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How do approaches to curriculum mapping affect comparability claims? An analysis of mathematics curriculum content across two educational jurisdictions

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Abstract:

Curriculum mapping is a comparability method that facilitates comparisons of content within multiple settings (usually multiple jurisdictions or specifications) and enables claims to be made about those curriculums/jurisdictions. Although curriculum maps have been published, there is little academic literature about the process of constructing and using them. Our study extends the literature by considering the different types of comparisons that can be made from curriculum maps: content coverage, placement, depth, and breadth. We also consider how these comparisons are affected by structural differences in the curricula or using a sub-set of the content.

We use our mapping of mathematics in the US Common Core State Standards (CCSS) and the national curriculum in England to explore this. The CCSS for mathematical practice are common to all grades; we mapped these standards against the content for individual years in the national curriculum. The CCSS for mathematical content are set out by grade; we mapped a subset of this content to the national curriculum.

Our mapping shows that it is possible to map curricula and make meaningful comparisons despite structural differences and content limitations. However, this affected the types of comparisons that we could carry out and the claims that we could make.

How do approaches to curriculum mapping affect comparability claims? An analysis of mathematics curriculum content across two educational jurisdictions

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Curriculum mapping is a method used within comparability studies to make comparisons of curriculum content within multiple settings: usually multiple jurisdictions or multiple specifications. These maps form the first part of the comparability studies. They present information from the jurisdictions/syllabuses (such as features of the education system or areas of curriculum content) in tables to make it easy for experts to make comparisons across the jurisdictions/syllabuses. These comparisons provide the evidence for claims about the jurisdictions/specifications. For example, the Department for Education (2012) used its mapping of curriculum content from six jurisdictions to claim that "Some mathematics curricula of high-performing jurisdictions are much more challenging than the 1999 and 2007 national curriculum for England, in particular on *number* and *algebra*, though *data and statistics* is slightly more challenging in England" (p. 3).

Curriculum maps are often used to compare the breadth and depth of curricula or specifications for qualifications (e.g., Alcántara, 2016; Department for Education, 2012; Ofqual, 2012). They often include the aims and content of the curriculum/specification, and features of examinations based on the curricula/specifications. Additional maps are sometimes included to provide information about the context, which enhances the analysis and key features of the education systems. Maps have also been used to compare features of interest across different jurisdictions (e.g., Elliott, 2014). Although curriculum maps have been published in policy documents and reports, studies using this method are rarely published and very little has been written about it in the academic literature (Elliott, 2014; Greatorex et al., 2019).

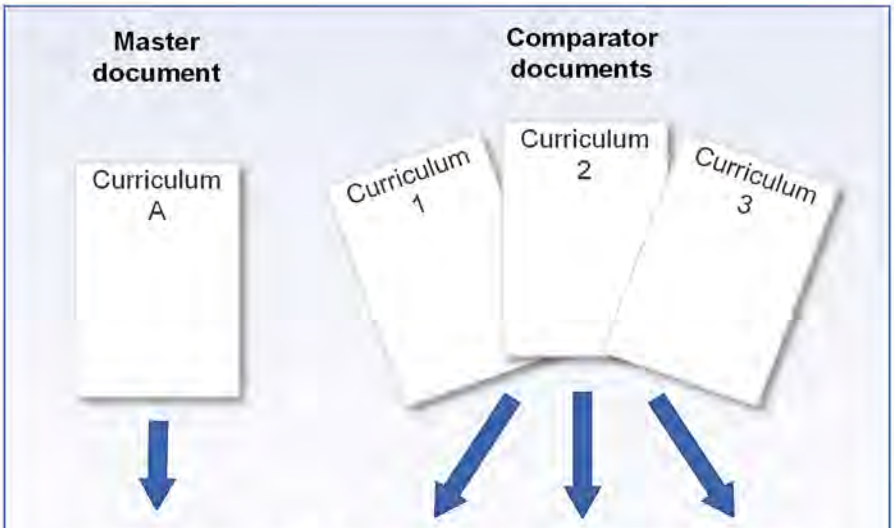
At this point, it may be helpful to clarify what is meant by the term *curriculum* in the context of curriculum mapping. We use the term curriculum to describe any document which forms part of the intended curriculum[1] in its respective jurisdiction. These can include:

- syllabuses or specifications, which set out the structure and content of courses and assessments
- educational standards, which are the documents used in the US to describe what students should "know and be able to do" (paragraph 2, Common Core State Standards Initiative, 2022).

It is important to note that comparisons that are based on documents which define the intended curriculum cannot provide any information about other types of curricula, such as the taught curriculum or the learned curriculum. Nor can they provide any information about the way in which the subject is taught within classrooms.

The maps usually consist of comparison tables or spreadsheets with specific comparators within each column (e.g., qualifications) and particular information in the rows (e.g., curriculum content) (Elliott, 2014). They differ from simply recording information as they enable direct comparisons to be made between jurisdictions by reading across a row; therefore, they are a tool to inform thinking and enable judgements. A document known as the *master* curriculum (Elliott, 2014) is always used as the basis of the comparison. Content from the other curricula (the *comparators*) is matched to this master curriculum, as can be seen in the examples of content mapping shown in Figure 1. Curriculum maps use one or more symbols in each cell of the table to indicate whether content from the master curriculum is covered in the comparators. For example, the TIMSS topic trace mapping (see Schmidt et al., 2018) uses two symbols to show whether each topic is taught in a particular year group and whether there is a particular focus on that content area in that year. Alternatively, maps may contain content descriptions instead of symbols, so that they can provide more detailed information.

1 The intended curriculum is "the overt curriculum that is acknowledged in policy statements as that which schools or other educational institutions or arrangements set out to accomplish" Kridel, C. A. (2010). Intended curriculum. In *Encyclopedia of curriculum studies* (Vol. 1, pp. 179-181). Sage Publications.



Content from master curriculum	Curriculum 1	Curriculum 2	Curriculum 3
Count to 100	✓	✓	✓
Count in multiples of 5	✓		✓
Identify the number one more and one less		✓	✓
Use equal to, less than, more than		✓	✓

Figure 1: Example of a curriculum map

There are circumstances when the mapping process needs to be altered sightly. For example, it may not be possible to map all the content because of time or budget limitations. There do not appear to be any studies in the public domain which consider a sub-set of content, so it is not possible to ascertain how this reduced content would affect any conclusions that could be drawn from the mappings.

More commonly, the structure of the content across the curricula may affect the mapping. For example, the content may be arranged differently across age groups in the curricula being compared. An example of this is the Department for Education (2012) mapping, where some curricula set out content by single year groups (e.g., Singapore) while others had multiple year group spans (e.g., Massachusetts and Finland). The authors found that this difference made it technically challenging to carry out the mapping and difficult to identify differences in the sequencing of content.

In this article, we will use a mapping study comparing the Common Core State Standards (CCSS) in the United States (US) and mathematics national curricula in England to discuss approaches to mapping when a sub-set of content is used or when curricula are structured differently by age. We will also discuss how the approaches differ from mapping whole curricula with matching age structures in terms of the conclusions or comparability claims that can be drawn from them.

Overview of the curricula

We used the following documents for our comparison:

- the CCSS for mathematics for grades K to 8, and
- the mathematics programmes of study for key stages (KS) 1, 2 and 3 (years 1–9).

These ranges of grades/years are considered equivalent (the grade number in the US is one less than the equivalent school year in England). We chose this range of grades because the CCSS standards are only aligned to particular grades until the end of grade 8. Beyond that, the standards are allocated to content areas, making it impossible to compare when content was taught. Additionally, year 10 in England marks the point when the curriculum differentiates between the content that is taught to all students and the content that is only taught to higher attaining students. This would complicate comparisons with the CCSS as it would require separate analysis of the content for all students and the content for higher achieving students.

The CCSS (see NGA Center & CCSSO, 2010)

The CCSS in the US are "a set of high-quality academic standards in mathematics and English language arts/literacy (ELA). These learning goals outline what a student should know and be able to do at the end of each grade" (Common Core State Standards Initiative, 2022, para 2). Use of the CCSS is not compulsory, but many states have chosen to adopt it, or have based their own standards on it. The CCSS for mathematics document is divided into two parts: the eight Standards for Mathematical Practice (SMP) and the Standards for Mathematical Content (SMC). The SMP are common to all grades and describe the expertise that teachers should aim to develop in learners (NGA Center & CCSSO, 2010). The SMC set out what students are expected to understand and do, and are set out by grade from kindergarten (K) to grade 8.

The national curriculum (see Department for Education, 2013a; Department for Education, 2013b)

The national curriculum in England "is a set of subjects and standards used by primary and secondary schools, so children learn the same things. It covers what subjects are taught and the standards children should reach in each subject" (UK Government, n.d., para 1) and is compulsory for many state schools in England. The documents contain a programme of study that lists the content that students should cover in particular key stages of schooling, and the matters, skills and processes that students are expected to be able to know and understand in those content areas (Department for Education, 2013b). These are set out by year group in KS1 and 2 (years 1–6), but KS3 content is common to all year groups (years 7–9).

Curriculum mapping methods

We used the CCSS as the master curriculum (Figure 1), because we wanted to see how its content differed from the national curriculum rather than the other way around. Carrying out a full-scale curriculum mapping comparison demands inordinate time and effort given the ultimate aims; therefore, we decided we could not map all the standards from the CCSS. Only three pages within the CCSS were devoted to the SMP, so we decided it would be possible to map that content. However, 76 pages were devoted to the SMC, so it was only possible to map a subset of the SMC content. The need to adopt different approaches for the two sections of the CCSS provided us with the opportunity to compare the two curriculum mapping methods (see Figure 2 for a visual representation of this and the mapping process).

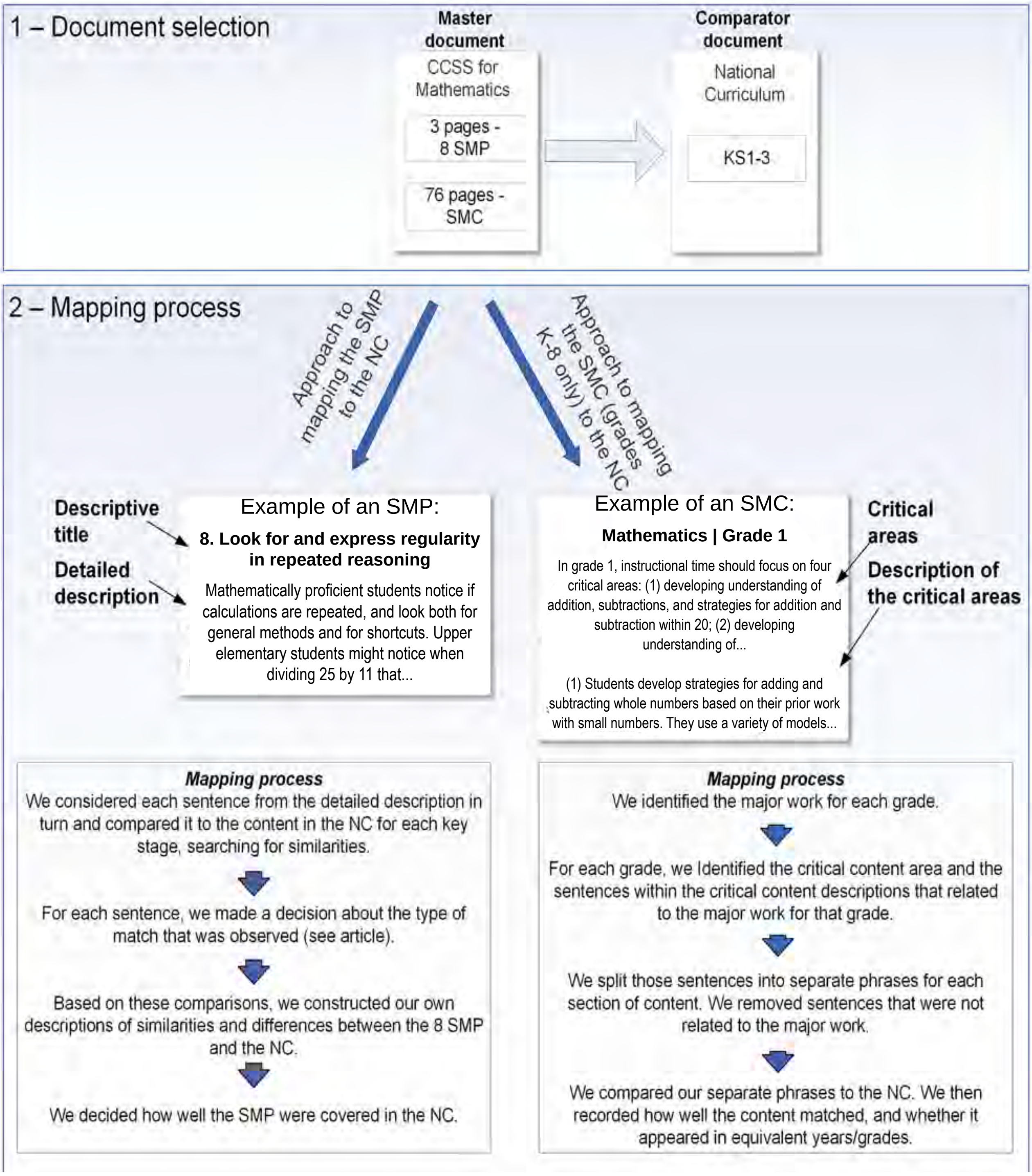


Figure 2: Approaches to mapping the Standards for Mathematical Practice (SMP) and the Standards for Mathematical Content (SMC)

Approach to mapping the SMP

There is no overarching content for the whole national curriculum, which means that there is no direct equivalent of the SMP. However, the skills described in the SMP can be found throughout the national curriculum content for specific year groups in KS1 and 2 (ages 6–11) and in the working mathematically content in the KS3 national curriculum (ages 12–14).

For the curriculum mapping, we took each sentence within the detailed SMP descriptions and compared it to the content in the national curriculum for each year to identify similar content. We then decided whether there was:

- a complete match with identical content (✓)
- a partial match with some matching content found (~)
- no match (×).

Where we could not find a match, but we felt that the content was needed in order to teach content that was listed, we noted this in the "notes on implicit matches" column. Table 1 shows an extract from this mapping. Row 2 shows the descriptive title for the first SMP, and rows 3-5 show the first three sentences from the detailed description for that SMP. The KS1, KS2 and KS3 columns show the matches for each sentence of the SMP. The best match for each sentence of the SMP was recorded in the overall KS1–3 column (e.g., the best match for row 4 was the partial match found in KS2, so this was the level of match recorded in the overall column). Finally, we recorded overall level of matching for the descriptive title of each SMP by tallying the number of sentences that were coded with each type of match (see Table 1, row 2).

Using these comparisons, we were able to make judgements about how well each of the SMP was covered explicitly and implicitly in the national curriculum.

Table 1: Example of curriculum mapping between the SMP and the mathematics national curriculum for KS1–3

SMP	SMP detailed description	KS1	KS2	KS3	Overall KS1–3	Notes on implicit matches
1. Make sense of problems and persevere in solving them.	**N/A**	✓✓ ~ ××××××	✓✓ ~~~ ××××	✓✓✓ ××××××	✓✓✓✓✓ ~~ ××	
	Mathematically proficient students start by explaining to themselves the meaning of a problem and looking for entry points to its solution.	×	×	×	×	Students will have to do this but is not stated in the documentation.
	They analyze givens, constraints, relationships, and goals.	×	~	×	~	Not explicitly covered but is needed when solving problems.
	They make conjectures about the form and meaning of the solution and plan a solution pathway rather than simply jumping into a solution attempt.	×	~	✓	✓	-

Approach to mapping the SMC

Because we were not able to map the whole of the SMC for grades K–8 as we normally would in comparisons, we had to reduce the content that was included. Therefore, we decided to focus on content associated with the major works –

the most important content for each grade which was intended to receive the majority of the teaching time (Achieve the Core, n.d.). There are five major works:

- "Addition and subtraction" (grades K–2)
- "Multiplication and division of whole numbers and fractions" (grades 3–5)
- "Ratios and proportional relationships, and early algebraic expressions and equations" (grade 6)
- "Ratios and proportional relationships, and arithmetic of rational numbers" (grade 7)
- "Linear algebra and linear functions" (grade 8)
  (NGA Center & CCSSO, n.d., section 1).

While previous studies do not appear to have used a sub-set of content in this way, we thought the method would provide us with useful information about the differences between the mathematics curricula in the two countries.

For the SMC mapping we compared the phrases we had identified in the descriptions to the national curriculum to identify matching content. We used ticks and tildes to show which year groups in England contained matching or partially matching content, and light grey shading to indicate the equivalent grades/school years. Table 2 rows 3–6 show the result of these comparisons for the K–2 major work, "Addition and subtraction". We then summarised the mappings for the major work row (shown in bold in row 2). Note that the grade 2 SMC descriptions are not shown in Table 2 but our curriculum mapping showed that it was also taught in year 3, hence the tick in row 2 for year 3.

Table 2: Example of the curriculum mapping process

US school grade	Major work and associated content	When covered in England?						
		Yr1	Yr2	Yr3	Yr4	Yr5	Yr6	Yr 7–9
K–2	**Addition & subtraction**	✓	✓	✓				
K	Join and separate sets of objects. (Writing of calculations encouraged but not required.)	[a]						
1	Add and subtract whole numbers within 20	✓						
1	Develop methods to add within 100		✓					
1	Develop methods to subtract multiples of 10		✓					

[a] This would be covered in the foundation curriculum.

Reporting findings from curriculum mappings

Mapping outputs: SMP and SMC overlap with the national curriculum

Table 3 and Table 4 show the outcomes of the analysis for the SMP and the SMC respectively. In Table 3 the symbols show the number of sentences within each SMP that were fully matched (a tick), partially matched (a tilde) or not matched (a cross) to the national curriculum for each of the key stages, as well as a summary across the three key stages. In Table 4, the ticks show when the SMC associated with each major work would be taught in the national curriculum. The shaded columns show the year groups and grades that are equivalent to each other.

Table 3: Comparison of the SMP to the national curriculum

Common Core standard	KS1	KS2	KS3	Across KS1–3
1. Make sense of problems and persevere in solving them	✓✓ ~ ×××××××	✓✓ ~~~ ×××××	✓✓✓ ×××××××	✓✓✓✓✓ ~~ ×××
2. Reason abstractly and quantitatively	×××	×××	~ ××	~ ××
3. Construct viable arguments and critique the reasoning of others	✓✓ ×××××××	✓✓✓ ××××××	✓✓✓ ×××××	✓✓✓✓ ×××××
4. Model with mathematics	✓✓ ×××××	✓✓✓✓✓ ~ ×	✓✓✓✓✓ ~ ×	✓✓✓✓✓ ~
5. Use appropriate tools strategically	××××××	✓ ×××××	✓ ~ ××××	✓ ~ ××××
6. Attend to precision	×××××××	✓ ×××××	✓ ××××××	✓✓ ×××××
7. Look for and make use of structure	✓ ×××××	✓ ×××××	✓✓ ××××	✓✓ ××××
8. Look for and express regularity in repeated reasoning	××××××	××××××	××××××	××××××

Table 4: Comparison of the SMC to the national curriculum

US grade	Major work for grade(s)	When covered in England?						
		Yr1	Yr2	Yr3	Yr4	Yr5	Yr6	Yr7–9
K–2	Addition & subtraction	✓	✓	✓				
3–5	Multiplication & division of whole numbers	✓	✓	✓	✓	✓	✓	
3–5	Multiplication & division of fractions	✓	✓	✓	✓	✓	✓	
6	Ratios & proportional relationships					✓	✓	✓
7	Arithmetic of rational numbers							✓
8	Linear algebra & functions							✓

Making comparisons from curriculum maps

Completed curriculum maps only form the first stage of a comparability study. The next stage requires the maps to be interpreted to compare the jurisdictions/curricula. Curriculum maps such as these can be used to identify similarities and differences in the content coverage, the ordering and progression of content across grades/school years, and the breadth and depth of the curriculum. In this section we will discuss these four comparisons and whether they could be made from our mappings given the approaches we used for the SMP (where age was only available for the national curriculum) and the SMC (where we used a sub-set of the content).

Content coverage

The most basic comparison that can be made is whether content from the master curriculum/jurisdiction is included within the other curricula/jurisdictions being compared (the comparators). These comparisons could be made for both the SMP (see Table 3) and the SMC (see Table 4). Our analysis of the SMC showed that almost all the content we mapped is included in the national curriculum – there were only four phrases without matching content. In contrast, there were considerable differences for the SMP, where half of the sentences could not be matched to the national curriculum. However, there were close matches for some of the individual SMP. Every sentence within the fourth SMP, "model with mathematics", could be matched to the national curriculum, with all but one of those being a complete match. Other SMP had good numbers of matches once the partial matches were included. For example, the first SMP, "make sense of problems and persevere in solving them" had complete matches for half its ten sentences and partial matches for a further two.

It is relatively easy to identify and code partially matched content; however, some content is not explicitly included but must be taught as other content relies on it, and this can be trickier to record. We found examples of implicit content in both the SMP and the SMC mappings. For example, the first of the SMPs requires students to explain the meaning of a problem and find entry points to a solution. We could not find refences to this in the national curriculum, but it does require students to solve problems and they cannot do this without working out what the problem means and trying to find an entry point to solve it. Therefore, we noted it as an implicit match.

We also found examples where the content from the CCSS was not included in the national curriculum content, but it was mentioned in the accompanying non-statutory notes and guidance. For example, the fractions content of the CCSS expects students to “Explain why procedures for multiplying fractions make sense” (NGA Center & CCSSO, 2010, p. 33). This is not included in the national curriculum content for multiplying fractions, but students would need to know this to be able to confidently multiply fractions (year 6 content). In addition, the non-statutory guidance states that “pupils should use a variety of images to support their understanding of multiplication with fractions” (Department for Education, 2013b, p. 41), which is similar. Therefore, we coded it as an implicit requirement.

Placement of content in grades/school years

When the content within curricula is allocated to particular school grades or year groups, it is possible to compare the ages at which particular areas of content are introduced and how many years they are taught for. Both the SMC and the national curriculum allocate the content in this way, so we were able to make these comparisons of content. For example, the fractions mapping (see Table 5) showed that students in England begin to recognise and generate equivalent fractions at a much earlier age and are taught this content for more years than students in the US, where this is only a requirement in grade 4. However, students in both countries learn to multiply fractions by whole numbers at the same age. Such comparisons were not possible for the SMP, as these standards are common to all grades in the US.

Table 5: Extract from the curriculum mapping of the SMC – multiplication and division of fractions

US school year group	Major work and associated content	When covered in England?						
		Yr1	Yr2	Yr3	Yr4	Yr5	Yr6	Yr7–9
4	Recognize & generate equivalent fractions		✓	✓	✓	✓		
4	Compose/decompose fractions from/into unit fractions							
4	Multiply a fraction by a whole number					✓		
5	Add and subtract fractions with unlike denominators					✓		

Depth of the curriculum

Curriculum maps can be used to compare the depth of the content coverage that students are expected to learn. Although depth can refer to the difficulty of the knowledge that students have learned in a particular area, it is more often used to indicate the amount of knowledge they have gained in that area within a period of time.

Regardless of which definition of depth is used, comparisons of the depth of curriculum are more difficult than considering whether content is present and when it is taught because a degree of expert judgement is required in order to consider whether additional and omitted content balance each other out. For example, Table 5 shows that there are differences in the fractions content included in grade 4 of the SMC and year 5 in the national curriculum. Anyone making a comparison of depth would have to consider how the additional content on adding and subtracting fractions in the year 5 curriculum compared to omission of the content on composing and decomposing from/into unit fractions and starting the equivalent fractions content in earlier year groups.

Despite the difficulties in making these judgements, and the requirement for expert opinion in order to make accurate judgements, it is possible to make some comparisons of the depth of content for both mapping methods. For the SMC mappings, which focused upon particular content areas, experts could look at those mappings and use them to decide whether students would have acquired a greater depth of knowledge in that area during a particular school grade/year, or whether they had acquired more difficult knowledge before a certain point in their schooling. However, they could not make an overall judgement about the depth of knowledge that was taught in a particular grade/year across all areas of mathematics.

The SMP mapping only allows comparisons of the depth of knowledge acquired over the course of schooling, as the content is common to all year groups. For example, there is almost complete overlap in the coverage of the fourth SMP, "Model with mathematics", so students are likely to achieve the same depth of knowledge in this area. In contrast, the final SMP, "Look for and express regularity in repeated reasoning", appears to be entirely absent from the national curriculum, so we can be reasonably confident in stating that students following the CCSS would have acquired a greater depth of knowledge in that area.

Breadth of the curriculum

Curriculum maps can also be used to make comparisons about the breadth of the curriculum coverage, either within particular grades/school years or across the whole of the curricula being compared. In order to make comparisons about the breadth of the curriculum coverage, it is necessary to map all the content from each curriculum that is used in the study. This means that as well as mapping matching content from all the comparator curricula to the master curriculum, it is necessary to record the content within each of the comparator curricula that is not included in the master curriculum. As comparing the entire content was out of the scope of our study, it was not possible to identify the breadth of either curriculum from our mappings.

Affordances and limitations of the methods for curriculum mapping and the resulting comparability claims

In this article we have described three different methods of curriculum mapping: (1) mapping the entire content, (2) mapping selected content and (3) mapping curricula structured differently by age. We have also considered the different sorts of comparisons that can be made from curriculum maps – content coverage, when taught, depth and breadth of coverage – and have discussed which comparisons can be made for each approach (see Table 6). In this section, we will consider the affordances and limitations of the different approaches to curriculum mappings and the comparability claims that can be made from them in these three approaches.

Table 6: Summary of the comparisons that can be made from each method

	Entire content	Different age structures	Selected content
Content coverage	Yes	Yes	Yes**
Content placement in grades/years	Yes	No	Yes**
Depth of curriculum	Yes	Possibly*	Partially**
Breadth of curriculum	Yes	Possibly*	No

* possible across multiple grades/years if the start and end grades/years align
** only possible for selected content areas

Generally (all methods)

Curriculum mapping is a very useful method for identifying differences in what is taught in terms of the content that is covered and the year in which it is taught. For example, our mapping of the SMC showed that, for the areas we looked at, there is very little difference in the content that is included in the SMC and the national curriculum, but the content is generally introduced earlier and taught over a greater number of years in the national curriculum. The visual nature of the mapping documents enables a focused comparison of the curricula (Greatorex et al., 2019) and allows comparisons to be made with relative ease (Elliott, 2014). These comparisons can be used to see what is happening at a particular time (Elliott, 2014) or to study differences between current and older versions of curricula (Greatorex et al., 2019). The maps may also provide insights into the approaches to a subject in the two countries. For example, while carrying out our mapping, we were able to identify that the CCSS had an emphasis on conceptual knowledge as well as procedural knowledge, whereas the national curriculum emphasised procedural knowledge.

However, there are limitations that should be considered. The mapping document enables the comparisons between curricula rather than providing instant answers about the comparability of curricula. Curriculum maps should be interpreted by subject experts (Elliott, 2014) who may then go on to make comparability claims. Summaries of the experts' interpretations are often given greater prominence in the resulting reports than the curriculum maps that they are based upon. The requirement to summarise the maps can introduce errors into the analysis, particularly where the interpreter is more familiar with the content in one curriculum than the others. Other misinterpretations could be introduced when terminology is used differently within the curricula meaning that identical content goes unmatched, or content is matched incorrectly. Finally, curriculum mapping can only provide information about the intended curriculum; it cannot provide insights into what is taught in schools or how it is taught (the enacted curriculum).

Mapping the whole curriculum

The most comprehensive mapping that is possible is when the whole comparator curriculum is compared to the whole of the master curricula. We saw in the previous section that this enables all four types of comparisons to be made – content coverage and placement, and the breadth and depth of the curricula. If content from multiple years is mapped, it is also possible to compare the progression in understanding across grades/years.

Bearing this in mind, it may seem difficult to justify moving away from this approach; however, there are some disadvantages to mapping entire curricula. Firstly, mapping is a time-consuming exercise. The greater the quantity of content that is mapped, the longer it takes and the more it costs. A second consideration is the amount of information that is produced and the usefulness of that information given the aims/purposes of the comparability study. In order to make useful observations and interpretations regarding mapping claims it is necessary to use the mapping to make one or more of the four types of comparisons. The more content that is mapped, the more difficult it is to make these comparisons. Even identifying similarities and differences between curricula can prove difficult when there are many pages of a mapping document to consult. Similarly, although it is possible to make comparisons of the depth and breadth of the curricula, it may be very difficult for an expert to decide how the multiple differences in the breadth and depth of coverage in each area of the curriculum balance out, and therefore to draw conclusions about which curriculum contains that greatest depth or breadth of content. A final limitation is that it does not provide any information about the importance of particular areas of content.

Mapping limited content

Including only certain topics, as we did for the SMC, is a pragmatic approach that still enables most types of comparisons to be undertaken. It may also make it easier to identify similarities and differences across the curricula being compared as there is less data to consider. However, this approach is inevitably less robust than comparing whole curricula as there is no information about the omitted content. The omission of content also precludes comparisons and claims about the depth or quantity of the content included in particular grades/years, as it is unlikely that the quantity of content contained within the selected areas is representative of the quantity of content in the omitted areas. Taking our mapping of the SMC as an example, we found that more areas of mathematics were included in the national curriculum for pupils in years 1–3 than were included in grades K–2 of the SMC. However, it would not be appropriate to use this finding to claim that the national curriculum contained a greater depth of content as it does not take into consideration the content areas such as geometry that were excluded from our mapping.

Perhaps the greatest difficulty with this approach is selecting content for the mapping that will enable meaningful comparisons to be made. This could be areas of the subject that have been identified as particularly important (e.g., the major works associated with the CCSS that we used in our mapping), but it could also be one or more domains within a subject (e.g., number as a domain of mathematics) or particular areas within a domain (e.g., fractions as an area within number). Whatever domain or area is chosen, it is important that there is an underlying justification for the choice. This will help to ensure that the resulting claims of comparison are useful and will reduce the likelihood of self-fulfilling claims resulting from the careful selection (or deselection) of content.

Mapping curricula with different age structures

These comparisons are effectively a subset of the whole curriculum mappings, but where one curriculum is arranged differently from another. One may have separate content for every age group (like the KS1 & 2 national curriculum in England) when its comparator curricula combine several year groups together or have identical content for all age groups (like the SMP). The researcher will not have any choice about whether to use this approach, as it is a characteristic of the documents they are working with. This was the case with our SMP mapping, which showed that it was still possible to make meaningful comparisons when working with curricula with this issue. This approach to mapping shares the affordances of mapping whole curricula, for example allowing most types of comparison to be undertaken and allowing comparisons of the depth and breadth of content covered over the whole of the age range. We were able to identify standards within the SMP that had different depths of content to the national curriculum, such as the 5th standard which contains requirements to use technological tools that had no equivalent in the national curriculum. When the mappings for all eight SMP are considered, there appears to be greater depth in the SMP content than in the national curriculum.

This approach also suffers from the same limitations as mapping the whole curricula. Moreover, it is more limited than other mappings of whole curricula in that it cannot be used to explore differences in the age at which particular topics are taught, or in the amount of content for particular age groups. Thus, although we identified areas of the SMP that are also covered by the national curriculum, such as "Model with mathematics", we could not state whether the CCSS require students to learn more content or to have greater knowledge of the content in a particular grade than would be expected in the equivalent year of the national curriculum.

Conclusion

Within comparability, curriculum mapping is used to analyse similarities and differences in the content of multiple curricula. It is important to note that it only provides insights into the intended curriculum; it cannot provide information about the taught or learned curricula, or the teaching methods that are adopted in classrooms. Although the preferred approach is for whole curricula to be compared, there will be occasions where this is not possible due to time constraints, lack of funding, or where the researchers are only interested in part of the curriculum. Our study has shown that it is also possible to use this method to map a sub-set of the content and make meaningful comparisons and claims from the mapping, provided that the content has been selected in a way that can be justified. Thus, we can use our mapping to claim that the number and algebra content contained within the SMC and the national curriculum is comparable.

However, it would not be appropriate to extend the claim to say that the national curriculum and CCSS are comparable for the whole mathematics curriculum, nor could we infer the comparability of other areas of mathematics on the basis of the areas we mapped.

There can be issues with curriculum mappings where the curricula that are used in the comparisons are structured differently. Some structural differences, such as the content appearing under different headings, may not affect the mapping or the comparisons that can be made from it. Other differences, such as differences in the way in which the content is structured by age, can affect the comparisons by restricting what can be compared or the precision of those comparisons. We showed that it was still possible to map the content when there were differences in the age structures of the documents, and to make justifiable claims on the basis of the mapping, but we could only do this for the whole document rather than for individual year groups. In the case of the SMP mapping, we can claim that the SMP require students to have greater understanding of mathematical processes than the national curriculum, but we could not state whether this was true for students in particular grades/years. We also could not claim that students in the US would be better at these skills than students in England, as students may be taught skills that are not included within the curriculum.

Both approaches we used (mapping a sub-set of content and mapping curricula that are structured differently by age) enabled us to make claims of comparisons of the similarities and differences in the content that is included and the depth of the content that is taught; however, the approaches did limit the other comparisons that were possible. When a sub-set of the content was mapped, it was not possible to compare the breadth of the content. Therefore, we cannot use our SMC mapping to compare the breath of the national curriculum to the breadth of the CCSS. When the content within one or more of the curricula was common to multiple age groups, it was not possible to compare the age when the content was taught. Therefore, we cannot make claims about the skills taught to equivalent year groups, or that students of a particular age would be expected to demonstrate.

This article has introduced the types of comparisons that can be made from curriculum mapping studies generally, and when features of the curricula or the study design affect the mapping that can be carried out. However, the approach that is chosen will affect the claims that can be made about the comparability of different curricula. Therefore, any researcher wishing to use curriculum mapping as the basis for a comparability study must balance the intentions of the comparability investigation with the rigour of the methodological approach that they use.

Future research may want to consider how the selection of content that is mapped can affect the claims that can be made, and how the comparisons that can be made from mappings are affected when the curricula are for skills-based subjects, such as English literature or foreign languages, rather than content-based subjects like mathematics.

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