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Analysis of Geometry Units in the Mathematics Curriculum of Cambodia from the Perspective of Coherence

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Abstract. This study aims to analyse the units in the Cambodian mathematics curriculum on geometry from the perspective of coherence. Four of the recently revised mathematics syllabi of primary and secondary education in Cambodia published in 2018, the latest version available during the research period of 2022-2023, have been collected. The document analysis following the procedure of General Topic Trace Mapping (GTTM) was used because it embraces curriculum coherence. The results of the analysis revealed that the Cambodian mathematics curriculum on geometry lacks coherence in terms of the four points: (1) the relations of the subdomains and contents are not well-organised and unnecessarily repetitive; (2) the contents and sub-contents are poorly ordered and are not age-appropriate, due to some contents are addressed as a prerequisite and other contents have a higher level than the student's grade level; (3) the relations of some contents, sub-contents, and their learning outcomes are not clearly specified, as through a lack of logical or conceptual connections within and across years; and (4) the domains, sub-domains, contents, sub-contents, and learning outcomes are not clearly related nor sequenced. These four points indicate the importance and necessity of improving the coherence of geometry units in Cambodia's mathematics curriculum. This analysis focused on the content relation aspect among three internal coherence aspects. Further research should be done on the two other aspects of internal coherence, structural and pedagogical, as well as external curriculum coherence. Analysis of all these aspects will contribute to the holistic improvement of the curriculum.

Keywords: cambodia, curriculum coherence, general topic trace mapping, geometry.

1 Introduction

1.1 Background

Cambodia became independent from French colonial rule in 1953, and the current general education practice only started after the end of the civil war of 1975–1979 (Khmer

Rouge). The general education system was divided into three levels: primary, lower, and upper secondary. The Ministry of Education, Youth, and Sport (MoEYS) has reorganised the general education system three times. First, from 1979 to 1986, a ten-year education system was introduced comprising four years of primary, three years of lower secondary, and three years of upper secondary education (4+3+3). Second, from 1986 to 1994, MoEYS changed the education system from ten to eleven years, with five years of primary, three years of lower secondary, and three years of upper secondary (5+3+3). Finally, from 1994 until today, general education has expanded to twelve years (6+3+3) to increase teaching-learning hours and deepen children's knowledge [1, 2].

In addition, pre-school education was emphasised also as a part of general education, which covers three years. Moreover, after graduation from upper secondary school, students could pursue a four-year bachelor's degree at universities. Non-formal education, which focuses on adult literacy, is also a part of the Cambodian education system.

Even though Cambodia's education has expanded in the number of years in general education, numerous documents and reports show that students' learning achievement is still low. For example, MoEYS reported that on the Programme for International Students Assessment for Development (PISA-D), only 8% of students had achieved the minimum level of proficiency in reading and 10% of students the minimum level of proficiency in mathematics [4]. Another report, the National Learning Assessment (NLA) of November 2021, showed that students' learning achievement in both Khmer (Cambodian official language) and math remained low compared to the NLA of 2016 [5], especially in maths, where the overall score is only 38%. At the same time, their Khmer achievement is remarkably low in dictation, with only 24% of the correct answers on average [6]. In mathematics, the average achievement is the lowest in the geometry domain among other (Algebra, Statistics, Measurement, and Number), as only 35% of students in the 6th grade could complete the assessment test correctly [6] and only 46% in the 8th grade [7]. Similarly, the report on the 12th-grade national examination in academic year 2020–2021 showed that only 47.93% of students could solve geometry problems correctly [8]. All these indicators reveal insufficient student achievement.

Factors which influence students' low achievement have been identified as educational policy, curriculum, and school-related, personal, and social factors [9, 10]. The curriculum is one of the most influential factors because it is the starting point forteaching and learning activities. Thus the whole curriculum should be consistent, and aligned with broader educational goals, objectives, contents, sub-contents, and learning outcomes. In other words, curriculum coherence is the most dominant predictive for student achievement because it refers to the connection and logical progression of contents, skills, and learning outcomes within a curriculum framework, syllabus, textbook, and assessment [11-13].

In this sense, there is a need to confirm the curriculum coherence of Cambodia's curriculum. Three main questions have been set for this study: (1) what is the definition of curriculum coherence? (2) what is the status of Cambodia's primary and secondary education geometry curriculum in terms of coherence? and (3) how can we enhance the coherence of the curriculum? In this study, the focus is placed on the geometry domain.

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1.2 Literature Review

The latest analysis of the education system suggests that 'curriculum coherence' is crucial and is linked with high-performing systems [14]. Curriculum coherence refers to more than just the simple, common use of the term 'coherence'; a curriculum is considered 'coherent' when the assessment, pedagogy, teaching content, textbooks, and national curriculum contents align with and reinforce one another [15]. Coherence means that all of them are interrelated.

However, different researchers have defined curriculum coherence in different ways. Newmann, Smith [16] defined curriculum coherence as the linkage and interconnectedness of the various components of a curriculum, such as the learning objectives, instructional materials, teaching methods, and assessments. These should be organised to ensure that all components work together logically and are integrated to support student learning and achievement. In summary, it provides students with a clear and consistent educational experience by avoiding gaps, repetitions, or contradictions.

Similarly, Schmidt, Houang [13] defined curriculum coherence as the logical and sequential organisation of the content standards and curricula across a period. It involves articulating a sequence of topics and performances that reflect the discipline's hierarchical nature. Coherent content standards and curricula are designed to progress from simple content to deeper and more abstract content which is inherent in the discipline.

Bateman, Taylor [17] defined curriculum coherence as the degree to which the intended learning outcomes (instructional objective), the instructional processes (learning activities), and the assessments (formative assessment and summative evaluations of the student learning) are connected or aligned. They are intricately related and connected, focusing more on objectives, activities and learning outcomes.

Wang and McDougall [18] defined curriculum coherence as the degree to which a curriculum is organised logically and meaningfully. Here, curriculum coherence builds on the student's prior knowledge and provides a clear learning progression, with each content or concept building on what the student has learned. This coherence helps students develop an understanding of one topic in connection to another. It also helps teachers plan and deliver instruction more effectively by providing a clear framework for what should be taught and when a given topic could be introduced.

Reeves and McAuliffe [19] defined curriculum coherence as the degree to which domain-specific or disciplinary content is systematically presented to learners in terms of the conceptual coherence of its organisation. In other words, it is the extent to which the curriculum is structured in a way consistent with the logical and hierarchical nature of the disciplinary content from which it is derived. This coherence includes the ordering relationships between content elements, the rationale for that order, and the connections and interlinkages between different contents and sub-contents within the subject field.

Confrey, Gianopulos [20] defined curriculum coherence as a well-structured and interconnected curriculum that ensures students a clear and logical progression of learning experiences. This coherence can be achieved by aligning contents across the grades, coordinating contents within a grade, and ensuring consistency in sequencing concepts and activities.

Oates [14] defined curriculum coherence as the coordination and consistency of national curriculum content, teaching materials, pedagogical approaches, assessment methods, and incentives within the education system. This coherence means linking and integrating various elements within an education system.

These discussions of curriculum coherence can be summed up under three points. First, it means such organisation as grades or grade bands, content domains, and cognitive domains across stages[13, 19]. This coherence can be called the structural aspect of curriculum coherence.

Second, it entails connections between different contents within a certain topic [18, 19]. This aspect of coherence means that the contents are sequenced coherently and logically, and such a sequence of contents supports learning progression across grades. In other words, students build their knowledge and skills from one grade to the next [15, 20]. This coherence can be called the content-relation aspect of curriculum coherence.

Third, it involves the connection between objectives, instructional processes, learning outcomes, and assessment [16, 17]. The curriculum's goals and objectives outline what will be achieved through the educational process. This relationship highlights the importance of aligning the goals of the curriculum with its actual implementation and leads to the intended outcomes. Such a relationship contributes to effective student learning experiences [14]. This can be called the pedagogical aspect of curriculum coherence.

The above three points are related to internal coherence. Through a curriculum with internal coherence, students are more likely to experience a logically connected progression of learning experiences, which can contribute to a deeper understanding and mastery of the content [18]. On the other hand, the curriculum can be aligned with social needs and expectation. This is called external coherence because social needs and expectation does not belong to the education itself. So, both internal and external coherences form the overall coherence of the curriculum. This paper will focus only on internal curriculum coherence because it is assumed to concern more directly student learning achievement. The table below shows the relational aspects of internal coherence.

Table 1. Aspects of Curriculum Coherence

Type	Aspects	Descriptions
Internal coherence	Structural	grades or grade bands, content domains, cognitive domains
	Content relation	different contents within a certain topic
	Pedagogical	objectives, instructional processes, learning outcomes, and assessment
External coherence		Relation with social needs and expectation

Source: (Authors developed based on the literature review)

Table 1 shows three interrelated aspects: structural, content relation, and pedagogical. These relations mean that an effective curriculum design considers the interplay

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between these three aspects to create a cohesive and meaningful learning experience for students. Among the three aspects of curriculum coherence, the content relation aspect will be the focus of this paper because it can most effectively direct student learning achievement by ensuring that the curriculum is organised coherently and meaningfully [20, 21]. By establishing meaningful connections between concepts, educators can help students see the relevance and significance of what they are learning, leading to deeper understanding and retention of the material.

In order to analyse the curriculum from the perspective of coherence, in this paper, curriculum coherence is defined as the relation between corresponding domains, sub-domains, contents, sub-contents, and learning outcomes within and across grades, and they are all arranged in order as a whole.

2 Method

Data Source

This study used four of the recently revised mathematics syllabi [22-25] for analysis. These were the latest versions available during the research period of 2022–2023, and together they cover primary education (1–6), lower secondary education (7–9), and upper secondary education (10–12) in general education. The last syllabi for grades 10–12 are separated into two files: one for the science track and the other for the social science track. All syllabi contain goals, objectives, domain, contents, sub-contents, and learning outcomes from grade 1 to grade 12.

Data Analysis Method

All the syllabi were translated from Khmer into English. Contents and sub-contents were translated exactly the same as the original, and the contents and sub-contents within geometry were allocated according to domains and sub-domains. The geometry domains were devided into five sub-domains: plane geometry, solid geometry, relations and transformations, constructions, and vectors. The contents and sub-contents were identified by analysing the syllabi for grades 1–12. Similarly, the learning outcomes were translated and summarised under knowledge, skills, and attitudes. The purpose of the translation is to facilitate consultations with mathematics experts regarding consistency and to ensure the validity and reliability of the syllabus analysis.

The data were then inputted into an Excel sheet. The domains, sub-domains, contents, sub-contents, and learning outcomes were arranged from grades 1 to 12 and examined within the same grade and across grades to determine whether the domains, subdomains, contents, sub-contents, and learning outcomes were related and corresponded to each other.

In this study, the domains, sub-domains, contents, and sub-contents and learning outcomes were analysed using General Topics Trace Mapping (GTTM), which was developed for content analysis in the Trends in International Mathematics and Science Study (TIMSS) [26]. It provides a way to compare and analyse curricula across coun-

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tries and identify the content intended for instruction at each grade level and the linkages between contents, sub-contents and learning outcomes. Based on this GTTM, the following procedures are set:

1. We first collected all the geometry contents from the syllabi and arranged each of them into appropriate sub-domains per grade. In this step, the sub-domains and contents are extracted from the syllabi and the grade levels when the contents within the sub-domains are to be addressed to confirm whether they are repeated or sequenced.
2. Second, sub-contents are identified and arranged under each content at each grade level. Here, we extracted the content and sub-contents from the syllabus and confirmed whether the contents and sub-contents are arranged in order within and across grades. This step identifies the relation of contents and sub-contents within each grade and across grades. The former relation entails the examination of sub-contents within each grade to indicate how the contents and sub-contents fit together.
3. Third, it analyses the relation between sub-contents and learning outcomes within the content for each grade level. This step we identified the relation of sub-contents and learning outcomes whether the sub-contents and learning outcomes are corresponding within at each grade level. Then, we match how each learning outcome fits together with sub-contents within each content at the grade level
4. Last, it analyses the contents, sub-contents, and learning outcomes across domains, subdomains, and grades. In this step, we examine the sequencing of those contents, sub-contents, and learning outcomes that are clearly related. Then show out the result of the curriculum response to the perspective of curriculum coherence, which have been indicated as the relation between corresponding domains, subdomains, contents, sub-contents, and learning outcome within and accress grade, and they are all arranged in order as a whole.

3 Result and Discussion

3.1 Results

Based on the content analysis across primary, lower secondary, and upper secondary education by following the steps described above, we have obtained the following results:

Regarding the arrangement of the geometry domain, subdomains, and the contents of geometry, the results show that 5 subdomains and 68 contents have been addressed under the geometry domain, as shown in Table 2.

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Table 2. The Arrangement of the Geometry Domain, Subdomains, and Contents from Grades 1 to 12

Subdomains and Contents in the Geometry Domain	**Grades**											
Plane geometry	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Points, lines, and curves	■											
Patterns	■											
Two-dimensional geometric shapes		■					■					
Rectangles and triangles			■									
Area and perimeter			■	■		■						
Angles				■	■		■					
Squares and rectangles				■								
Construction geometry					■							
Area of a triangle					■							
Circles						■						
The foundation of geometric shapes							■					
Perimeter and area of a polygon							■					
Perimeter and area of a circle							■					
Rectangles								■				
Polygons								■				
Area of a rectangle								■				
Position of circles and lines								■				
A line and a special segment intersect in a triangle								■				
Circles and lines									■			
Properties of angles within circle and regular polygons									■			
Thales' theorem									■			
Parabolas												■
Ellipse												■
Hyperbola												■
Solid Geometry												
Geometric shapes	■											
Three-dimensional geometric shapes		■										
Volume of a solid					■	■	■	■				

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Solids			■					
The surface area of a solid				■	■			
Geometric shapes and planes in space					■			
Surfaces of similar shape						■		
The volume of a similar solid						■		
Geometric shapes in space								■
Lines and parallel planes in space								■
Orthogonal in space								■
Relations and Transformations								
Perpendicular and parallel lines	■							
Symmetric shapes	■							
Puzzle (Tessellation)	■							
Properties of triangles and rectangles		■	■					
Parallel lines and perpendicular lines				■				
Symmetries of a point				■				
Symmetries of lines and planes				■				
Equilateral triangles					■			
Similarity of triangles						■		
Translations							■	
Reflections							■	
Rotations							■	
Homotheties							■	
Construction								
Plane coordinates (cartesian plane)				■				
Construction of mediators, bisectors of angles and triangles				■				
Construction of rectangles				■				
Scale					■			
Pythagorean theorem					■			
The trigonometric ratio in a triangle					■			
Triangle inequalities						■		
Distance between two points						■		
Linear equations						■	■	
Coordinate points in a plane							■	
Equation of a circle							■	

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Solving inequation by graph	■	
Equation of a plane		■
Linear equation in space		■
Equation of a sphere		■
Vector		
Vectors and operations on vectors	■	
Practice with vectors	■	
Vector spaces		■
Scalar product of two vectors		■
Scalar product of two vector spaces		■

Noted: Bold indicates sub-domains, non-bold contents; ■ the contents are addressed

Table 2 shows that the Cambodian mathematics syllabi in the geometry domain contain more contents than most international mathematics curricula [27]. However, these contents are neither well-organised nor well-sequenced. For example, the contents of 'Angle' addressed in grades 4, 5, and 7 are repeated. In grade 4 about the content concerns how to construct acute and perpendicular angles using a protractor and lines and involves practice measuring the angle with eight directions; at grade 5, the use of a protractor to construct straight angles, full rotation angles, and vertical angles; and at grade 7, the notion of angle, type of angle, measuring angles, and the use of a protractor to measure the angle by constructing an angle with a line, a compass, and perpendicular lines; this topic is skipped in grade 6. On the other hand, the relation of the contents 'Parabola, Ellipse, and Hyperbola' are advanced contents involving quadratic curves or conic curves that require a higher level of mathematical knowledge. These contents should be brought up in the context of a specific skill or at the university level [27]. Therefore, this curriculum has weak coherence as a whole because some contents are repeated, and some contents are not appropriately placed per grade level.

The analysis based on the GTTM procedure [26] yields the following results regarding the Cambodian syllabi for geometry as a whole:

1. The sub-domains and contents are extracted from the syllabi, and the grade levels when the contents within the sub-domains are to be addressed and indicated with the symbol ■. In this case, the sub-domain is Solid Geometry, as shown in Table 3.

Table 3. The Relation of Sub-Domains and Contents

Sub-domain and Contents	1	2	3	4	5	6	7	8	9	10	11	12
Solid Geometry												
Geometric shapes	■											
Three-dimensional geometric shapes		■				■						
Solids						■						

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Volume of a solid	■	■	■	■			
The surface area of a solid			■	■			
Geometric shapes and planes in space				■			
Surfaces of similar shape					■		
The volume of a similar solid					■		
Geometric shapes in space							■
Parallel lines and planes in space							■
Orthogonality in space							■

Note: Bold font indicates a sub-domain; others are contents; ■ the contents within the sub-domain are to be addressed.

Comprehensive analysis shows that the relation of some sub-domains and contents are not continuously dealt with or are repeated by simply adding superficial complexities to the contents without much difference in geometrical ideas from lower to upper grades. In Table 3, an example of non-continuous treatment is the content of the 'Three-dimensional geometry shape'. It is addressed in grade 2 and again in grade 6, which means that it is not continuously treated from grade to grade. On the other hand, the content of 'Solid' is addressed in grade 6, while the content of 'Volume of solid' is addressed in grade 5. This can be interpreted as reverse treatment. In fact, the content of 'Solid' should be introduced before that content of 'Volume of solid' in order to measure the solid we have to know that shape first.

2. The relation of contents and sub-contents across grades is repeated, and their order is not sequenced, as shown in Table 4.

Table 4. The Relation Between Contents and Sub-Contents Within and Across Grades

Grade 5	Grade 6	Grade 7	Grade 8
Volume of Solid - Extension of a solid shape - Construction of a solid with a unit of cubes - Construction of Cubes - Measurement and measuring a volume - Volume of a cube and cuboid - Volume of liquid	**Solid** - Notion of a solid - Notion of the surface area of a solid	**Volume of solid** - Notion of solid - Change the unit of volume - Volume of a right prism - Volume of cylinder	**Volume of solid** - Volume of a right prism - Volume of a cylinder - Volume of a pyramid - Volume of cone - Volume of sphere - Solve problems related to the surface edge of combined solids

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	Volume of solid - Unit of volume - Volume of solid - Length of cube edge - Volume of liquid - Practice	

Note: Bold indicates contents, non-bold sub-contents.

Table 4 shows an example of the content 'Volume of Solid' to indicate how the contents and sub-contents are arranged across the grades. For example, in grade 5, there are sub-contents such as 'Extension of a solid shape', 'Construction of a solid with a unit of cubes', and 'Construction of cubes'. First the sub-content, 'Extension of solid shape', represents the continuation of previous knowledge. The following sub-contents, such as 'Construction of a solid with a unit of cube' and 'Construction of cubes' (without a unit), are some of the main concepts to be developed in this grade regarding the construction of a cube. The last three sub-contents, 'Measurement and measuring a volume', 'Volume of a cube and cuboid', and 'Volume of liquid', are related to measurement. They are arranged in an increasing difficulty from the concept of a unit of measurement, application of the unit to a simple case and the extension of such measurement. Conversely, the latter relation is identified by examining sub-contents across grades. For example, in grades 5 and 6, the sub-contents in grade 6 are analysed in relation with sub-contents in grade 5 discussed above. The sub-content 'Unit of volume' within the content 'Volume of solid' seems to be repetitive, although it may introduce other units such as km3, m3 and mm3. The sub-content 'Volume of solid' also seems to be repetition, although it may deal with different solids from the cube and cuboid. The sub-content 'Length of a cube' looks new, but in order to find a volume in grade 4, the length of one side of a cube is already required; thus, it is not very clear. Therefore, the sub-content 'Volume of liquid' seems to be a repetition.

Another example is the content of 'Solid'. It should be introduced before the contents of 'Volume of solid' because the latter depends on the sub-content of 'Solid' having been introduced, such as the notion of a solid and the surface of a solid. These are the basic concepts for understanding the solid. Therefore, it should be introduced before the sub-content of the volume of solid.

As a result, the relation of contents and sub-contents within each grade and across grades, and thus, the development of the concepts should be deliberated more in the curriculum.

Additionally, for example, in the sub-content of grade 5, students should learn 'Construction of a solid with a unit of cubes' before the sub-content of 'Extension of a solid shape'. Another example is that 'Solid' was addressed in grade 6, while the 'volume of solid' content was addressed in grade 5. These are reversed, because students should learn new concepts based on their previous knowledge and experiences, as reflected in the syllabus of other countries such as Zambia, Japan, and Singapore [28-30]. Another

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example is in Table 4, where the contents and sub-content of 'Volume of solid' are repeated in grades 5 and 6. The contents of 'Volume of solid' have been repeated in grades 5, 6, 7, and 8.

3. The relation between the contents, sub-contents, and learning outcomes do not correspond within a given grade. The identification of the relation of sub-contents and learning outcomes as shown in Table 5.

Table 5. The relation of a content, sub-contents, and learning outcomes within the grade level.

Grade	Content	Sub-contents	Learning outcomes
5	Volume of solid	- Extension of a Solid shape - Construction of a Solid with a unit of cubes - Construction of cubes - Measurement and measure a volume - Volume of a cube and cuboid - Volume of liquid	- Cut or fold a shape to make various solids, such as parallelepiped, cube, cylinder - Use the unit of the cube to find a rectangular parallelepiped and cube - Use a measuring cup $1000\,ml$ and a cube with a volume $10\,cm$ to prove that $1l = 1000ml = 1000\,cm^3$, and $1l = 1\,dm^3$. - Use the dimensions of a cubic or rectangular parallelepiped to find the volume of liquid in a non-specific geometric container used in daily life.

Table 5 shows an example of sub-contents and learning outcomes within the content 'Volume of a solid' in grade 5. Along this content, there are six sub-contents appear under the content 'Volume of solid', but the learning outcomes included only four points, which indicated that there is no direct correspondence between learning outcomes and sub-contents. Besides, it is difficult to identify the relation between the learning outcomes and the sub-contents because the descriptions of learning outcomes are mixed together. The first outcome seems to correspond with the first and second sub-contents and the last outcome with the fifth and sixth sub-contents. The learning outcome should be explicitly tied to the intended content and sub-contents because it can support textbook writers and teachers in unpacking the geometric content for writing the textbooks and planning the lesson [27]. Therefore, the learning outcomes should be clearly identified to correspond to the sub-contents and contents.

4. In summary, in the analysis of geometry as a whole, the relations of the domain, subdomains, contents, sub-contents, and learning outcomes do not correspond across grades and are not sequenced. In this case we take an example of grade 5 and 6 as shown in Table 6.

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Table 6. The Relation of a Domain, Sub-Domains, Contents, Sub-Contents, and Learning Outcomes Across the Grades

Grade	Domain	Sub-domain	Contents	Sub-contents	Learning outcome
5	Geometry	Solid geometry	Volume of solid	- Extension of a Solid shape - Construction of a solid with a unit of cubes - Construction of cubes - Measurement and measure a volume - Volume of a cube and cuboid - Volume of liquid	- Cut or fold a shape to make various solids, such as parallelepiped, cube, cylinder - Use the unit of the cube to find the rectangular parallelepiped, and cube - Use a measuring cup $1000ml$ and a cube with a volume $10cm$ to prove that $1l = 1000ml = 1000cm^3$, and $1l = 1dm^3$. - Use a cubic or rectangular parallelepiped by knowing its dimensions to find the volume of liquid in a non-specific geometric container used in daily life.
6	Geometry	Solid geometry	Solid	- Notion of Solid - Notion of surface of solid edge	- Define a solid by cutting a shape from paper and folding it - Cut and fold paper to create solids such as prisms, cubes, angles, cylinders, and pyramids.
			Volume of solid	- Unit of volume - Volume of solid - Length of the cube - Volume of liquid - Practice	- Convert scale from small to large and vice versa. - Use the volume formula of a solid to calculate a rectangular parallelepiped and cylinder. - Find the length of the cubic edge from the surface base or its volume using the square root or cube root and a calculator. - Find an edge of a rectangular parallelepiped by knowing the volume and two of its edges or the surface area of the base. - Find volumes and the height of liquid in a container or rectangular parallelepiped.

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		- Use the volume formula of a cube, rectangular parallelepiped, cylinders, and a volume of liquid to solve problems related to daily life.

Table 6 shows an example of the relation of a domain, sub-domains, contents, sub-contents, and learning outcomes across grades 5 and 6. Here, the content 'Solid' is addressed in grade 6, while 'volume of a solid' is addressed in grades 5 and 6. We consider that the content 'Solid' should be introduced before the content 'Volume of solid' because students have to learn the shapes before calculating their volumes. Without understanding the basic concept of a solid, the students cannot acquire a new concept knowledge of 'Volume of solid'. This means that 'Solid' should be taught in grade 5 and the 'Volumes of solid' in grade 6. The learning outcome should be more specific in term of what students are expected to understand and work with various solids, including prisms, cones, pyramids and cylinders. They are also expected to explore the relationships between the dimensions, perimeter area, and volume of different shapes and solids.

Therefore, the results of analysis indicate that the detailed mathematics syllabi on geometry lack coherence due to (1) repetition of some sub-domains and contents, (2) contents and sub-contents are not sequences across grades, (3) contents, sub-contents, and learninig outcomes do not correspond within a given grade, and (4) the domain, subdomains, contents, sub-contents, and learning outcomes do not correspond across grades.

3.2 Discussion

The content-relation aspect is critical in curriculum coherence by ensuring that the contents correspond with the learning objectives, instructional materials, and overall educational goals. This coherence means that when the content is carefully selected, sub-contents and learning outcomes are interrelated to support a logical progression of learning experiences to meet learning outcomes and promote meaningful student learning. [18] studied curriculum coherence and learning progression. They agreed that educators can create a cohesive and practical curriculum that supports students' learning and achievement by developing curriculum coherence with a focus on content relations.

While structural and pedagogical aspects are also essential in curriculum design and delivery, the emphasis on content relation is crucial for fostering deep understanding, integration of knowledge, coherent learning progression, enhanced retention and transfer, alignment with standards, and preparation for future academic and career success. Educators can create a curriculum that maximises student learning outcomes and supports holistic development by prioritising content relations.

Moreover, the logical sequence of contents, sub-contents, and learning outcomes within and across grades can help students see the connection between contents and understand how those concepts are related [13, 27]. It also allows students to see the progress of certain content knowledge from lower to upper grades[26]. This promotes a deeper understanding of the subject matter within and across years.

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According to the assessment of coherence in the implemented curriculum of school mathematics in South Africa by Reeves and McAuliffe [19], this analysis of geometry units in the school mathematics curriculum in Cambodia supports the previous findings that incoherence in the curriculum can increase the difficulties for teachers and learners in achieving mastery of the subject matter. This result is also supported by scholars who have indicated that curriculum coherence can improve student learning achievement [11-13, 26].

4 Conclusion

The analysis of the Cambodian mathematics curriculum on geometry has revealed significant deficiency in coherence. Through this analysis, the current study found certain points regarding the lack of coherence of content relation aspect within the geometry domain. The identified issues included:

1. The relation of the subdomains and contents is not well-organised and unnecessarily repetitive;
2. Contents and sub-contents do not follow a proper order and are not age-appropriate, as some contents are addressed before others that they depend on, and some are higher than the student's grade level;
3. The relation of some contents, sub-contents, and their learning outcomes is not clearly specified, resulting in such problems as a lack of a logical or conceptual connection within and across years; and
4. The relations of domain, sub-domains, contents, sub-contents, and learning outcome are not clear nor sequenced well as a whole

To address these various incoherences, it is essential to revise the curriculum to align contents and sub-contents with learning objectives, provide professional development opportunities for teachers, integrate technology into teaching practices, foster collaboration among educators, and take holistic approach to improving coherence across all curriculum domains.

While this research focused only on the content-relation aspect of internal coherence, further research should be done on the three other aspects: structural, pedagogical, and external curriculum coherence. Analysis of all these aspects will contribute to the holistic improvement of the curriculum and the Cambodian mathematics curriculum can better support student learning outcomes and promote a deeper understanding of geometry concepts.

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