translated curriculum statements has been aided by an explanation of “action verbs” used in the curriculum document found in the Appendix of the C-NCM, an in-depth analysis of envisaged student learning activities clearly is not possible with the machine translation. However, Bernstein’s (1996) notion of “classification” can be applied to the structuring of the content in the documents, as his notion does not differentiate between forms of expression and content.

Outcomes

The C-NCM has four main sections: “Section I: Preamble”; “Section II: Curriculum Objectives”; “Section III: Content Standards”; “Section IV: Recommendations” (including suggested pedagogic

strategies, evaluation recommendations, guidance on textbook development, development and usage of resources). If from Section III only the text for grades 1-6 is taken (which is relevant here), the proportions of the sections (pages of the English version) are very roughly as follows: One fifth for sections I and II together; one fifth for section III; three fifths for section IV. Obviously, the section that describes content standards is comparatively short.

The German G-BBM has three main sections: “1. Development of Competencies in Mathematics”, “2. Competencies and Standards”, “3. Topics and contents”. If from Section 3 only the text for levels A-D is taken, the proportions of the sections (pages) are very roughly as follows: Five eights for sections 1 and 2 together; three eights for section 3. Obviously, the section that describes “topics and content” is also comparatively short, but fills a larger proportion of the document than in the C-NCM.

Table 1 depicts the number of statements for each stage by topics and subtopics in “Section III: Content Standards” of the C-NCM. The abbreviations are explained under the table. Topics and sub-topics are enlisted in rows and columns in the order of appearance in the text. “Practical and integrated applications” (in some publications the English term is “Practice and Synthesis Application”), aims at providing opportunities for cross-disciplinary work as well as for inter-disciplinary connections, and so guide “students to focus on practice and application” and “making the abstract mathematical concepts deeply rooted in children’s real lives” (Wang et al., 2018 p. 67). The standards for statistics and probability obviously are less detailed than for the other topics.

| | First Stage (Grades 1-3) | | | | Second Stage (Grades 4-6) | | | | | Sum |
|--|-----------------------------|-----------------|-----------------|-----------------|------------------------------|-----------------|-----------------|-----------------|-----------------|------------|
| <i>Numbers and Algebra</i> | NA ₁ | NA ₂ | NA ₃ | NA ₄ | NA ₁ | NA ₂ | NA ₅ | NA ₆ | NA ₄ | |
| | 7 | 8 | 5 | 1 | 9 | 10 | 4 | 4 | 1 | 49 |
| <i>Graphics and Geometry</i> | GG ₁ | GG ₂ | GG ₃ | GG ₄ | GG ₁ | GG ₂ | GG ₃ | GG ₄ | | |
| | 7 | 6 | 3 | 2 | 9 | 8 | 4 | 4 | | 43 |
| <i>Statistics and Probability</i> | no sub-division | | | | SP ₁ | SP ₂ | | | | |
| | 3 | | | | 6 | 2 | | | | 11 |
| <i>Practical and Integrated Applications</i> | no sub-division | | | | no sub-division | | | | | |
| | 3 | | | | 4 | | | | | 7 |
| Sum Total | | | | | | | | | | 110 |

Table 1: Number of statements in “Section II: Content” (First Stage and Second Stage) of the C-NCM.

Abbreviations used for subtopics in Table 1 are as follow: NA₁ *Knowing Numbers*; NA₂ *Number Operations*; NA₃ *Common Quantities*; NA₄ *Exploring Patterns*; NA₅ *Expressions and Equations*; NA₆ *Direct and Inverse Proportion*; GG₁ *Knowing Figures*; GG₂ *Measurement*; GG₃ *Figures and their Transformation*; GG₄ *Figures and their Positions*; SP₁ *Simple Statistical Data Processing*; SP₂ *Random Phenomena*.

Table 2 (next page) depicts the number of statements for the levels A-D by topics and subtopics in the section “3. Topics and contents” of the G-BBM.

A comparison of the two tables suggests that the German content standards (Berlin-Brandenburg) provide more detailed descriptions than the Chinese. There are three levels in structuring the content in G-BBM, while in the C-NCM there are only two. As to the content, the school mathematical area *Quantities and Measuring* of the G-BBM, a topic that only appears in the German document, is in the C-NCM integrated into *Numbers and Algebra* in the subtopic *Common Quantities* (NA₃), and into *Graphics and Geometry* in the subtopic *Measurement* (GG₂). Here the classification of the C-NCM is stronger as it reflects classificatory principles of academic mathematics. The other extra topic in the G-BBM, namely *Equations and Functions*, is in the C-NCM largely contained in the topic *Numbers and Algebra*. The German G-BBM does not include an extra cross-topic field (such as *Practical and Integrated Applications* in the C-NCM), but outlines six mathematical “process standards” (generic skills or key competencies), which are described in the section “1. Development of Competencies in Mathematics” and “2. Competencies and Standards”.

| | Level B (End of grade 2) | | | | | Level C (End of grade 4) | | | | | Level D (End of grade 6) | | | | | Sum |
|---------------------------------|-----------------------------|-----------------|-----------------|-----------------|-----------------|-----------------------------|-----------------|-----------------|-----------------|-----------------|-----------------------------|-----------------|-----------------|-----------------|-----------------|-----|
| <i>Numbers and Operations</i> | Na | | | Nb | | Na | | | Nb | | Na | | | Nb | | |
| | Na ₁ | Na ₂ | Na ₃ | Nb ₁ | Nb ₂ | Na ₁ | Na ₂ | Na ₃ | Nb ₁ | Nb ₂ | Na ₁ | Na ₂ | Na ₃ | Nb ₁ | Nb ₂ | |
| | 8 | 5 | 5 | 4 | 6 | 4 | 4 | 4 | 4 | 7 | 5 | 5 | 6 | 5 | 7 | 79 |
| <i>Quantities and Measuring</i> | Qa | | | Qb | | Qa | | | Qb | | Qa | | | Qb | | |
| | Qa ₁ | Qa ₂ | | Qb ₁ | | Qa ₁ | Qa ₂ | | Qb ₁ | | Qa ₁ | Qa ₂ | | Qb ₁ | | |
| | 7 | 5 | | 3 | | 7 | 4 | | 4 | | 8 | 8 | | 6 | | 52 |
| <i>Space and Shape</i> | Sa | | | Sb | | Sa | | | Sb | | Sa | | | Sb | | |
| | Sa ₁ | Sa ₂ | Sa ₃ | Sb ₁ | Sb ₂ | Sa ₁ | Sa ₂ | Sa ₃ | Sb ₁ | Sb ₂ | Sa ₁ | Sa ₂ | Sa ₃ | Sb ₁ | Sb ₂ | |
| | 6 | 3 | 9 | 4 | 4 | 4 | 5 | 7 | 3 | 4 | 3 | 5 | 4 | 2 | 2 | 65 |
| <i>Equations and Functions</i> | Ea | | Eb | | | Ea | | Eb | | | Ea | | Eb | | | |
| | Ea ₁ | Ea ₂ | Eb ₁ | Eb ₂ | Eb ₃ | Ea ₁ | Ea ₂ | Eb ₁ | Eb ₂ | Eb ₃ | Ea ₁ | Ea ₂ | Eb ₁ | Eb ₂ | Eb ₃ | |
| | 3 | 6 | 3 | 2 | 1 | 4 | 5 | 2 | 2 | 2 | 3 | 3 | 2 | 2 | 1 | 41 |
| <i>Data and Chance</i> | Da | | | Db | | Da | | | Db | | Da | | | Db | | |
| | Da ₁ | Da ₂ | Da ₃ | Db ₁ | Db ₂ | Da ₁ | Da ₂ | Da ₃ | Db ₁ | Db ₂ | Da ₁ | Da ₂ | Da ₃ | Db ₁ | Db ₂ | |
| | 2 | 3 | 3 | 3 | 3 | 2 | 2 | 3 | 2 | 5 | 1 | 2 | 1 | 1 | 2 | 35 |
| Sum Total | | | | | | | | | | | | | | | 272 | |

Table 2: Number of statements in section “3. Topics and Contents” (levels A to D) of the G-BBM.

Abbreviations used for subtopics in Table 2 are as follow: **Na** *Conceptions of Number*: **Na₁** Perceiving and representing numbers; **Na₂** Ordering numbers; **Na₃** Describing number relationships; **Nb** *Conceptions of Operations and Calculation Strategies*: **Nb₁** Developing conceptions of operations; **Nb₂** Using calculation procedures and strategies; **Qa** *Conceptions of Quantities and Measuring*: **Qa₁** Utilizing conceptions of quantities and their units; **Qa₂** Determining expressions for quantities; **Qb** *Calculating with Quantities*: **Qb₁** Calculating quantities in contexts; **Sa** *Geometrical Objects*: **Sa₁** Describing geometrical objects;

Sa₂ Describing relationships between geometrical objects; **Sa₃** Representing geometrical objects; **Sb** *Geometrical Transformations*: **Sb₁** Utilizing geometrical transformations and their properties; **Sb₂** Carrying out geometrical transformations; **Ea** *Terms and Equations*: **Ea₁** Representing terms and equations; **Ea₂** Solving equations; **Eb** *Mappings and Functions*: **Eb₁** Exploring mappings and functions; **Eb₂** Representing mappings and functions; **Eb₃** Utilizing properties of functional relationships; **Da** *Data*: **Da₁** Collecting data; **Da₂** Representing data; **Da₃** Evaluating statistical investigations; **Db** *Counting strategies and probabilities*: **Db₁** Using counting strategies; **Db₂** Determining probabilities of events.

Concluding comments

Contrary to what might have been expected, the German content standards (Berlin-Brandenburg) describe learning outcomes at a much higher level of detail than the Chinese. This conflicts with the official policy discourse which preceded their development. According to Klieme et al. (2003), the new standards should describe broader competency outcomes. The similarities in the main structuring of the topics in both documents suggests some cross-system harmonization of objectives in the 2000s (see Lv & Cao, 2018; Ye, 2018). The Chinese content standards, however, appears to leave more discretionary space to teachers and schools for making micro-curricular decisions. In both contexts, the role of accountability measures vis-à-vis the standardization of the curriculum needs to be investigated. Regarding the naming of the topics and sub-topics, the Chinese appears to be more specialized, but complemented by the topic *Practical and Integrated Applications*. If Bernstein's (1996) concept of "classification" is applied here, this interpretation suggests an intended move towards weakening (internal and external) classification by establishing more relations with other school subjects as well as with everyday practice. This might be one of the reasons for the opposition against the reform from mathematicians reported by Yin (2013).

One conspicuity that emerged in the course of the investigation concerns the use of verbs that refer to students' competencies in terms of "experiencing", "developing a feeling for" or "grasping". Examples of such statements are, "[Students are] able to feel the meaning of large numbers when associated with realistic material, as well as to make estimations." (First Stage, "Numbers and Algebra: Knowing Numbers"), "Experience that amongst all lines connecting two points the segment is the shortest." (Second Stage, "Graphics and Geometry: Knowing Figures"). The German document does not contain similar statements. A consistent investigation of this observation has been hampered by the low-quality machine translation. However, it can be taken as an indication for a greater focus on non-discursive dimensions of mathematical practice. A systematic investigation of differences in curriculum statements with regard to privileged forms of knowledge and skills will have to include an analysis of stated overall objectives as well as pedagogic recommendations or examples of student activities that are given to exemplify the envisaged classroom practice. An important follow up question then is whether the documents aim at providing insights into the principles on the basis of which the curriculum has been developed.

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