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GLOBAL ALLIANCE TO MONITOR LEARNING

SUSTAINABLE DEVELOPMENT GOALS

Monitoring Progress towards SDG 4.1: Comparative Analysis of Curriculum and Assessment National Frameworks for Mathematics

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Summary

Background

This paper presents the comparative analysis of 20 countries' national curriculum frameworks (NCFs) and national assessment frameworks (NAFs) for Mathematics. The study was conducted with the purpose of examining the alignment between what countries intend to teach and what they assess. The study falls under the overall aim of the UNESCO Institute for Statistics (UIS) to support the monitoring of learning outcomes with regards to SDG 4.1, by finding ways to link them globally in a comparable way.

> *4.1: By 2030, ensure that all girls and boys complete free, equitable and quality primary and secondary education leading to relevant and effective learning outcomes.*
> *4.1.1 Proportion of children and young people: (a) in grades 2/3; (b) at the end of primary; and (c) at the end of lower secondary achieving at least a minimum proficiency level in (i) reading and (ii) mathematics, by sex.*

The initial analysis of 115 NAFs from 53 Member States revealed a consistently low coverage of the Math Proficiency domain in NAFs (IBE-UNESCO and UIS, 2017). In the analysis among different income classification levels, High-Income Member States had a higher coverage of that domain in their NAFs. A possible reason that was believed to contribute to higher coverage of domains and sub-domains within NAFs of High-Income Member States, was critical mass. Critical mass could potentially lead to a better alignment between NCFs and NAFs. The study emphasized the need to further investigate this hypothesis, the possibility of alignment of curriculum and assessment and a call for better correlation between NCFs and NAFs. This would allow Member States not only to develop competency-related indicators within their NCFs, but also to effectively reflect them within their NAFs.

The investigation into this hypothesis led to a decision to map and analyse the NCFs of 20 Member States, whose NAFs had already been mapped. For this study's comparative analyses, the NAFs and NCFs were mapped using the *same* Coding Scheme as the one used in the previous study (IBE-UNESCO and UIS, 2017), which allowed for a meticulous documentation of the presence and/or absence of learning outcomes and objectives in each framework. Moreover, commonalities and differences in the assessed and curricular content were identified and analysed by country, income classification levels, education levels, and languages.

A total of 53 NAFs and 53 NCFs, in English, French and Spanish, from a sample of 20 Member States[1] and 6 regions of the world[2], covering the three points of measurement of Indicator 4.1.1 (grades 2/3, end of primary and end of lower secondary education) were analysed in this study.

Limitations of the study:

Before viewing the findings, it must be noted that due to the relatively small sample size used in this comparative analysis, the findings must be interpreted with careful attention and valid consideration before drawing invalid conclusions. One must note that the region of Central and Eastern Europe was solely represented by Estonia. Additionally, the information

[1] The 20 Member States whose NAFs and NCFs were analysed for the purposes of this study were (in alphabetical order): Australia, Canada-Ontario, Dominica, Dominican Republic, England-UK, Estonia, Fiji, France, Gambia, Guatemala, Honduras, India, Ireland, Ivory Coast, Micronesia, New Zealand, Pakistan, Peru, Seychelles, and Uganda.
[2] No countries from Central Asia and the Arab States were used in this study, due to language limitations.

i was analysed for quantity and presence of criteria, not quality, and therefore does not necessarily represent rigor of curricular or assessment objectives, or capture the nuances present in pedagogy- integral to curriculum, nor represent a way to standardise information across content areas. It is important, when interpreting the results of these analyses that careful consideration be given.

Findings of the study

- An overall analysis revealed that the domain with the highest percentage of alignment between NAFs and NCFs was *Number Knowledge* domain (100%), which means that this domain was present in both the NAFs and NCFs analysed.

- *Math Proficiency* was the domain with the lowest percentage of alignment, with only 22%, a trend that remained apparent across all levels of analysis. Several possibilities could explain this low percent of alignment, many of which would require further research and analysis into the structure, terminology, definition and application intended in this domain. One possible explanation, however, is that both NAFs and NCFs view and represent 'proficiency' as an area and even a practice that should be taught within each domain and subject. The majority of Member States' frameworks included *Math Proficiency,* (or similar terminology, such as, 'mathematical processes', 'applying', 'solving' and 'cognitive domains') as a current running throughout curricular and assessment outcomes, and not a stand-alone category which can be easily quantified. *Math Proficiency* is critically important to teach, yet extremely hard to assess, especially in the context of a national standardized assessment. Consequently, in the coding of this domain, it was mapped present if Member States dedicated an individual domain to *Math Proficiency* (or analogous terminology), in either their NAF or NCF. This presence demonstrated the importance to which certain Member States prescribe and ascribe to this approach. For example, in the majority of NCFs, Member States describe the vision, goals and curricular expectations for learners, at all education levels, clearly detailing the relevance of scope and sequence of learning outcomes and objectives. As such, if the organization and terminology used in NCFs were analogous and thus comparable to the criteria found in *Math Proficiency* domain in the Coding Scheme, the presence of this domain was indicated.

- All High-Income Member States displayed the highest percent of alignment across all domains. Two possible reasons could perhaps explain this phenomenon.
    a) High-Income Member States represent the largest percent of Member States within this study, at 40%, therefore, with a larger sample of High-Income nations, it is natural to see the data indicate a higher percent of alignment.
    b) Critical mass may be an advantage counter to Member States of lower income levels. Is the higher alignment of sub-domains, within NAFs and NCFs, of High-Income Member States a guarantee that learners of these Member States develop skills and knowledge, and have them equally assessed, in contrast to learners of Member States of other income levels who may not? From an assessment point of view, alignment of domains and sub-domains within NAFs and CNFs equals more 'content' precision in the assessment, because students are being assessed what they have been taught and learnt. In the case of countries that show no alignment between the two frameworks (presence of criteria in either the NAF or NCF of a Member State and absence from the other), there is a higher chance that the test does not reflect what

the students have been taught (and learnt), which only decreases the content validity of the test. Subsequently, low learning outcomes might be a derivative of the lack of content validity in the test, as students fail to perform what they have never learnt.

- Through the analysis by level of education, the disparities between Upper Primary and Lower Secondary were quite noticeable. A higher alignment and correlation between Lower and Upper Primary is logical, considering the scope and sequence of mathematical concepts within primary education grades; yet increasingly evident in data is a precipitous transition between Upper Primary and Lower Secondary in both curricular and assessment outcomes. This claim would be better elaborated upon with an increase in Lower Secondary classified national frameworks (larger than the existing 19% in this study). Nonetheless, this finding is woven throughout all domains and calls for Member States to re-examine the scope and sequence of NCFs and their corresponding NAFs to ensure learning outcomes and objectives are not only horizontally but vertically articulated and aligned.

- Finally, a few sub-domains appear to be assessed without being included in the NCF; *Chance, Probability and Probability Experiments (Statistics domain); Functions (Algebra); Numerical Patterns (Algebra); Properties of Space (Geometry).* Explanations and needed investigations into these instances would require further levels of analyses.

Recommendations – Competency-based learning approach

The increasing prevalence of competency-based national frameworks or components of competency-based education (CBE) within national frameworks suggests a paradigm shift from traditional, subject-based curricula and assessment approaches (common in the 1960's-70's) towards competency-based approaches (Harden, 2002). Gradually emerging since the 1970's, CBE is comprised of a competency framework and competency assessments – the former describes skills, knowledge and abilities while the latter measures and determines mastery (McClarty and Gaertner, 2015). This study has shown that within this paradigm shift, well-articulated competency-based assessment (types, tools, metrics and scale) are lacking. Many Member States, in this study, detailed in great length the importance of assessment and learning; however, there is a need for a concerted and data-driven approach to determine how best to measure competency-based curricula nationally and globally. Further questions are raised; what metrics are used in assessing 'cognitive domains' and 'general competencies' which are, by nature of their function, often loosely understood or difficult to describe as an observable behaviour? In cases that these assessment tools are framed and designed - are well resourced capacity building programmes in place for educational practitioners so that they may develop, implement and manage the assessment data in service of the learner?

In order to fully comprehend the complexities inherent within these discussions, a recommendation is made to caste a wider net in data collection and data analysis - to collect an extended number of national frameworks, related documents and additional pieces of evidence from Member States (such as educator input, lesson plans, regional school districts, student testimonials and more). This wider net will help to better capture the real 'look and feel' of assessment and curriculum's ongoing relationship as it relates to the monitoring of learning outcomes with regard to SDG 4.1 - Education 2030.

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In-Progress Reflection No. XX on
Current and Critical Issues in Curriculum, Learning and Assessment

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Monitoring Progress towards SDG 4.1:
Comparative Analysis of Curriculum and Assessment National Frameworks for Mathematics

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Title

Monitoring Progress towards SDG 4.1: Comparative Analysis of National Assessment Frameworks and National Curriculum Frameworks for Mathematics

Series

Current and Critical Issues in Curriculum, Learning and Assessment

In-Progress Reflection

March, 2018, No. 17

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Open Note of the IBE

The IBE has launched the series In-Progress Reflections on *Current and Critical Issues in Curriculum, Learning and Assessment* to open a communal space for a global conversation, collective production and discussion on those issues of high concern for Member States. It intends to support country efforts in mainstreaming challenging issues within the processes of curriculum renewal and development across different levels, settings and provisions of the education system.

Initially, the focus areas of the In-Progress Reflections series encompass, among others,: (i) Early Childhood Care and Education (ECCE) as a foundation of holistic child development and learning; (ii) Reading and writing in early grades to support the development of essential competencies; (iii) Youth Culture and competencies for Youth in the early 21st century (covering formal, non-formal and informal education); (iv) ICT curricula and inclusive pedagogy contributing to relevant and effective learning outcomes; (v) STEM (Science, Technology, Engineering and Mathematics) curricula to foster sustainable development; (vi) Curriculum for Global Citizenship Education (peace, human rights, sustainable development, values, ethics, multiculturalism, etc.); (vii) Assessment to enhance and support learning opportunities; and (viii) Inclusive education as an over guiding principle of education systems.

The series of reflections covers a wide array of knowledge products, among them: discussion papers, policy briefs, frameworks, guidelines, prototypes, resource packs, learning tools and multimedia resources. These materials are discussed, refined, used and disseminated engaging education and curriculum agencies / institutes, and in particular curriculum developers and specialists, development experts, policy makers, teacher trainers, supervisors, principals, teachers, researchers and other educational stakeholders. In addition, they serve as reference materials for the IBE menu of capacity-development training on curriculum, learning and quality education – namely masters, diplomas, certificates and workshops – to forge policy and technical dialogue involving a diversity of stakeholders and to support sustainable country fieldwork.

Through blogs and e-forums, we encourage the audience to actively interact and bring in diverse perspectives. Effectively, the online space for reflection allows us to stay connected, facilitates exchange between experts from different regions of the world, and truly fosters continuous reflection on the issues concerned. The blog is structured to gather diverse resources, which include tools and documents (as previously mentioned) under specific themes to provide a complex and rich set of materials targeted to the specific needs of Member States. The In-Progress Reflections will capture relevant visions, views and comments shared by the audience, and serve as a key resource to support Member States' efforts in mainstreaming relevant findings and effective practices in national policies, curriculum frameworks and developments and in professional practices.

Dr. Mmantsetsa Marope: Director, International Bureau of Education

Monitoring Progress towards SDG 4.1: Comparative Analysis of Curriculum and Assessment National Frameworks for Mathematics

Abstract: This report guides the reader through a comparative analysis of 20 countries' national curriculum frameworks (NCFs) and national assessment frameworks (NAFs), to examine the alignment between what countries intend to teach and what they assess. The report details the study's findings with an in-depth analysis of the symmetry between *intentional* learning outcomes and *assessed* learning outcomes. Disconcerting issues are identified – yet not resolved- in instances of asymmetry that shed light on areas of alignment for countries' considerations. The findings emphasises the ambiguity of global understanding around *Math Proficiency* and its integration, or lack thereof, in national frameworks. The report continues with a discussion on competency-based education (CBE) approaches and lastly, calls for stronger alignment of curriculum and assessment outcomes; and further research into competency-based assessment tools as they pertain to the monitoring progress towards SDG 4.1 - Education 2030.

Sustainable Development Goal (SDG) Target 4.1

"By 2030, ensure that all girls and boys complete free, equitable and quality primary and secondary education leading to relevant and effective learning outcomes."

Keywords: Assessment – Curriculum – Education 2030 – mathematics – national assessment framework (NAF) – national curriculum framework (NCF) – SDG 4.1

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Background Information

The UNESCO Institute for Statistics (UIS) has the mandate to 'work with partners to develop new indicators, statistical approaches and monitoring tools to better assess progress across the targets related to UNESCO's mandate, working in coordination with the Education 2030 Steering Committee' (UIS, 2017). As the custodian agency for SDG 4.1, the UIS is coordinating the development of methodologies, indicators, and data reporting to achieve the objectives of these agendas. This implies, among others, finding ways to link different assessment results and to report them in a globally comparable way, in order to help Member States to measure progress towards SDG 4 and the Education 2030 agenda.

The UNESCO International Bureau of Education (IBE-UNESCO), as UNESCO's Centre of Excellence in curriculum, learning, assessment and related matters, supports Member States to enhance the effectiveness of student learning by promoting excellence in curriculum design, learning, teaching, and assessment processes. Its overarching aim is to strengthen the capacities of Member States to design, develop, implement and assess curricula that ensure the equity, quality, development-relevance, and resource efficiency of education and learning systems.

UIS and IBE-UNESCO have been working collaboratively to support the monitoring of learning outcomes with regards to SDG 4.1, by finding ways to link them globally in a comparable way. During the first step of this collaboration, the two institutions focused on the skills and content coverage of learning assessment, which '…refers to a wide range of methods and tools used to evaluate, measure and document learning outcomes, learning progress and learning needs and conditions' (UNESCO, 2017). A content and skills framework for Mathematics was thus developed from cognitive theory and various national curricula, which was then followed by the development of a Coding Scheme (Cunningham, 2017). This tool was used to map 115 National Assessment Frameworks (NAFs) from a total of 53 Member States (IBE-UNESCO and UIS, 2017). The choice of mapping NAFs was made as these documents are designed and used as 'outlines of desirable item types' (Cunningham, 2017) that include the content and skills assessed by a Member State. This mapping exercise provided valuable information about the mathematical content and skills assessed globally at the national level.

The initial analysis focused on 115 English, French, and Spanish-language National Assessment Frameworks (NAFs) for Mathematics from 53 Member States (25% of 210[1] UNESCO Member States) and 7 out of the 8 regions of the world[2] (IBE-UNESCO and UIS, 2017). The NAFs covered the three points of measurement of Indicator 4.1.1: (a) grades 2/3; (b) end of primary; and (c) lower secondary. The NAFs were analysed to reveal trends, commonalities and differences in the content assessed in mathematics (1) globally; (2) by region of the world; (3) by income classification level; (4) by education level; and (5) by language.

A consistently noticed trend among all levels of analysis was the low coverage of the *Math Proficiency* domain in NAFs. In the analysis among different income classification levels, High-Income Member States had a higher coverage of that domain in their NAFs (IBE-UNESCO and UIS, 2017). A possible reason that was believed to contribute to higher coverage of domains and sub-domains within NAFs of High-Income Member States, was critical mass. Critical mass could potentially lead to a better alignment between NCFs and NAFs. The study emphasized the need to further investigate this hypothesis, the possibility of alignment of curriculum and assessment and a call for better correlation between NCFs and NAFs. This would allow Member States not only to develop competency-related indicators within their NCFs, but also to effectively reflect them within their NAFs.

1 This number includes Members and Associate Members of UNESCO, as well as administrative regions, countries, and provinces. The full list of UNESCO Member States and UNESCO Associate Members may be found here: http://www.unesco.org/eri/cp/ListeMS_Indicators.asp (Accessed 15 June 2017.)

2 Central Asia and the Arab States were the regions of the world not represented in the study, due to language limitations.

Interested in the link between NAFs and National Curriculum Frameworks (NCFs), UIS and IBE-UNESCO are now working together towards mapping the content of NAFs and NCFs, to produce cross-nationally comparable indicators for SDG 4.1.1 for Reading and Mathematics:

> *'Target 4.1: By 2030, ensure that all girls and boys complete free, equitable and quality primary and secondary education leading to relevant and effective learning outcomes*
>
> - *Indicator 4.1.1: Proportion of children and young people: (a) in grades 2/3; (b) at the end of primary; and (c) at the end of lower secondary achieving at least a minimum proficiency level in (i) reading and (ii) mathematics, by sex' (UN, 2015).*

Introduction

The investigation into this hypothesis led to a decision to map and analyse the NCFs of 20 Member States, whose NAFs had already been mapped. IBE-UNESCO's internal database of NCFs was used to extract the required documents and an effort was made for a fair representation of all regions, income classification levels, education levels and languages in the study. However, the fact that both a NAF and a NCF were needed from a Member State to be included in the study, language limitations and a small number of either NAFs or NCFs collected from specific regions hindered this effort. As a result, two regions of the world are not represented in this study: Central Asia, which was absent in the initial study too due to language limitations (IBE-UNESCO and UIS, 2017) and the Arab States, due to the NCFs of Member States of this region being in languages other than English, French, or Spanish, and as such, were seen to be outside the scope of this study. In summary, (i) language limitations, (ii) availability of both types of documents (NAF and NCF), and (iii) representation of all income levels and regions available considering language limitations resulted in a total number of 53 NAFs and 53 NCFs, from a sample of 20 Member States and 6 regions of the world (*see Annex 1 for regional classification of Member States*), covering the three points of measurement of Indicator 4.1.1 (grades 2/3, end of primary, and end of lower secondary education). The 20 Member States whose NAFs' and NCFs' were mapped, analysed, and compared in this study are listed in *Annex 1*. Income classification levels, education levels and language classifications among the 20 countries are also listed in *Annex 1.*

The purpose of this analytical study is to compare English-, French-, and Spanish-language NAFs and NCFs for Mathematics, ranging from Lower Primary education to Lower Secondary education in order to examine the alignment between assessment and curricular outcomes in national frameworks; as "alignment is central to current efforts of systemic and standards-based education reforms…" (Webb, 1997). The intention of this report is to detail the study and its findings - with a specific analysis of the symmetry between *measured* learning outcomes and objectives in NAFs and *intentional* learning outcomes and objectives in NCFs. The underlying inquiry of this study was - **are assessment frameworks measuring learning outcomes for Mathematics present in curriculum frameworks, and what findings are most salient within such an inquiry?** This inquiry relied on the mapping and analysis of assessment outcomes and objectives (referred to as 'criteria' in this report) to the presence of learning outcomes and objectives in curriculum; and as such, absences in both NCF and NAF were excluded from the study (*see Methodology section below*).

This report is divided into five major sections, I) the methodology of the study; II) the findings of data analyses by domain and sub-domain levels - the findings are presented based on five levels of analysis of symmetry in conformity with the Coding Scheme: 1) overall analysis between NAFs and NCFs; (2) analysis by Member States; (3) analysis by income classification levels; (4) analysis by education level; and (5) analysis by language, with commonalities and differences of symmetry at every level of analysis presented -; III) observations on asymmetry analyses; IV) case-studies from Member States with discussions on competency-based education (CBE) approaches in national frameworks; and V) a conclusion stating the importance and efficacy of symmetrical learning outcomes and assessment outcomes; and a call to action for a further research into competency-based assessment tools as learning and assessment progress and respond to changing times and evolving societies in monitoring progress towards SDG 4.1 - Education 2030.

I. Methodology

For this study's comparative analyses, the NAFs and NCFs were mapped using the *same* Coding Scheme as the one used in the previous study (IPR series N° 15, IBE-UNESCO and UIS, 2017), which allowed for a meticulous documentation of the presence and/or absence of learning outcomes and objectives in each framework. Moreover, commonalities and differences in the assessed and curricular content are identified and analysed by country, income classification levels, education levels, and languages.

NAF and NCF- mapping alignment:

The following categories and their descriptors inform the methodology used to guide the data analysis.

Symmetry: NAF and NCF criteria (in reference to domains and sub-domains, as they conform to the Coding Scheme) are both present (values of 1).

Asymmetry: NAF and NCF criteria are not aligned as per conformity to the Coding Scheme.

- Curriculum- based: NAF criteria are absent (0) in the presence (1) of NCF criteria.
- Assessment- based: NAFs criteria are present (1) in the absence (0) of NCF criteria.

Excluded datum: NAF and NCF criteria are both absent (value of 0). As this study was intended to assess the overall consistency of Member States with regards to the alignment of assessment and curriculum, rather than the robustness of curriculum and assessment in relation to the criteria that were examined, instances where there was an absence of a criterion from both the curriculum and assessment have been excluded from this analysis. These exclusions were thought to be necessary due to the fact that the inclusion of data points where curriculum and assessment were aligned in their *absence* would bias conformity upwards. For example, if a Member States' curriculum included six of the 17 sub-domain criteria and assessed three criteria (all aligning within the five included within the curriculum), and the study were to include the 11 instances of full absence, the analysis would yield a conformity rate of 82.35%. However, by excluding the 11 instances of full absence, a conformity rate of 50% would follow, which would likely be a much fairer assessment of the Member States' conformity.

While it could be possible that components captured by the criteria were *intentionally* excluded by the authors of the framework, thus implying conformity, it would seem that such instances would be significantly less present than those of unintentional exclusion, and without being able to discern the intention of the authors of framework within the scope of this study, it would be impossible to determine. This possible (albeit likely subtle if present) sampling error is partially offset by and is a logical extension of instances where Member States have included educational components in both curriculum and assessment that do not fall within the criteria that were assessed by the scope of this report. This is especially salient in instances of robust educational criteria, such as geo-spatial investigations which is included in both of France' NCFs and NAFs at Cycle 4,[3] but inherently excluded from the scope of the study due to the constraints of the criteria included in and subjects-based structure of the Coding Scheme. Therefore, in certain cases, comprehensive and competency-based education systems may be slightly weighted downward in terms of conformity (or skewed in other manners), details of which are found in the *Discussions* section. A significantly more advanced study both in terms of the methodological inclusion of criteria stemming from a more vigorous Coding Scheme, and statistical modelling would be needed to fully understand the implications of intentionally excluded criteria and included criteria that were not present in the indicator set used for assessment. However, it would appear to be a reasonable assumption that such implications are likely of a negligible overall magnitude for this study, and therefore the handling of the data in this manner was

[3] While this instance was noticed during the study, the assessment of all of such instances was seen to be beyond the scope of this document, and therefore a full assessment of such instances has not yet been conducted.

seen to be the most practical application. Lastly, the methodology will be continuously detailed at relevant segments of this report.

1. National Assessment Frameworks and National Curriculum Frameworks

Readers are welcome to view *Annex 1* for the list of NAFs, NCFs and all their specifics like grades, income, language, region, authors, year, document title, for reference.

2. Coding Scheme

The Coding Scheme is comprised of six domains, which are then broken down into 17 sub-domains. The six domains and subsequent sub-domains are presented in *Figure 1* below.

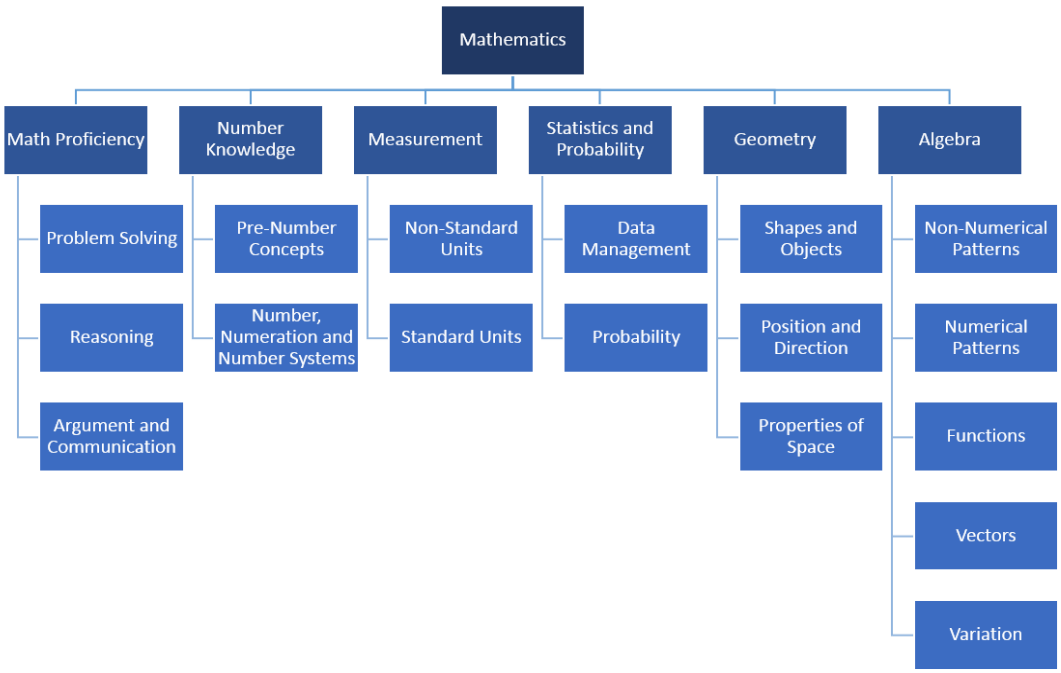

Figure 1: Coding Scheme - Domains and sub-domains[4]

Following the categorisation into domains and sub-domains, the Coding Scheme is then broken down into constructs and their descriptive criteria. Finally, in what is clearly the most detailed portion of the Coding Scheme, each construct is further divided into sub-constructs with explicit descriptions of what should be included in an objective in order to be mapped. Each domain is presented in *Figures 2.1-2.6 (Annex 2)*, with its corresponding sub-domains, constructs and sub-constructs.

An ongoing challenge in a comparative analysis, explicitly when using a coding scheme and a quantitative database, is how to respect and most accurately represent the qualitative nature of documents – such as national frameworks. Due to the relative nature of each NAF and NCF designed by Member States in response to their respective context, a thorough, unbiased, examination of each framework was conducted before mapping and analysing criteria in the quantitative database. This preliminary exploration allowed for a more nuanced representation of each NAF and NCF as they pertain to each Member State's relative curricular and assessment goals, expectations and indicators, as reflected in the observations and discussion section of this report. In cases where the layout of the Coding Scheme - domains and sub-domains– corresponded to the organization used in Member State's NAF and NCF, the mapping exercise was seamless. In other instances, where Member States used a

[4] Source: IBE-UNESCO and UIS, 2017.

different structure or terminology, the integrity of the Member State's classification and grouping was valued and safeguarded - with as much respect to and full understanding of a particular Member State's educational philosophy and approach as possible. An exemplar of this would be in instances when the term 'cognitive domains' – which comprised of 'applying', 'analysing', 'solving' - was used in a framework, being an analogous term with 'Math Proficiency' - a domain in the Coding Scheme, it was mapped to it. Although challenging within the boundaries of an analytical study, this approach was supported by the knowledge that each Member State designs and develops national curriculum and assessment frameworks to articulate and reflect its country-specific visions, approaches and goals. Knowing this, equating one Member State to another does not respect the nuances relative to the context of each country; and therefore, one should be keep this in mind when viewing the findings of this study and understanding their significance.

The specific limitations of the Coding Scheme and its subject-based/objectives-based structure surfaced a considerable number of cases NAFs' and NCFs' structures and/or criteria spanned above and beyond the spectrum described in the Coding Scheme. One of these cases is France, amongst others, whose frameworks were anchored in competency-based and cross-disciplinary approaches rather than subject-based ones. The broad scale of these approaches reached across multiple subjects and clearly exceeded the descriptive language and breadth of the Coding Scheme. Further discussion on competency-based frameworks is found in the *Discussions* section. In summary, when viewing the analyses in the below sections, it is vital to recall that Member States' approaches and educational philosophies vary and are thus reflected in their inclusion or exclusion of specific outcomes and objectives in their NCFs and NAFs (this is assumed given the limitations of this study).

3. Quantitative Database

The NAFs and NCFs criteria were coded into one quantitative database to allow for valid comparisons. The database denotes the presence or absence, with a value of one or zero, of a certain sub-domain or domain in each NAF and NCF. Once coded, the database analysed incidents of alignment (symmetry) between criteria to identify where in a NCF corresponding assessment criteria were present. Similarly, the database analysed incidents of asymmetry between corresponding NAF and NCF criteria at all levels – domain or sub-domain levels *(*see Asymmetry Analysis*).* In cases where an entire category - either domain or sub-domain - did not exist, a value of zero was assigned across that category in the database; this process was consistent throughout the mapping of the 53 NAFs and NCFs in conformity to the Coding Scheme.

Within the quantitative database, several coding decisions had to be made in order to denote the presence of symmetry between NAFs and NCFs, at each category level. Quantitative analyses were conducted to examine the relationship between assessment and curriculum frameworks as well as to extract any discrepancies, commonalities or emerging insights within the underlying inquiry of this study.

Understanding the quantitative database and the methodology can better situate the reader in fully understanding the analyses provided below. The following analyses aim to identify instances of symmetry, (areas of asymmetry – curriculum-based or assessment-based - will be exemplified in the *Asymmetry Analysis*), between the curricular (intentional) and assessment (measured) criteria for Mathematics.

II. Findings of the Study

Data analysis allowed for comparisons to be drawn in the two category levels of the Coding Scheme – domain or sub-domain. In the presence of curriculum criteria (NCF), the findings illustrate the percentage of symmetry with which assessment criteria (NAF) was existent, in conformity with the Coding Scheme. Before viewing the findings, it must be noted that due to the relatively small sample size used in this comparative analysis, the findings must be interpreted with careful attention and valid consideration before drawing invalid conclusions. Therefore, in this section, the findings will be interpreted to best point out these instances and to reflect the aim and intent of this study. The Member States are detailed in Annex *1* classified by region; however, one must note that the region of Central and Eastern Europe was solely represented by Estonia. Additionally, the information in the quantitative database was analysed for quantity and presence of criteria, not quality, and therefore does not necessarily represent rigor of curricular or assessment objectives, or capture the nuances present in pedagogy- integral to curriculum, nor represent a way to standardise information across content areas. It is important, when interpreting the results of these analyses that careful consideration be given.

1. Analysis of NAF Symmetry to NCF presence: An Overall Look

It is important to first understand, at an overview, the distribution of the data points (criteria) across all 53 NAFs and 53 NCFs, regardless of region, income-classification level, education level, or language.

Domain level

Figure 2 shows a breakdown of, by percent, the symmetry of NAFs to NCFs per domain groups.

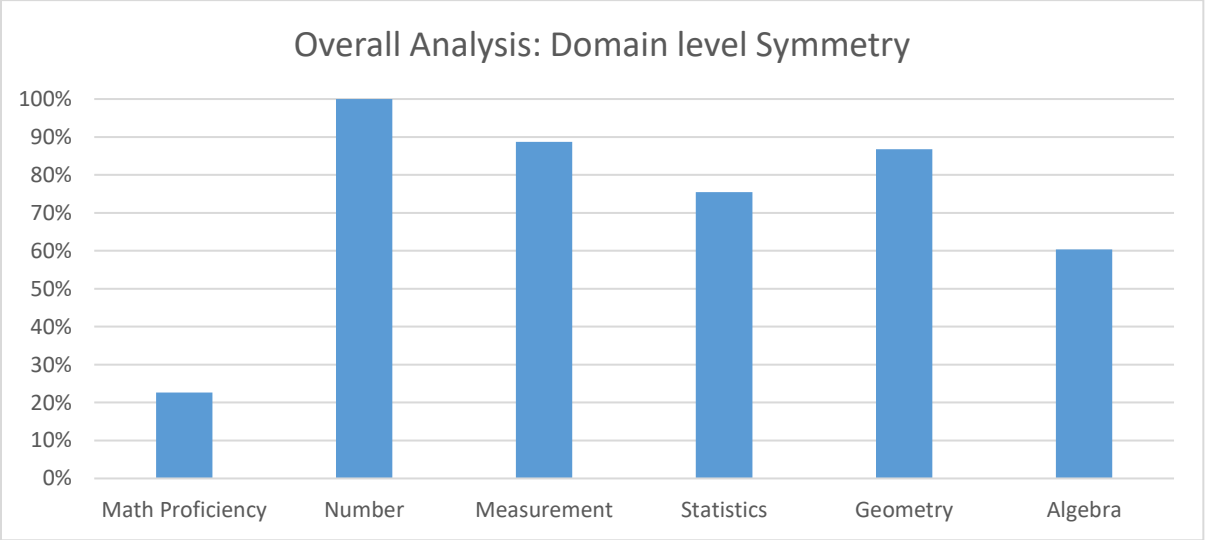

Figure 2: Overall Analysis: Domain level (NAF symmetry to NCF presence)

An overall analysis, as shown in *Figure 2,* revealed that the domain with the highest percentage of symmetry between assessment and curriculum criteria was *Number Knowledge* domain (100%), which means that this domain was present in both the NAFs and NCFs analysed. This was closely followed by *Measurement and Geometry* with 88% and 86% respectively.

Math Proficiency was the domain with the lowest percentage of symmetry, with only 22%. This domain had significant asymmetrical incidents, more than all other domains - a fact that will remain apparent across all levels of analysis. Several possibilities could explain this low percent of symmetry, many of which would require further research and analysis into the structure, terminology, definition and application intended in this domain. One possible explanation, however, is that both NAFs and NCFs

view and represent 'proficiency' as an area and even a practice that should be taught within each domain and subject. The majority of Member States' frameworks included *Math Proficiency,* (or similar terminology, such as, 'mathematical processes', 'applying', 'solving' and 'cognitive domains') as a current running throughout curricular and assessment outcomes, and not a stand-alone category which can be easily quantified. *Math Proficiency* is critically important to teach, yet extremely hard to assess, especially in the context of a national standardized assessment. Consequently, in the coding of this domain, it was mapped present if Member States dedicated an individual domain to *Math Proficiency* (or analogous terminology), in either their NAF or NCF. This presence demonstrated the importance to which certain Member States prescribe and ascribe to this approach. For example, in the majority of NCFs, Member States describe the vision, goals and curricular expectations for learners, at all education levels, clearly detailing the relevance of scope and sequence of learning outcomes and objectives. As such, if the organization and terminology used in NCFs were analogous and thus comparable to the criteria found in *Math Proficiency* domain in the Coding Scheme, the presence of this domain was indicated in the database.

Sub-domain level

Figure 3, below, shows a breakdown of, by percent, the symmetry of NAFs and NCFs per sub-domain groups.

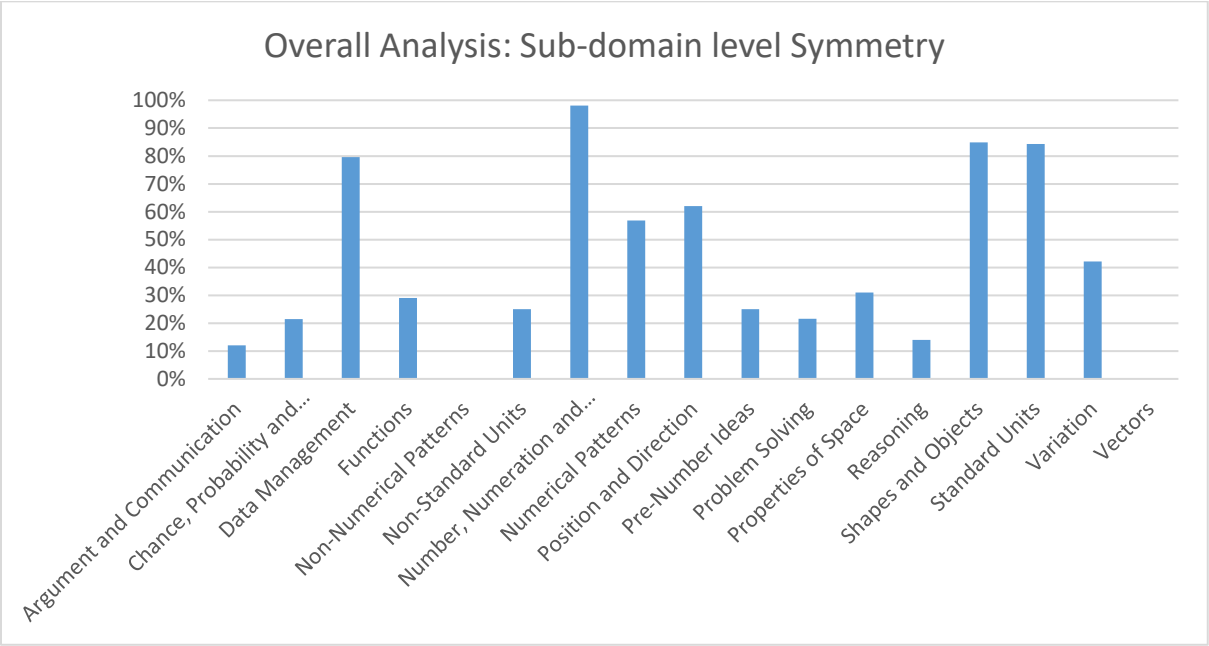

Figure 3: Overall analysis: Sub-domain level (NAF symmetry to NCF presence)

An overall analysis of sub-domain level, in *Figure 3*, indicated that two sub-domain groups, *Non-Numerical Patterns* and *Vectors,* showed 0% symmetry. A deeper investigation into the specifics of asymmetry is needed and will be alluded to in the following analyses of this study; however, the lack of alignment can be viewed as troubling if intentionally omitted. A possible explanation for the absence of *Vectors,* found in the domain of *Algebra,* could be that this sub-domain is present at higher grades (which would thus exceed the scope of this study, which only examined grades 1-8). This trend remained mostly consistent across all the analyses of the study and will therefore not be repeated in this document.

The highest percent of symmetry (97%) was in *Number, Numeration and Number Systems*, found in the domain of *Number Knowledge*, which shows signs of a building trend between Member States in the collective agreement that numeracy is a vital component of Mathematics curriculum and

assessment frameworks. Coinciding with the overall analysis by domain is the low percent (12%) in *Argument and Communication*, which is a sub-domain in *Math Proficiency*.

One of the aims of this study is to highlight and interpret findings which are most notable in relation to the line of inquiry – are assessment frameworks measuring learning outcomes present in curriculum frameworks for Mathematics, and what findings are most salient within such an inquiry? As the overall analysis indicates, seen in the aforementioned charts, further analyses are required to dive deeper into the data to observe any emerging trends in symmetry. The following analyses – by Member State, income classification, education level and language, are centred around this need.

2. Analysis of NAF Symmetry to NCF presence: Classification by Member State

Data analysis by regional classification can provide a global overview; however, given the nature and limitations of this study (Estonia being the only Member State to represent Central and Eastern Europe), a regional analysis was determined to be inappropriate due to the unequal representation of all regions in the study. Nonetheless, out of the 20 Member States included in this study, 4 (20%) were from East Asia and the Pacific, 1 (5%) from Central and Eastern Europe, 5 (25%) from Latin America and the Caribbean, 4 (20%) from North America and Western Europe, 2 (10%) from South and West Asia, and 4 (20%) from Sub-Saharan Africa. There were no NCFs collected for this study from Central Asia or the Arab States, and therefore, these regions are not included in this study.

Due to the nature of a comparative analysis, the assumption of a possible regional analysis was tested, and it was concluded that combining the data points into regions would remove the nuances present in this type of analysis. Therefore, for this part of the study, the data is analysed by each Member State to accurately illustrate the incidences of symmetry (and asymmetry) at every criteria level. Also, this is supported by the knowledge that curriculum frameworks are designed with scope and sequence to encompass the gradual progression of learning outcomes and a Member State's development of such components ought not be excluded by amalgamating data points. For example, at the sub-domain level, data points are present at the sub-domain *Reasoning* (located in the domain of *Math Proficiency*) across the different grade levels detailed in Australia's national frameworks. *Table 1*, below is an excerpt from the database to illustrate this example. Australia had three grade levels in its national frameworks, with scope and sequence of learning outcomes and objectives unique to each, one will note that in the first row, symmetry exists between NAF and NCF; however, the last two rows indicate a curriculum-based asymmetry. Combining or grouping Australia's unique data points would omit these data points and misrepresent the full spectrum of differences present within such a robust dataset.

Table 1:

LP	East Asia and the Pacific	Australia	Reasoning	1	1	Symmetry	
UP	East Asia and the Pacific	Australia	Reasoning	0	1	Curriculum Bias	
LS	East Asia and the Pacific	Australia	Reasoning	0	1	Curriculum Bias	

Although it could be seen that not combining the data points would allow for a Member State that included multiple grade levels in their national frameworks to be repeated and thus skew the data, Member States which have comprehensive national frameworks, ranging across their education levels, are statistically more prone to incidences of symmetry or asymmetry than Member States which only included one grade level in their national framework. The inevitable shortcomings in this study are fully disclosed in order to rationalise the approach taken and the reasons for it; whilst safeguarding each Member State's educational philosophy and relevant values inherent in their national

frameworks. Lastly, regional comparative analyses were not possible due to the unequal representation of all regions in this study.

Domain level

Figure 4, shows a breakdown of, by percent, NAFs symmetry to NCFs presence per domain.

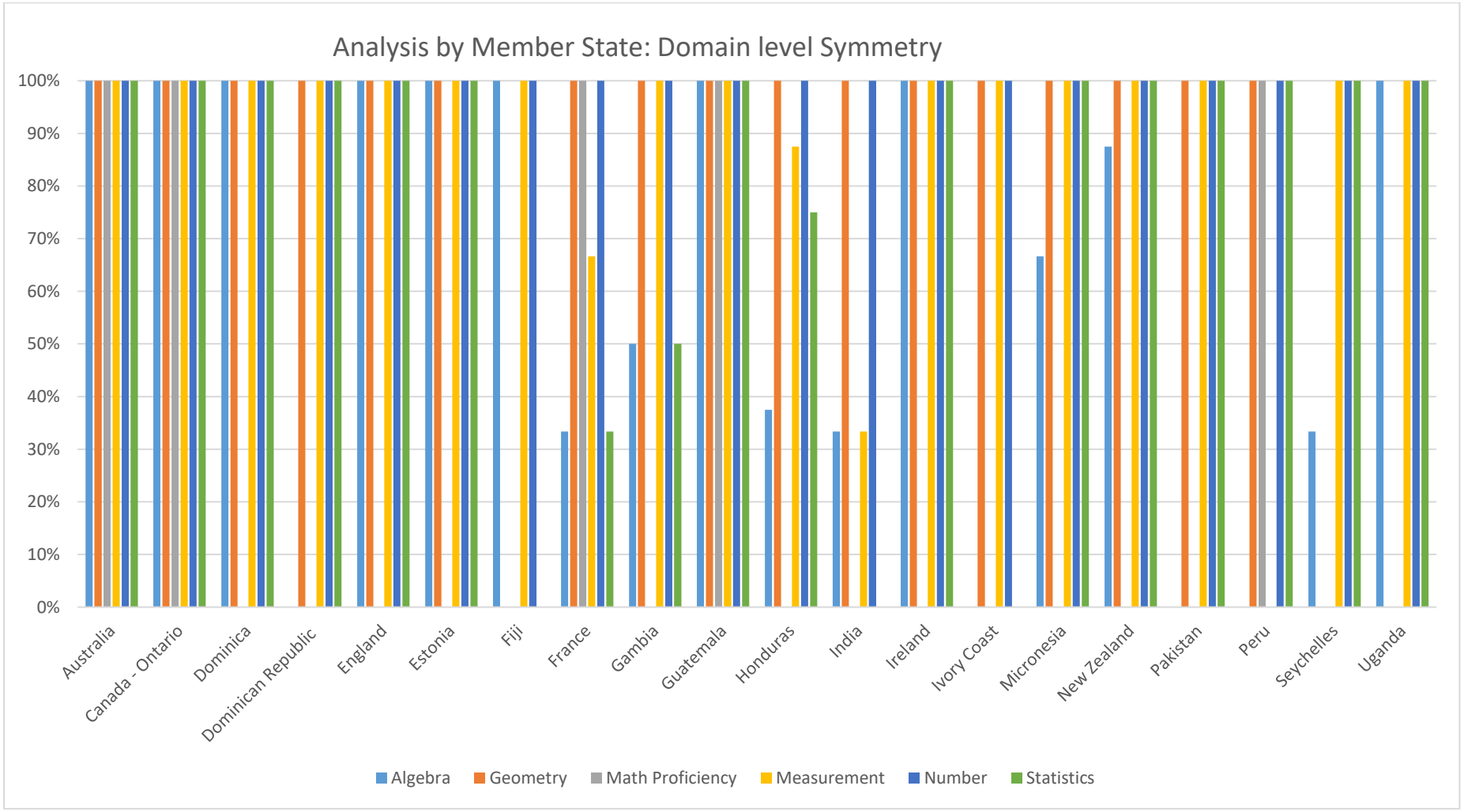

Figure 4: Analysis by Member State: domain level (NAF symmetry to NCF presence)

Figure 4 above illustrates the visual complexities present in an analysis comprising of a large dataset at the domain level. This part of the report will detail the statistical significance at each level as per limitations and complexities of the data set.

One may note that certain Member States, such as Australia, Canada-Ontario and Guatemala, have 100% symmetry among all six domains. This may be attributed to an explicit design and development of national frameworks as to ensure that assessment outcomes match curricular outcomes without exception. It is understood that without having direct inputs from the authors of national frameworks, during the course of the data interpretation, one must make assumptions which are open to considerations from Member States.

Also visible in *Figure 4* is Fiji's mapping of 100% symmetry in *Number Knowledge*, *Measurement* and *Algebra* domains, and of 0% symmetry in the other three domains – *Math Proficiency, Statistics* and *Geometry*. The trend of 100% symmetry in some domains and absence of symmetry in others is repeated in the frameworks of other Member States, such as Ivory Coast, Pakistan, and Uganda, to name a few, although with different domains each time. Further examination into the Member State's national frameworks and input from the authors would be needed to draw any conclusions about the rationale behind these polarized findings.

There were significant disparities in *Math Proficiency*'s percent of symmetry across all Member States, with only five Member States representing any symmetry in this domain. The low percent of occurrence in this domain is not striking, or inconsistent with previous data findings. *Math Proficiency* is prescribed in the Coding Scheme as a stand-alone domain, however, apparent in the majority of national frameworks is the integration of proficiency throughout all other domain categories. The limitations of the Coding Scheme's structure and its presentation of this domain, in particular, may shed light on the consistent, yet inconsistently, symmetrical nature of *Math Proficiency* in Member States' NAFs and NCFs for Mathematics.

Sub-domain level

An even more nuanced understanding of the results can be seen when looking at a breakdown of the data by sub-domains for each Member State. The information displayed in *Figure 5* below shows a breakdown of, by percent, NAFs symmetry to NCFs presence per sub-domain.

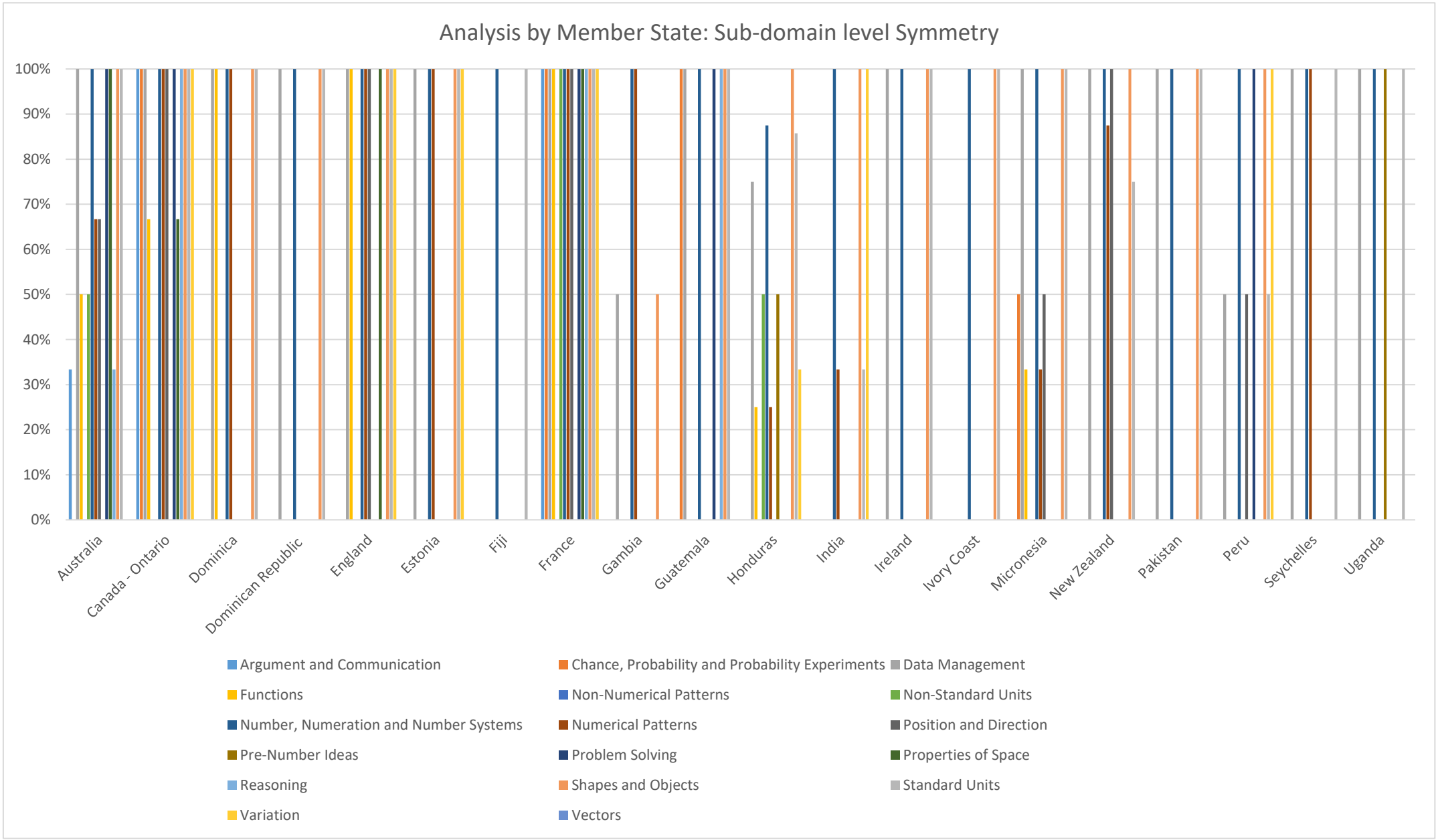

Figure 5: Analysis by Member State: Sub-domain level Symmetry

The greatest disparities in symmetry among the sub-domains can be observed within the *Math Proficiency* domain, similar to the findings of the domain level analysis above.

Another commonality noted in this analysis is found within the sub-domains related to *Number Knowledge*, showing the highest percent of symmetry across all Member States, which is not surprising given the overall data findings. Additionally, it is clear to see that the sub-domain of *Standard Units* (*Measurement* domain) appears to be symmetrical (to varying percentages according to the Member State) across the array of data. This may explain a global consensus on the importance of including number related content and measurement with standard units in curriculum and assessment national frameworks, as well as the clarity in both teaching and assessing content related to these areas of matheamtics.

The four Member States classified in the North America and Western Europe region (Canada-Ontario, England, France (and Ireland – with some exceptions)), as illustrated in *Figure 5,* seem to display the highest percent of symmetry across the majority of all sub-domains. Although this may appear to indicate a significance of commonalities across these Member States and this region, additional research and input would be required before making such assumptions.

An analysis based on income classification levels could perhaps provide additional insights to commonalities and differences among the symmetry of NAFs to NCFs presence.

3. Analysis of NAF Symmetry to NCF presence: Classification by Income

The classification of the 20 Member States by income, (see *Annex 1)* in *Low-Income*, *Lower-Middle-Income*, *Upper-Middle-Income*, and *High-Income* countries (World Bank, 2017)[5] was used for this part of the analysis: 8 High-Income at (40%), 4 Upper-Middle-Income at (20%), 6 Lower-Middle-Income at (30%), and 2 Low-Income at (10%).

Similar to the previous section, the data points collected from one Member State's national frameworks were not combined, as to not exclude the incidences of variation present in the scope of sequence of curricular outcomes and the nuances necessary for such a comparative analysis. This decision was made knowing that many Member States had multiple national frameworks developed for different grades and by viewing the *Annex* section, their statistical significance in this part of the analysis are well situated.

Domain level

The information displayed in *Figure 6* below shows a breakdown of, by percent, NAFs symmetry to NCFs presence per domain in each income classification level.

[5] This classification was preferred over the separation between developed and developing countries, which are terms that are no longer used by the World Bank (Fantom, 2016). Instead, the classification was made between Low-Income, Lower-Middle-Income, Upper-Middle-Income, and High-Income Member States. This classification was used to provide a precise description and facilitate a richer analysis of the data collected.

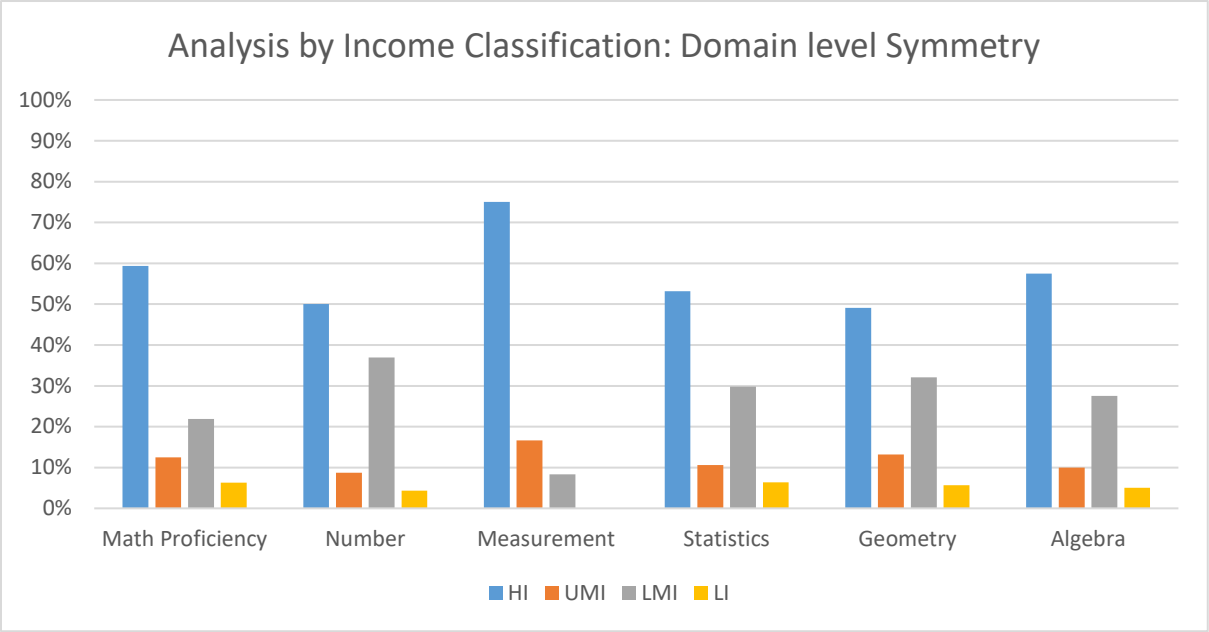

Figure 6: Analysis by income classification: Domain level Symmetry

All High-Income Member States display the highest percent of symmetry across all six domains, with *Measurement* indicated with the highest at 75% symmetry. It is important to note that High-Income Member States represent the largest percent of Member States within this study, at 40%, therefore, with a larger sample of High-Income nations, it is natural to see the data indicate a higher percent of symmetry. The number of frameworks in each income level should be kept in mind when interpreting the data. It must be clearly stated that the quantity of frameworks may mislead initial interpretation of the percentile representation in the figures in this section.

What is possibly most prominent, in *Figure 6,* occurs in the data from the Lower-Middle-Income Member States which appears to have a higher percent symmetry across all domains more so than in the Upper-Middle-Income classification. Perhaps contrary to assumptions that higher income Member States' results would denote higher symmetry due to possible higher level of resources and critical mass (among others). It is pertinent to recognize that Honduras' national frameworks (classified as Lower-Middle-Income) provided data points from grades 1-8 and are evidently a large contributor to this statistic appear on *Figure 6*.

Other striking data revolves around Member States classified as Low-Income. This observation should be read with caution knowing the number of Low-Income Member States (2 out of 20, at 10% in comparison to the other income classifications). Member States classified as Low-Income do not, in comparison to the other income classifications, show symmetry in the *Measurement* domain. The findings in this data, putting aside the inclusions of Honduras' multiple frameworks, demonstrate a delicate and nuanced relationship between data from Lower-Middle-Income Member States and data from Upper-Middle-Income Member States in every domain – warranting a deeper look into the differences and subtleties between these two classification levels. Further analysis, with the national documents of more Low-Income Member States would be required to investigate whether this is a consistent trend across Member States of this income level.

Sub-domain level

The information displayed in *Figure 7*, below, shows a breakdown of, by percent, NAFs symmetry to NCFs presence per sub-domains by each of the income classification levels.

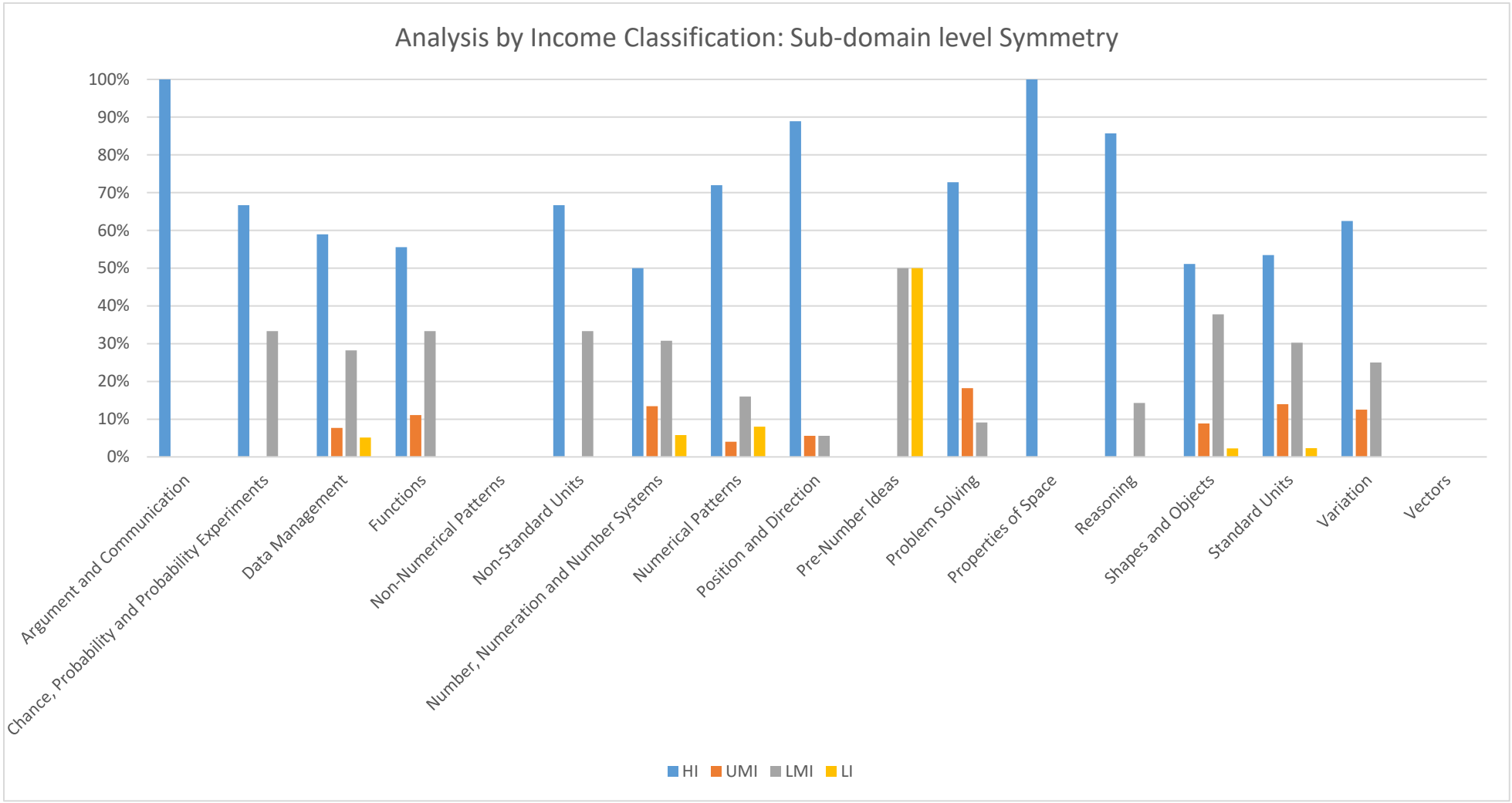

Figure 7: Analysis by income classification: Sub-domain level Symmetry

Sub-domain level analysis revealed that there was primarily more symmetry across High-Income Member States. For example, in the sub-domain of *Pre-Number Ideas* (*Number Knowledge* domain) the absence of High-Income Member States is justified by the grade levels collected and analysed, which began at grade 3 and of which *Pre-Number Ideas* is scaffolded at the early grades of primary education.

Another interesting note is seen between the High-Income and Lower-Middle Income Member States across several domains, where only the two classifications display symmetry. It could be interpreted as a salient observation, however, again due to Honduras' multiple frameworks included in the data set, the Lower-Middle Income Member States' percent is higher. Even though such an instance may seem misleading for the reader, the determination to include, and not combine, instances of multiple frameworks from one Member State is credible within the nature of this comparative analysis and will become more evident at deeper levels of analysis.

A trend emerges from Low-Income Member States in its absence of symmetry, across the majority of the sub-domains in *Figure 7*; this is perhaps concerning as one could inquire about the breadth of these national frameworks and to what extent they are including curricular expectations and assessing them, if symmetrical. As *Figure 7* denotes, Low-Income Member States display symmetry, albeit at a low percent, in the sub-domains of *Data Management, Numbers, Numeration and Number Systems, Numerical Patterns, Pre-Number Ideas, Shapes and Objects* and *Standard Units.*

Mentioned in the *Introduction*, an additional factor that may contribute to higher symmetry of domains and sub-domains in NAFs to NCFs of High-Income Member States is critical mass, which may be an advantage counter to Member States of lower income levels. Is the higher symmetry of sub-domains, within NAFs and NCFs, of High-Income Member States a guarantee that learners of these Member States develop skills and knowledge, and have them equally assessed, in contrast to learners of Member States of other income levels who may not? From an assessment point of view, symmetry of domains and sub-domains within NAFs and CNFs equals more 'content' precision in the assessment, because students are being assessed what they have been taught and learnt. In the case of countries that show no alignment between the two frameworks (higher levels of asymmetry), there is a higher chance that the test does not reflect what the students have been taught (and learnt), which only decreases the content validity of the test. Subsequently, low learning outcomes might be a derivative of the lack of content validity in the test, as students fail to perform what they have never learnt.

4. Analysis of NAFs symmetry to NCFs presence: Classification by Education Level

The classification of all NAFs and NCFs by education level based on the three points of measurement of SDG 4.1.1 (grades 2/3; end of primary; end of lower secondary) was used for the analysis of the NAFs symmetry to NCFs presence across all four categories of the Coding Scheme. The 53 NAFs and 53 NCFs were organized in such classification levels thus allowing for comparisons to be analysed: Lower Primary[6] (21 NAFs with corresponding 21 NCFs, or 40%), Upper Primary (22 NAFs with corresponding 22 NCFs, or 42%), and Lower Secondary (10 NAFs with corresponding 10 NCFs, or 19%). In respecting the integrity of each Member State's national framework and the inherent relevance of educational philosophy within each design and development, grades indicated in each framework was grouped according to the Member States' classification of education levels. For example, if a Member State stated grade 6 as Upper Primary, this grouping was respected, and that national framework was classified as part of the Upper Primary. On the contrary, if another Member State stated grade 6 as part of Lower Secondary, then this was respected and included in the Lower Secondary data.

[6] Even though the first point of measurement of indicator 4.1.1 focuses only on grades 2 and 3, data from grade 1 was also mapped and analysed, to expand the scope of this report and analysis.

The number of NAFs and NCFs in each education level should be kept in mind when interpreting the data. It must be clearly stated that the quantity of NAFs and NCFs classified in the Lower Secondary level is only 19% of the entire dataset, which may mislead initial interpretation of the percentile representation in the charts in this section. In light of this information, a thorough interpretation of the charts and their values are represented below.

Domain level

The information displayed in *Figure 8*, below, shows a breakdown, by percent, of NAFs symmetry to NCFs presence by domains per education level. As the legend in *Figure 8* displays, (LP) is Lower Primary, (UP) is Upper Primary and (LS) is Lower Secondary.

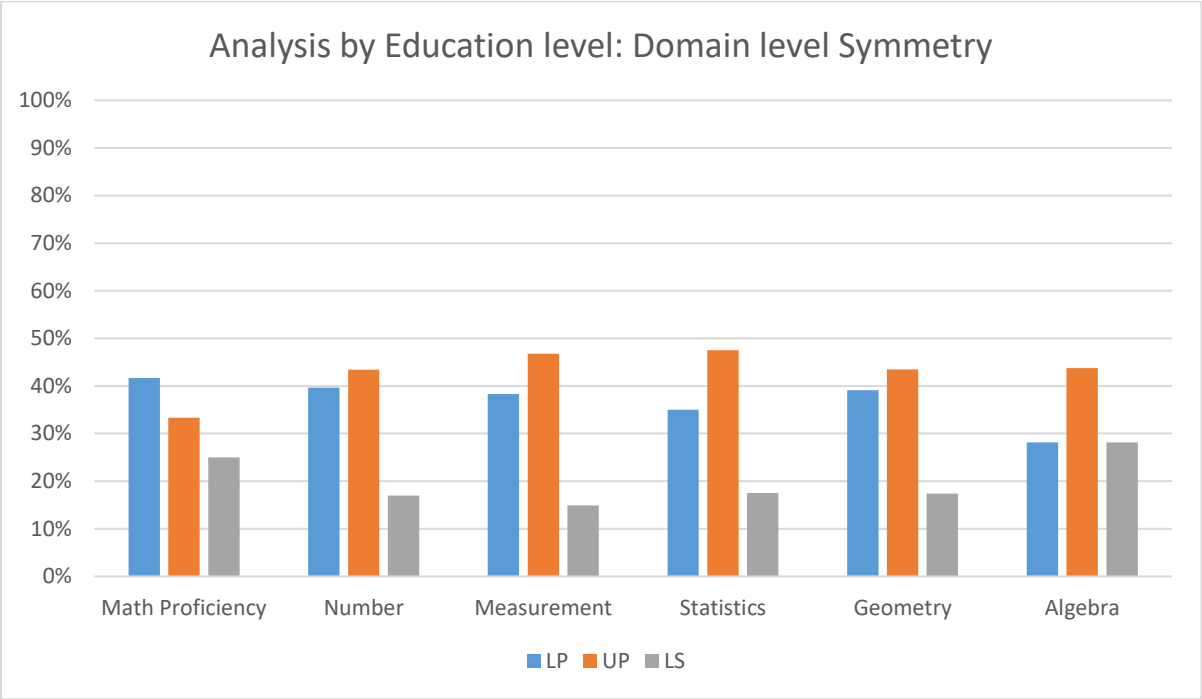

Figure 8: Analysis by level of education: Domain level Symmetry

Not surprising to education practitioners, *Figure 8* indicates a pertinent finding - the disparities between Upper Primary and Lower Secondary are quite noticeable. A higher symmetry and correlation between Lower and Upper Primary is logical, considering the scope and sequence of mathematical concepts within primary education grades; yet increasingly evident in data is a precipitous transition between Upper Primary and Lower Secondary in both curricular and assessment outcomes. This claim would be better elaborated upon with an increase in Lower Secondary classified national frameworks (larger than the existing 19% in this study). Nonetheless, this finding is woven throughout all domains in *Figure 8* and calls for Member States to re-examine the scope and sequence of curriculum frameworks and their corresponding assessment frameworks to ensure learning outcomes and objectives are not only horizontally but vertically articulated and aligned.

Sub-domain level

The information displayed in *Figure 9*, below, shows a breakdown of, by percent, NAFs symmetry to NCFs presence by sub-domains per education level.

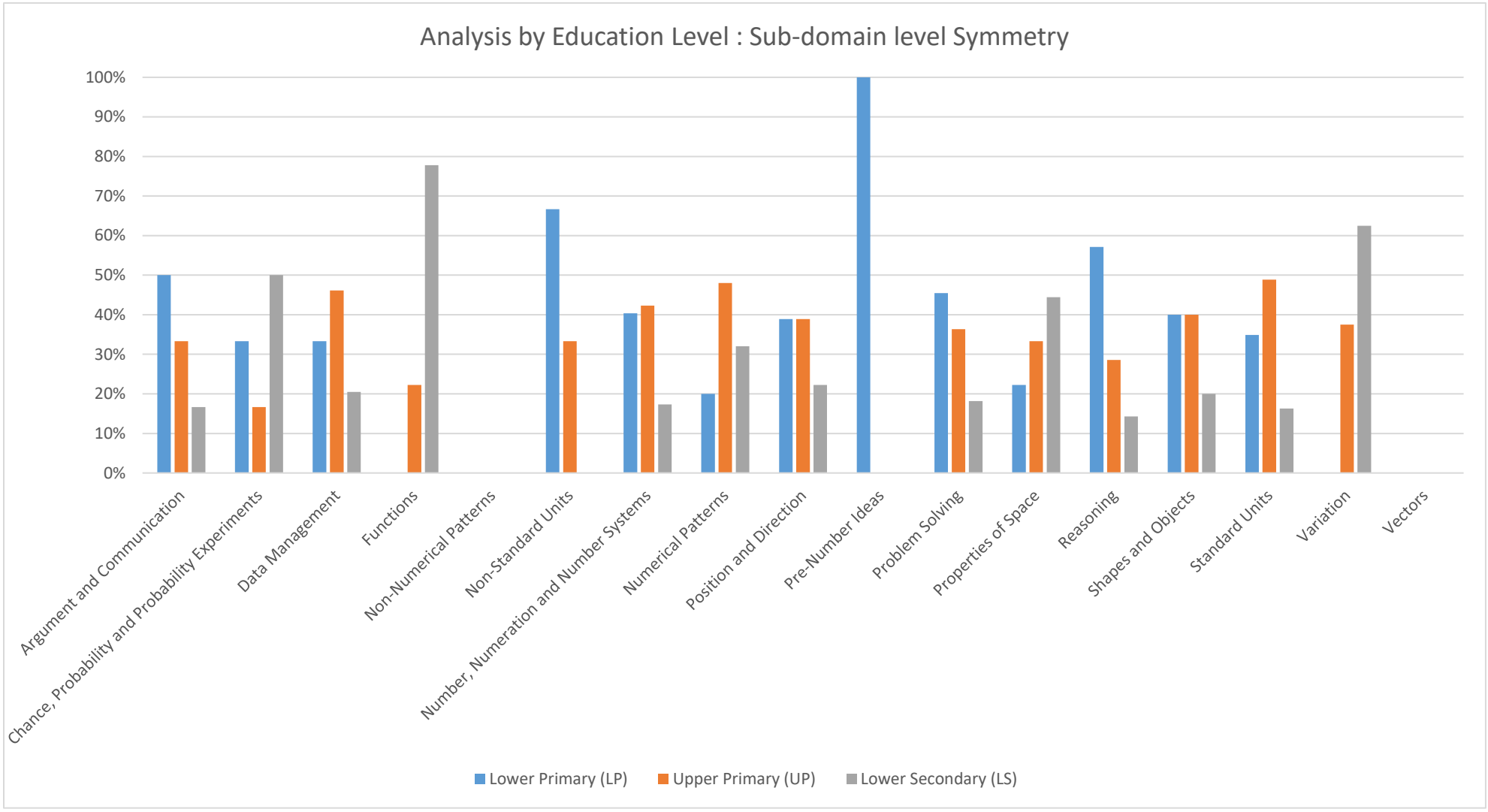

Figure 9: Analysis by Educational Level: Sub-domain level symmetry

Analysis on the sub-domain level was consistent with the domain level analysis. It revealed, for the most part, that a consistent increase in Upper Primary sub-domains symmetry in comparison to Lower Primary symmetry. *Pre-Number Concepts* sub-domain, shows 100% symmetry in Lower Primary, this symmetry is only naturally because *Pre-Number Concepts* is a sub-domain relevant to early grades and is not mapped, taught nor assessed in higher grades. Another example of grade level relevance in *Figure 9* is noted in the sub-domains of *Functions (Algebra* domain*), Variations (Algebra* domain*)* and *Chance and Probability (Statistics* domain*),* which are all mathematical concepts designed in sequence for higher grades.

Outstanding occurrences were found in the mapping of Lower Primary level symmetry. Since this education level is comprised (from the most part of Member States) of grades 1-4 inclusively, distinctions exist therein. To illustrate this point, one may note in *Figure 9* that the percentages of symmetry vary significantly in Lower Primary – as *Pre-Number Ideas*, *Counting with Symbols, Counting along a Number Line* and other lower grades' sub-domains. Furthermore, due to the nature of curriculum frameworks' scope and sequence, there are obvious differences between mathematical concepts at a grade 1 level and grade 4, which can be seen through the varying levels of symmetry in *Figure 9.*

5. Analysis of NAFs Symmetry to NCFs presence: Classification by Language

Among the range of national frameworks collected and analysed in this study, a disproportionately higher number of English-language frameworks were gathered; therefore, this must be kept in mind when viewing this data and its findings.

Similar to previous sections, the data was not combined but rather considered for particularities, thus allowing for specific findings to become apparent at all levels of analysis. In accordance to the transparent methodology of this study, all analyses will be fully disclosed.

The linguistic distribution among Member States is as follows; 14 out of 20 Member States (70%) had national frameworks in English, 2 out of 20 (10%) had national frameworks in French, and 4 out of 20 (20%) had national frameworks in Spanish. It is noteworthy that all of Member States with Spanish-language frameworks belonged in the Latin America and the Caribbean region. Member States with French-language national frameworks, one came from North America and Western Europe and the other from Sub-Saharan Africa, whereas Member States with English-language national frameworks came from a vast number of regions of the world.

Domain level

The information displayed in *Figure 10*, below, shows a breakdown of, by percent, NAFs symmetry to NCFs presence by domains in each language classification.

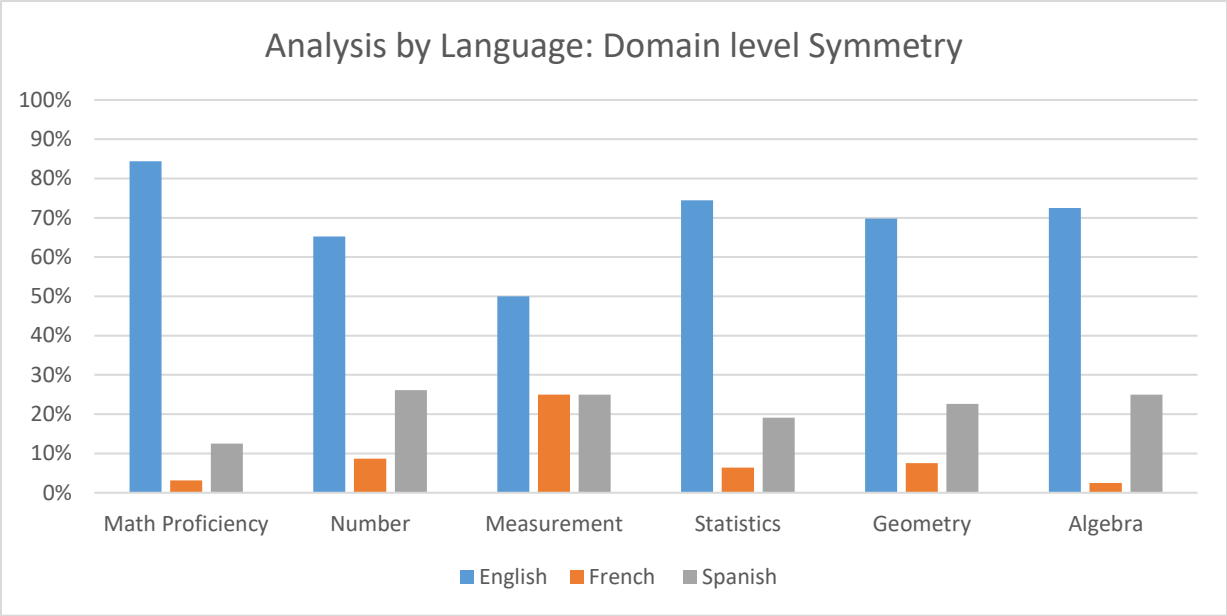

Figure 10: Analysis by language: Domain level Symmetry

Commonalities can be seen across the English-language in *Figure 10*. Notwithstanding that this language is represented in 70% of the data set, (due to the larger number of English-language national frameworks collected and analysed). A thread can be woven between the high percent of symmetry in English-language frameworks and the high percent of symmetry in High-Income Member States alike (this assumption is based on the findings in this study and would require much more comprehensive analysis to fully confirm).

Most apparent, and not foreign to these analyses, is the biggest discrepancy in *Math Proficiency*. This domain is expressed at 84% symmetry across all English-language frameworks and at 12% in Spanish-language and at 3% in French-language frameworks. Given the fact that, within the Spanish-language frameworks, the Member State of Honduras had multiple frameworks (grades 1-8) which are included in this 12%; it is fair to state that *Math Proficiency's* low percentage of symmetry should be a concern for the Member States within the Spanish-language classification group.

Sub-domain level

The information displayed in *Figure 11*, below, shows a breakdown of, by percent, NAFs symmetry to NCFs presence by sub-domain per language.

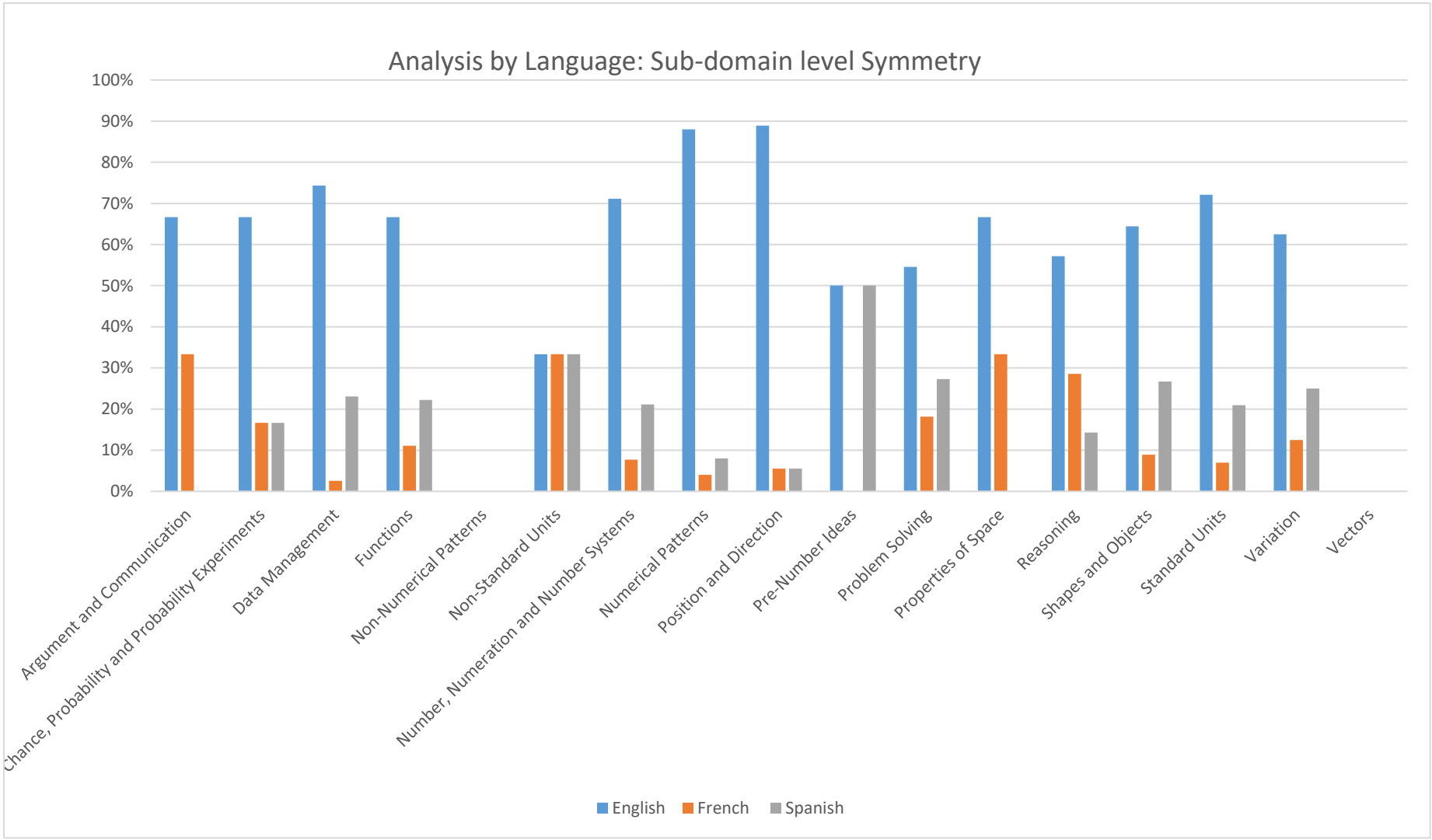

Figure 11: Analysis by language: Sub-domain level symmetry

An even more nuanced understanding of the results can be garnered when looking at a breakdown of the sub-domains by language. Consistent with the domain level analysis, differences were mostly manifest between English-language national frameworks and the other two languages.

Most outstanding is the representation of the sub-domains within the *Math Proficiency* domain, *Reasoning, Argument and Communication,* and *Problem Solving* within the two Member States with French-language frameworks. Such findings were not evident at the domain level analysis (where French-language frameworks were minimally displayed in this domain); however, upon closer look, incidences of symmetry are manifest among the sub-domains. This is due to France's inclusion of sub-domains throughout their national frameworks, specifically integrated at all levels and in all four categories of the Coding Scheme, caused by France's competency-based frameworks which expanded across and beyond the structure of the Coding Scheme. (A case study of this particular Member State will be included in the *Discussions* section).

Among Spanish-language frameworks, sub-domains that display the highest percentage of symmetry are seen in *Pre-Number Ideas* (*Number Knowledge* domain) – explained by Honduras' strong presence of early grades' frameworks. Other notable sub-domains are *Shapes and Objects* (*Geometry* domain), *Problem Solving* (*Math Proficiency* domain) and *Data Management* (*Statistics* domain). Such range of symmetry across the majority of sub-domains may express the potential breadth and scope of learning outcomes in NAFs and NCFs within Spanish-language Member States.

In sum, as much as the above analyses offer data-driven insights, to better understand the relationship between assessment and curriculum and to hopefully answer the line of inquiry in this study, it is crucial to examine instances of asymmetry. The following section aims to shed some light on asymmetrical incidents between assessment and curriculum within Member States' national frameworks.

III. Asymmetry Analysis

This study has, thus far, highlighted some interesting trends. Particularly worth mentioning – and addressing the line of inquiry of this study – are findings from an analysis into asymmetry. This section focuses on observations made of asymmetrical instances, when curriculum and assessment outcomes do not align, by means of data analysis.

Asymmetry

In instances of asymmetry between NAF and NCF criteria (at all levels), the data was analysed by two categories in order to focus and address the distinctions therein *(see Methodology).*

1. Curriculum-based Asymmetry

Occurred when the presence of a curriculum criteria (value of 1) was mapped from a NCF, and an absence (value of 0) of the same criteria was mapped from a NAF.

2. Assessment-based Asymmetry

Occurred when the presence of an assessment criteria (value of 1) was mapped from a NAF, and an absence (value of 0) of the same criteria was mapped from a NCF.

The following figures illustrate the overall findings from the data in regards to asymmetry, both curriculum-based and assessment-based (symmetry is shown again in the charts for visual comparisons). These figures illustrate the prevailing incidents of asymmetry across the spectrum of Member States and their respective NAFs and NCFs; and are divided by domain and sub-domain level as per conformity to the Coding Scheme.

Domain level

Figure 12 and *Table 2*, below, show the breakdown of, by percent, the incidents of symmetry and asymmetry (curriculum-based or assessment-based)[7] between NAFs to NCFs presence by domain.[8]

[7] In Figures 12 and 13, asymmetry is divided into two categories – assessment-based and curriculum-based. Indicated, by data terms, as assessment bias and curriculum bias; they are referred to, in the text of the analysis, as assessment-based and curriculum-based asymmetry. Bias and based are the same in definition. See *Methodology* for definitions of both.

[8] It is essential to remember the fact that the excluded data when viewing the figures and tables, explained in the *Methodology* section, is not included in this section.

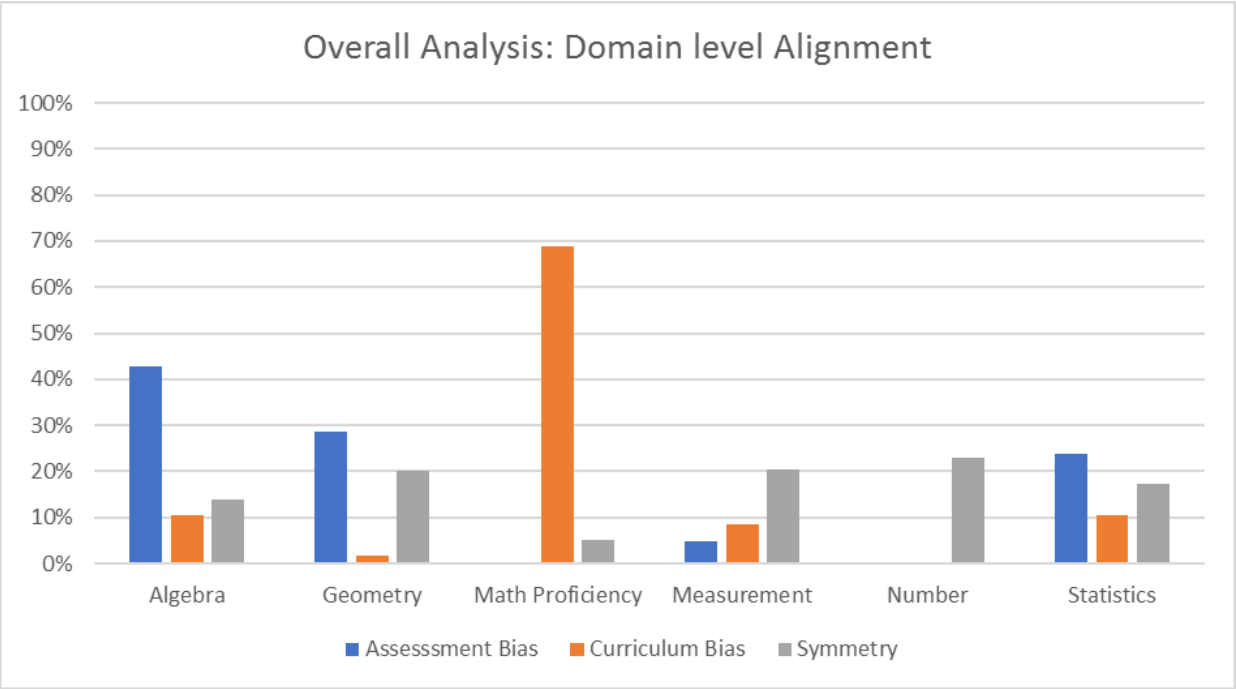

Figure 12: Overall analysis of alignment: asymmetry and symmetry at domain level

Domains	**Assessment-based Asymmetry**	**Curriculum-based Asymmetry**	**Symmetry**
Algebra	9	6	32
Geometry	6	1	46
Math Proficiency	0	40	12
Measurement	1	5	47
Number	0	0	53
Statistics	5	6	40

Table 2: Overall breakdown of domain level alignment by criteria count (data points)

Figure 12 and *Table 2* denote interesting findings as they pertain to asymmetry and symmetry between NAFs and NCFs. (Readers must understand that this section aims to highlight these incidents and will not provide, at this time, a robust analytical interpretation of the data findings). It can be noted that incidents at the domain level of asymmetry are less prevalent, with 25.5% of symmetry out of the entire domain criteria dataset. At the domain level, it is natural to see a higher level of symmetry between NAF and NCFs due to Member State's common use of such domain categories in their national frameworks. However, most salient of findings is the count of curriculum-based asymmetry for the domain, *Math Proficiency.* Concurrent with the rest of this study's findings, there is much to research and analyse within this domain

and explore how Member States integrate its concepts in their NCFs, let alone how they measure it in their NAFs.

Sub-domain level

Figure 13 and *Table 3*, show the breakdown of, by percent, the incidents of symmetry and asymmetry (curriculum-based or assessment -based) between NAFs to NCFs presence by sub-domain.

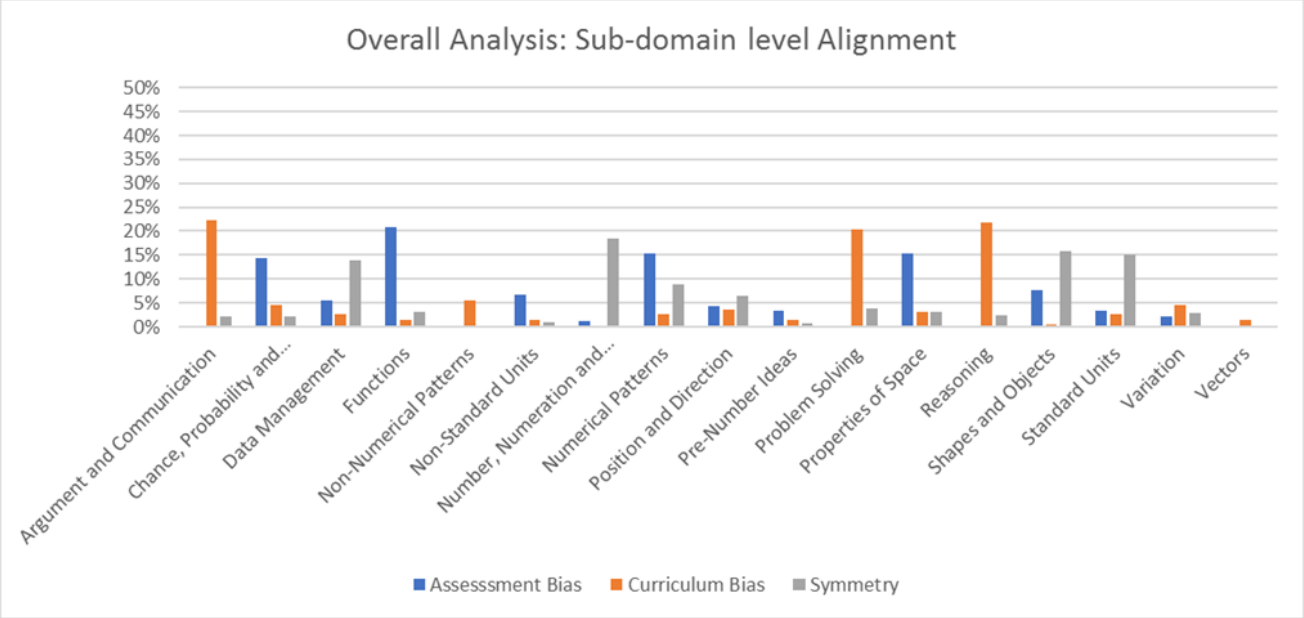

Figure 13: Overall analysis of alignment – asymmetry and symmetry by sub-domain (*Y Axis up to 50%*)

Domain	Sub-domains	Assessment-based Asymmetry	Curriculum-based Asymmetry	Symmetry
Math Proficiency	Argument and Communication	0	44	6
Math Proficiency	Problem Solving	0	40	11
Math Proficiency	Reasoning	0	43	7
Number Knowledge	Number, Numeration and Number Systems	1	0	52
Number Knowledge	Pre-Number Ideas	3	3	2

Data Management	Chance, Probability and Probability Experiments	13	9	6
Data Management	Data Management	5	5	39
Measurement	Non-Standard Units	6	3	3
Measurement	Standard Units	3	5	43
Algebra	Numerical Patterns	14	5	25
Geometry	Position and Direction	4	7	18
Geometry	Properties of Space	14	6	9
Geometry	Shapes and Objects	7	1	45
Algebra	Variation	2	9	8
Algebra	Vectors	0	3	0
Algebra	Functions	19	3	9
Algebra	Non-Numerical Patterns	0	11	0

Table 3: Overall breakdown of sub-domain level alignment by criteria count (data points)

Figure 13 and *Table 3* represent significant findings which follow the same trends as in *Figure 12* and *Table 2*; which are overall consistent with a lower level of symmetry in the domain of *Math Proficiency* and a concerning level of asymmetry both in domain and sub-domain levels. Although encouraging to see that symmetry between NAF and NCFs presence appear higher than asymmetrical ones, of keen interest is the *increasing* occurrences of assessment-based asymmetry. Recalling the line of inquiry of this study – are assessment frameworks measuring learning outcomes that are present in curriculum frameworks for Mathematics, and what findings are most salient within such an inquiry? Although assessment-based asymmetry instances are less than instances of symmetry, assessment-based asymmetry instances highlight a troubling trend in response to this study's line of inquiry. Are learners being assessed on content they have not been taught? Given the definition of an assessment-based asymmetry, a few sub-domains appear to be assessed without being included in the NCF; *Chance, Probability and Probability Experiments (Statistics domain); Functions (Algebra); Numerical Patterns (Algebra); Properties of Space (Geometry).* Explanations and needed investigations into these instances would require further levels of analyses.

IV. Discussion

Despite the breadth of detail of the Coding Scheme, it is still quite challenging to create a 'one size fits all' scheme, which could code and quantify the very qualitative nature of learning. Insomuch as this may be challenging, it must be attempted. This statement lends itself to a discussion on the progressive nature of both assessment and curriculum and how we might monitor SDG 4.1, with better accuracy.

Within the confines of this report, the global dialogue around comparative educational research and a tiered classification scheme (Benavot, 1992) in curricular content and structure is ongoing among many educational bodies and therefore, will not be at the centre of discussion in this section.

As mentioned in the *Methodology*, conducting an analytical study faced many challenges on how to value and respect the relative and relevant intricacies within each Member State's NAF and NCF. What happens when a Member State's national frameworks do not necessarily fit within the structure of the Coding Scheme? Are those national frameworks not accurately represented in the data and their distinguishing features not included? The answers to these questions require a look at specific cases that include such features and provide examples of what and how some Member States are interpreting the relationship between assessment and curriculum. Could these case studies demonstrate best practices for other Member States to consider?

A competency-based learning approach (or outcome-based approach) is commonly characterised by curriculum expectations and an assessment process corresponding to those learning outcomes – hence, a symmetrical relationship (Harden, 2002). A higher level of symmetry between assessment and curriculum *may* be reflected in a Member State's design and development of competency-related indicators within national frameworks. Of principal importance would be to test this assumption with further research into the long-term outcomes of competency-based Member States' educational results and learning outcomes and see if there is any correlation to socio-economic growth and/or quality of life. Moreover, there is need to research into the correlation between competence in curriculum to competence in action (Jonnaert et al., 2009).

Case Studies – France, Uganda, Pakistan

Competency-based approaches to national curriculum and assessment frameworks

France

France's national frameworks, called "projet de programmes pour les cycles", (Programme of Study for the Cycles) were structured on competency-based and cross-disciplinary approaches rather than subject or objectives-based ones. France's NAFs and NCFs spanned across a broad scope of competency-based approaches integrating multiple subjects within each, referred to as "croisements entre enseignments", (cross-curricular), this breadth clearly exceeded the descriptive language and scale of the Coding Scheme). In France's NCF, the value and results of transdisciplinary approaches were used to yield better results for learners. Data to support this claim, from France, was not accessible at the time of this study; however, the data findings of this study show France's NAF to NCF symmetry as exceptionally high (Conseil Supérieur des Programmes, 2015).

Uganda

Similar to France, Uganda developed a competency-based curriculum. This NCF's structure was referred to as a "Thematic Curriculum" which was divided into twelve themes, such as, "Our Sub-county/Division", "Livelihood in our Sub-county/Division", "Our Environment in our Sub-county/Division", "Culture and Gender in our Sub-county/Division", wherein multiple subjects (including mathematics) are integrated in order to create a relevant, responsive and textured curriculum scope and sequence for the learner. "The thematic curriculum does not use the term "objectives" as an organising principle. While all teaching has objectives, the thematic curriculum has chosen a competence-based approach rather than an objective-based approach. This is based on the belief of the curriculum planners that objectives refer more to the teaching process rather than the learning process." Furthermore, within each theme, Uganda's NCF included a "Suggested Assessment Guidelines for Themes", to guide and standardise assessment development (National Curriculum Development Centre, 2008).

Pakistan

Unlike most of the Member States in this study, Pakistan's NCF strongly articulated the role of assessment within teaching, learning and curriculum development. For this study, its grade 4 NCF was examined and analysed, however, its unique approach explicitly mentions that assessment development is equally vital as curriculum development. Pakistan included a "table of specification" which appears to provide an example of how domains, or "content strands", may be aligned with cognitive domains (such as, knowing, applying, reasoning), and used to develop a summative assessment to measure student learning outcomes; "In order to develop/construct a summative assessment tool, two-dimensional table known as table of specification is used to align objectives, instructions and assessment." (Ministry of Federal Education & Professional Training , 2017)

Another crucial point of Pakistan's NCF, also prevalent in most Member States, is the following approach, "This Mathematics Curriculum consists of four above standards: Numbers and Operations, Measurement and Geometry, Algebra and Data Handling. All of this content is underpinned by reasoning and logical thinking." The mapping and organisation of the domain, *Math Proficiency* requires adjustments based on the design and approaches within the majority of Member States' NCFs. Furthermore, Pakistan's NCF explained that, "Cognitive domains plays vital role in the development of assessment." This illustrates the need for a robust Coding Scheme to help map the relationship between assessment and competency-based or "cognitive domains" as described by Pakistan, and others (Ministry of Federal Education & Professional Training , 2017).

Competency-based approaches

All the structural components of NCFs will not be detailed in this report. However, as it pertains to the relationship between assessment and curriculum, a relevant observation was made. There were 17 out of 20 Member States, (85%) that included a substantially elaborate section on the role of assessment in curriculum and learning. This 85% of Member States, specifically highlighted the integral role assessment in all areas of curriculum and learning of which the majority offered lengthy descriptions of the development of assessment tools, the role of educators in assessing learning outcomes, performance levels, and the validity of using assessment results to inform pedagogical adjustments as they relate to student learning. For example, Fiji connected outcomes-based approaches in their NCFs to teaching, learning and assessments inclusively. The representation of 'assessment mentioned approaches' in 85% of Member States' NCFs would require further analytical research to determine if these Member States'

symmetry is higher than the other 15% which do not explicitly mention assessment in their NCF. One may inquire if the inclusion of an assessment section in an NCF translates to an aligned assessment and curriculum relationship **in practice**, or does it remain solely in policies and national documents?

Additionally, the 85% of Member States that included a section on assessment in their NCFs detailed types of assessment – 1) diagnostic, 2) formative, and 3) summative. Regardless of competency-based or subject-based NCFs, many Member States stated the vital importance of assessing learning outcomes and the process of learning instead of assessing content against arbitrary standards, such as only using standardized tests as assessment. Still, most NCFs did not elaborate on how or what those assessment tools might be look like, specifically those measuring competency-based learning. (It has been considered that supporting documents containing such details, may exist; however, they were not included in the data collected for this study).

Another reoccurring observation in NCFs was the integration of the domain of *Math Proficiency* as defined in the Coding Scheme. The majority of Member States, whether competency-based national frameworks or subject-based, have integrated *Math Proficiency* across the spectrum of the curriculum (competency-related indicators, subjects, or content areas) as fundamental to mathematical thinking, processes and skill acquisition(s). As such, *Math Proficiency* was mapped present (value of 1) across the quantitative database if Member States included it as an underpinning to all mathematics learning. Furthermore, an elaborate discussion around this domain, in which the highest rate of asymmetry occurred, is exceedingly needed. If *Math Proficiency* is being defined and viewed by Member States as 'general competencies' or 'cognitive domains' or 'cross-curricular competencies' or 'mathematical processes', what metrics are being used to measure these broadly inclusive terms? Moreover, are they measurable using quantitative assessment tools? If not measurable within the function of NAFs, what metrics are being engaged to monitor and evaluate system-level outcomes?

Lastly, the select case studies do not exclude the existence of other Member States' competency-based frameworks. The qualitative research conducted in this study showed that the majority of Member States' national frameworks do contain varying elements of competency-based or competency-related indicators. As such, a continuum, of sorts, could be designed to help place Member States based on their inclusion or exclusion of competency- based learning processes and components, as a starting point before adjusting the Coding Scheme's use of *Math Proficiency*.

Conclusion

The numerous analyses in this report provide invaluable information; however, the most prominent analytical distinctions were seen in the Member States, income classifications and education level analyses- which concludes that the linguistic analysis seems to echo many of the other analyses' findings. Another key finding, which resonated throughout all levels of analysis, was the categorization and interpretation of the domain, *Math Proficiency*. Additional research is needed on its integration in national frameworks and how it connects to learning competencies rather than specific objectives.

Several observations and discussions in this report demonstrate that Member States' educational philosophies, critical mass and relative contexts are overall reflected in the structure of their NAFs and NCFs. Insomuch as a Member State's NAF is structured as competency-based or subject-based, so will its NCF. Fully considering the excluded data from these analyses, the alignment between assessment and curriculum is existent. But, given the line of inquiry of this study – are assessment frameworks measuring learning outcomes that are present in curriculum frameworks, and what findings are most salient within such an inquiry? – it is important to distinguish that disparities do exist in the between assessment criteria and curricular criteria. Such disparities were seen in the data points on assessment bias asymmetry and raise questions, such as, which types of assessment and tools should be used for better alignment; are all criteria being measured at the relevant grade level; which resources metrics, scale and performance levels indicate achievement of learning competencies? Reiterating the fact that the count of curriculum-based asymmetry for the domain, *Math Proficiency* was most notable and concurrent throughout the study – how are Member States integrating this domain in their NCFs and, how are they measuring it?

The increasing prevalence of competency-based national frameworks or components of competency-based education (CBE) within national frameworks suggests a paradigm shift from traditional, subject-based curricula and assessment approaches (common in the 1960's-70's) towards competency-based approaches (Harden, 2002). Gradually emerging since the 1970's, CBE is comprised of a competency framework and competency assessments – the former describes skills, knowledge and abilities while the latter measures and determines mastery (McClarty and Gaertner, 2015). This study has shown that within this paradigm shift, well-articulated competency-based assessment (types, tools, metrics and scale) are lacking. Many Member States, in this study, detailed in great length the importance of assessment and learning; however, there is a need for a concerted and data-driven approach to determine how best to measure competency-based curricula nationally and globally. Further questions are raised; what metrics are used in assessing 'cognitive domains' and 'general competencies' which are, by nature of their function, often loosely understood or difficult to describe as an observable behavior? In cases that these assessment tools are framed and designed - are well resourced capacity building programmes in place for educational practitioners so that they may develop, implement and manage the assessment data in service of the learner?

In order to fully comprehend the complexities inherent within these discussions, a recommendation is made to caste a wider net in data collection and data analysis - to collect an extended number of national frameworks, related documents and additional pieces of evidence from Member States (such as educator input, lesson plans, regional school districts, student testimonials and more). This wider net will help to better capture the real 'look and feel' of assessment and curriculum's ongoing relationship as it relates to the monitoring of learning outcomes with regard to SDG 4.1 - Education 2030.

In conclusion, this report seeks to accomplish two goals, i) to contribute to the ongoing discussions around intentional, and assessed outcomes of curriculum and assessment frameworks; and ii) to be most practical

to Member States in the identification and examination of alignment between their NAFs and NCFs for Mathematics; and thus stimulate an examination of the effectiveness and application of assessment and curricular expectations. The importance of such alignment is crucial to any education system and its national frameworks as mentioned in the *Introduction* of this report- reinforcing the efficacy of symmetry between learning outcomes and assessment outcomes. Upon reading this report, Member States (and all of UNESCO and its institutions) may be better positioned to reflect on the alignment between assessment and curriculum in their own country and context, and to perhaps, develop competency-based learning outcomes and competency-related indicators (if deemed appropriate and relevant to their educational philosophy and national needs).

Lastly, this report calls to action international bodies, and national bodies to explore these findings, observations and discussions in relation to the design, development and implementation of national and global curriculum and assessment policies and practices in an ever-changing and ever-dynamic, globalising world.

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Annex 1: NAFs and NCFs analysed

Regions of the world:

1: North America and Western Europe

2: East Asia and the Pacific

3: South and West Asia

4: Latin America and the Caribbean

5: Central and Eastern Europe

6: Sub-Saharan Africa

Income classification levels:

HI: High-Income

UMI: Upper-Middle-Income

LMI: Lower-Middle-Income

LI: Low-Income

Education levels:

LP: Lower Primary

UP: Upper Primary

LS: Lower Secondary

Country	Region	Income	Education Level(s)	Language	Title	Author	Year	Framework(s)
Australia	2	HI	LP; UP; LS	English	The Australian Curriculum	Australian Curriculum, Asse	2013	NCF
Australia	2	HI	LP; UP; LS	English	Minimum standards – numeracy (Ye	NAPLAN and ACARA	2016	NAF
Canada-Ontario	1	HI	LP; UP; LS	English	The Ontario Curriculum Grades 1-8:	Ministry of Education	2005	NCF
Canada-Ontario	1	HI	LP; UP; LS	English	Framework – Assessment of Readin	Education Quality and Acc	2007	NAF
Dominica	4	UMI	UP	English	Programme of studies for the prima	Ministry of Education and I	2006	NCF
Dominica	4	UMI	UP	English	Report on Candidate's Performance	Ministry of Education and I	2014	NAF
Dominican Republic	4	UMI	UP	Spanish	Diseño Curricular Nivel Primario Seg	Ministerio de Educación Re	2014	NCF
Dominican Republic	4	UMI	UP	Spanish	Evaluación Diagnostica de Inicio del	Ministerio de Educación, R	2010	NAF
England, UK	1	HI	LP; UP	English	The National Curriculum in England	Department for Education	2013	NCF
England, UK	1	HI	LP; UP	English	Key Stage 1 – Mathematics Test Fra	Standards and Testing Ager	2015	NAF
Estonia	5	HI	LP; UP	English	National Curriculum for Basic Schoc	Government of the Republ	2011	NCF
Estonia	5	HI	LP; UP	English	National Curriculum for Basic Schoc	Government of the Republ	2014	NAF
Fiji	2	UMI	LP; UP; LS	English	The Fiji Islands National Curriculum	Ministry of Education	2007	NCF
Fiji	2	UMI	LP; UP; LS	English	Year 4 Numeracy Outcomes. Year 6	Ministry of Education, Heri	2016	NAF
France	1	HI	LP, UP, LS	French	Projet de Programmes pour les Cycl	Conseil Superieur des Prog	2015	NCF
France	1	HI	LP, UP, LS	French	Compétences du Socle – Document	Ministère de l'Éducation na	2016	NAF
Gambia	6	LI	LP; UP	English	Curriculum Framework for Basic Edu	Ministry of Basic and Seco	2011	NCF
Gambia	6	LI	LP; UP	English	Introduction to the Learning Achiev	Ministry of Basic and Seco	n.d.	NAF
Guatemala	4	LMI	LP	Spanish	Curriculum Nacional Base Tercer Gr	Ministirio de Educacion	2007	NCF
Guatemala	4	LMI	LP	Spanish	¿Qué Debo Saber para Realizar la Pr	Ministerio de Educación	2016	NAF
Honduras	4	LMI	LP; UP; LS	Spanish	Diseño Curricular Nacional para la E	Republica de Honduras - Se	2003	NCF
Honduras	4	LMI	LP; UP; LS	Spanish	Estándares Educativos Nacionales E	República de Honduras, Se	n.d.	NAF
India	3	LMI	LP; UP; LS	English	Syllabus Volume 1 - Elementary Leve	National Council of Educat	2006	NCF
India	3	LMI	LP; UP; LS	English	National Achievement Survey (Cycle	National Council of Educat	2014	NAF
Ireland	1	HI	LP; UP	English	Primary School Curriculum - Introdu	Government of Ireland	1999	NCF
Ireland	1	HI	LP; UP	English	The 2014 National Assessments of E	Educational Research Cent	2014	NAF
Ivory Coast	6	LMI	LP	French	Programme Educatifs et Guides d'Ex	Ministere de l'Education N	n.d.	NCF
Ivory Coast	6	LMI	LP	French	Evaluations des Compétences des E	Ministère de l'Éducation Na	2016	NAF
Micronesia	2	LMI	LP; UP; LS	English	Curriculum Frameworks	Pohnpei Department of Ed	2009	NCF
Micronesia	2	LMI	LP; UP; LS	English	FSM National Minimum Competenc	Department of Education,	2015	NAF
New Zealand	2	HI	LP; UP; LS	English	The New Zealand Curriculum for Eng	Ministry of Education	2007	NCF
New Zealand	2	HI	LP; UP; LS	English	Mathematics Standards for years 1-	Ministry of Education	2009	NAF
Pakistan	3	LMI	LP	English	Curriculum for Mathematics Grades	Ministry of Federal Educati	2017	NCF
Pakistan	3	LMI	LP	English	Mathematics Framework – Nationa	Ministry of Federal Educati	2008	NAF
Peru	4	UMI	LP; UP	Spanish	Diseño Curricular Nacional de Educa	Ministerio de Educación	2008	NCF
Peru	4	UMI	LP; UP	Spanish	Evaluación Censal de Estudiantes (E	Ministerio de Educación de	2009	NAF
Seychelles	6	HI	LP; UP; LS	English	The National Curriculum Framework	Ministry of Education	2013	NCF
Seychelles	6	HI	LP; UP; LS	English	Primary National Curriculum – Attai	Ministry of Education	2015	NAF
Uganda	6	LI	LP	English	Primary School Curriculum - Primary	National Curriculum Devel	2008	NCF
Uganda	6	LI	LP	English	Uganda – National Assessment of P	Uganda National Examinat	2015	NAF

Annex 1: NAFs and NCFs analysed

Annex 2: Coding Scheme – Domains, sub-domains, constructs, and sub-constructs

Figure 2.1: Math Proficiency domain

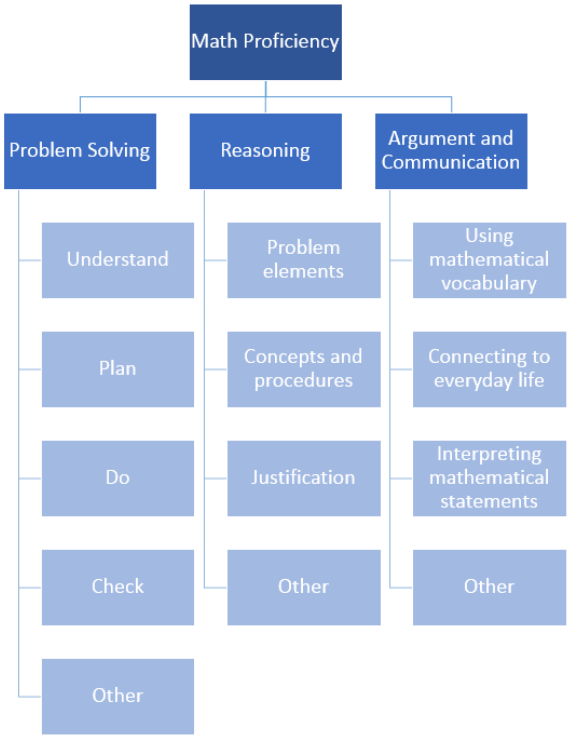

Figure 2.2: Number Knowledge domain

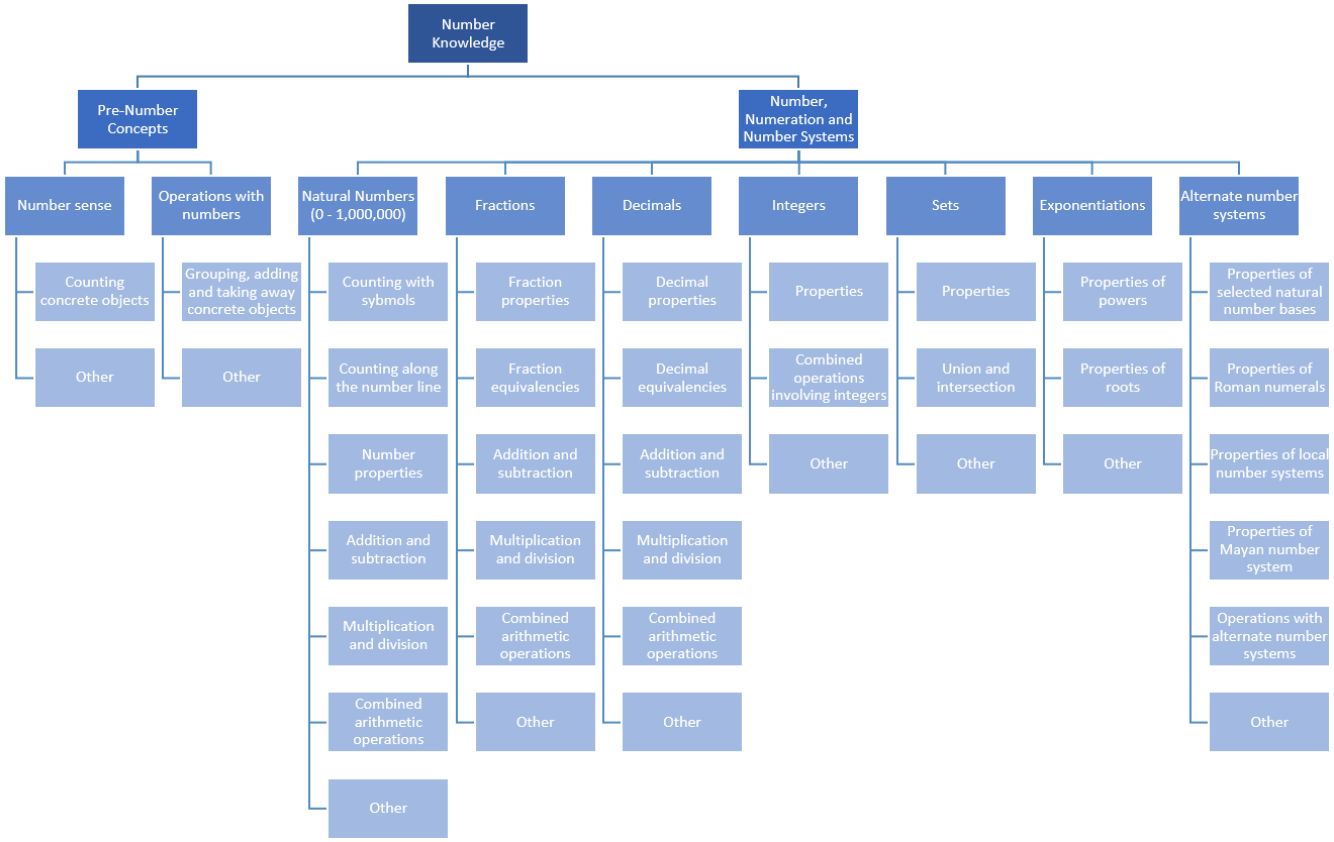

Figure 2.3: Measurement domain

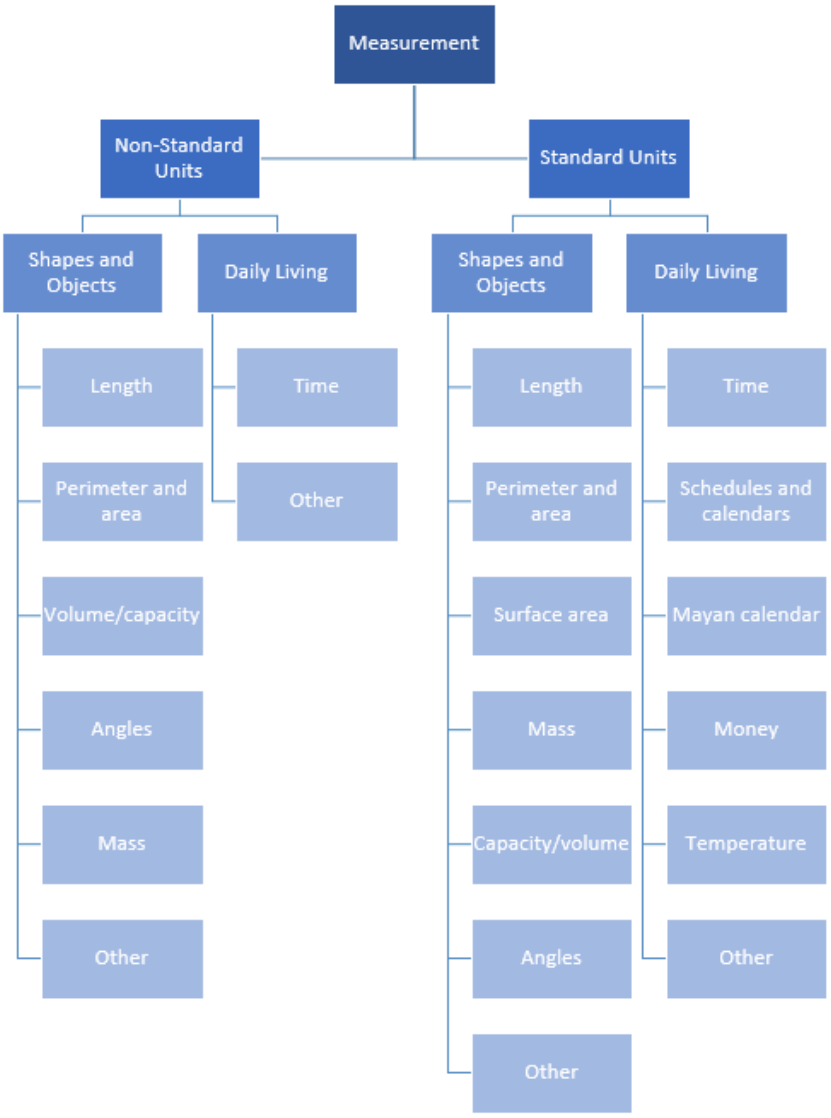

Figure 2.4: Statistics and Probability domain

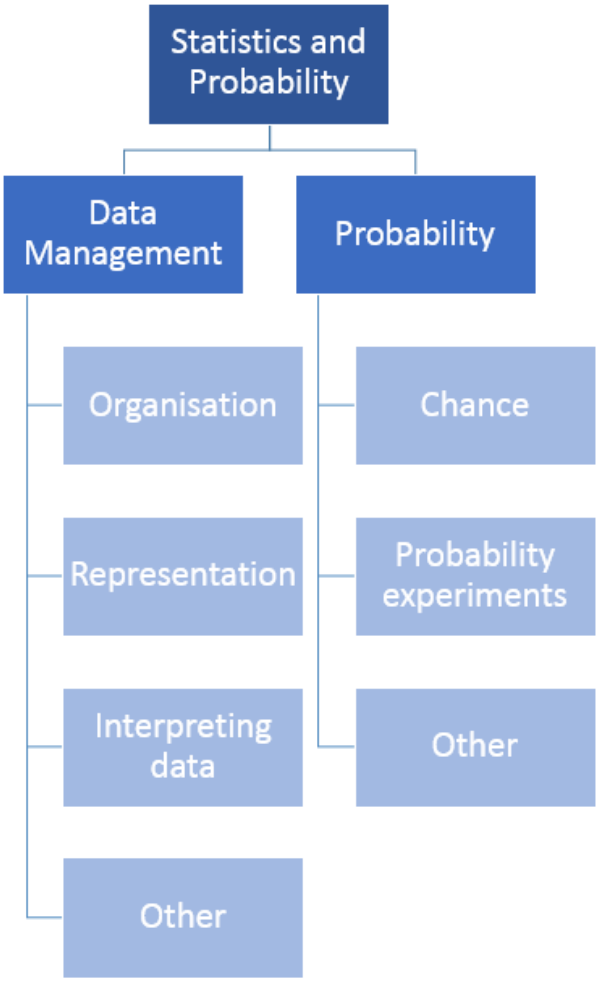

Figure 2.5: Geometry domain

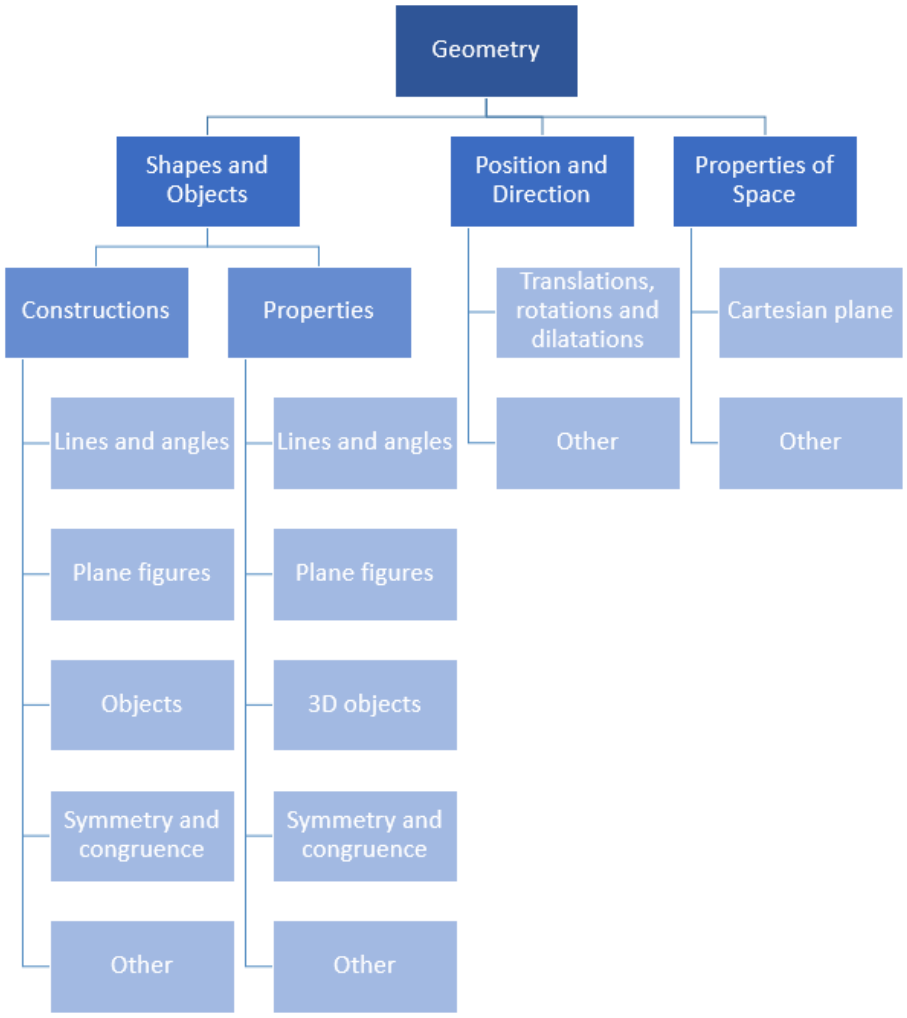

Figure 2.6: Algebra domain