A comparative exploration of Turkish and Irish curricula via TIMSS cognitive domains

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This qualitative study aimed to explore Turkish and Irish mathematics curricula via TIMSS cognitive domains by way of a comparative investigation of first-grade to fourth-grade learning goals. For this purpose, 500 learning goals from both Turkish and Irish curricula were qualitatively analysed and classified by two experts. The findings of the study revealed that while Irish curricula have more learning goals in the first to fourth grades, the percentage distribution of these learning goals between learning strands were similar for both curricula. Moreover, the Turkish curricula devoted a greater percentage of learning goals to the cognitive domain than Irish curricula, while the Irish curricula had a greater percentage of learning goals in the applying and reasoning domains; although both curricula lacked sufficient learning goals in the applying and knowing cognitive domains where TIMSS' suggestion on the distribution of cognitive domain learning goals was considered. Thus, both Turkish and Irish curriculum developers should consider transferring some cognitive domain learning goals to the applying and reasoning domains. Devoting additional effort on the integration of numeracy into curriculum development processes by establishing connections between mathematical concepts and daily life situations could present an efficient means of increasing the effectiveness of Turkish curricula.

Introduction

The association between the positive effect of high mathematics achievement scores and national economic performance and growth (Baker & LeTendre, 2005), and the importance of developing students' early mathematical skills to ensure higher mathematics achievement scores in later grades (Claessens & Engel, 2013), are frequently highlighted in the literature. Countries have aimed to place greater emphasis on developing effective science and mathematics curricula in order to meet the demanding technological standards of the age (Uzun et al., 2010). Thus, countries have become increasingly more willing to participate in international exams as a means for exploring other educational systems and acquiring information on how to improve their national systems (Johansson, 2016). As suggested in the literature, national and international standardised exams play an essential role in the assessment of educational systems and for stimulating various policy changes (Greaney & Kellaghan, 2008; Johansson, 2016). International standardised exams provide necessary and unique opportunities to collect comparative, quantitative data on students' international achievement levels, which in turn triggers policy changes and inspires internationally competitive standards (Addey et al., 2017). With this perspective in mind, the current research aimed to compare Turkish and Irish educational curricula so as to provide valuable information on how to increase the effectiveness of both curricula via TIMSS' cognitive domains.

Turkey and the Republic of Ireland, like many other countries, share an interest in the TIMSS exams and regularly chose to participate. Turkey participated in the 1999 and 2007 TIMSS exams with only eighth-grade students, but then later added fourth-grade students in 2011, 2015, and 2019 (Milli Eğitim Bakanlığı [Turkish Ministry of National Education], 2020). The Republic of Ireland participated in the 1995, 2015, and 2019 TIMSS exams with both fourth-grade and eighth-grade students, while for the 2011 TIMSS exam only fourth-grade students attended from the Republic of Ireland (Perkins & Clerkin, 2020). While the Turkish fourth-grade students' achieved a mathematics score of 469 in 2011, 483 in 2015, and 523 in 2019, Irish fourth-grade students' scores were 527 in 2011, 547 in 2015, and 548 in 2019. Although both countries' fourth-grade students' mathematics achievement scores were shown to have increased, the Irish fourth-grade students demonstrated significantly higher mathematics skills over the years (Milli Eğitim Bakanlığı [Turkish Ministry of National Education], 2020; Perkins & Clerkin, 2020).

The Turkish educational system is predominantly under the centralised control of the Ministry of National Education, which regulates the pace of education, develops the national curricula, and manages the recruitment of its teachers, as well as being involved in the teaching of candidate and inservice teachers (Topçu et al., 2016). Political issues, international reports, and the results of international exams directed Turkey's Ministry of National Education to implement curriculum changes during the early 2000s. In 2002, the ruling Justice and Development Party declared their intention to implement curriculum changes aimed at elevating the quality of the Turkish educational system (Gür et al., 2012). Reports on the Turkish educational system by the OECD and the World Bank as well as international PISA exam results were cited by the Ministry of National education at the time to explain their desire to integrate some of the suggestions made regarding the curriculum development process in Turkey (Gür et al., 2012).

The desire to enhance the quality of the Turkish educational system triggered some significant changes, and in 2005 the Ministry of National Education updated curricula across the board with new sets of educational approaches. The 2005 Mathematics curriculum was designed around student-centred teaching approaches, promoted active student participation, and aimed to develop students' mathematical reasoning and problem-solving skills (Sezer et al., 2012). Turkey's Ministry of National Education continued to apply adjustments to the mathematics curriculum in 2006, 2009, 2015, 2017, and 2018 (Baş, 2017; İlhan & Aslaner, 2019; Milli Eğitim Bakanlığı [Turkish Ministry of National Education], 2018a) with the aim of increasing the effectiveness of mathematics education in Turkey. Finally, Turkey's *Education Vision for 2023* was announced in 2018 to declare the country's educational goals for the coming 5 years for all stakeholders in Turkey's educational system (Milli Eğitim Bakanlığı [Turkish Ministry of National Education], 2018b).

Like many European countries, the results of the 2009 PISA exam created a shockwave that triggered an appetite for positive change in the Republic of Ireland. In 2011, the Irish Department of Education and Skills introduced significant changes to mathematics education, and created a new *National Literacy and Numeracy Strategy* (Department of Education & Skills, 2011) in response to Irish students' decreasing reading literacy and mathematics scores in the PISA exam (Clerkin, 2017; Perkins et al., 2012). The strategy was developed around six key components: (1) empowering communities and families on supporting students to develop literacy and numeracy skills; (2) enhancing teachers' and practitioners' professional practices; (3) developing the abilities of school leaders; (4) advancing curriculum effectiveness; (5) supporting low-achieving students on reaching higher performances; and (5) improving the assessment and evaluation process so as to increase students' literacy and numeracy (Department of Education and Skills, 2011). The Irish Department of Education and Skills investigated and reviewed the effect of these critical amendments on the Irish educational system and proposed greater emphasis on raising awareness regarding students' literacy and numeracy skills, taking action to further support parents on helping students, and renewed efforts on strengthening the collaboration between educational stakeholder groups with the aim being to increase students' literacy and numeracy (Department of Education and Skills, 2017).

As Addey et al. (2017) noted, impactful curriculum changes mostly stem from national political pressures, and that this in turn triggers a desire for countries to enhance their students' achievement in international standardised exams. Similarly, both Turkey and the Republic of Ireland implemented widespread educational changes and introduced various adjustments to their mathematics curricula in order to improve their students' mathematics achievement scores. Since then, the results from the past three TIMSS exams has indicated that both Turkish and Irish students' mathematics achievement has consistently increased (Milli Eğitim Bakanlığı [Turkish Ministry of National Education], 2020; Perkins & Clerkin, 2020). With the Turkish Minister for Education's declaration of the importance of Turkish students' achievement in international standardised exams and the Ministry's goal of Turkey becoming among the top 10 countries (Selçuk, 2020), it has become imperative to explore ways to improve Turkish students' mathematics achievement scores in standardised international exams. With this perspective in mind, the researcher aimed to create this comparative study of Turkish and Irish mathematics curricula in order to investigate some of the curricula-related differences, to identify potential factors that could positively affect Turkish students' mathematics achievement levels going forwards.

Method

Fourth-grade Turkish students' TIMSS mathematics achievement results have increased at a consistent rate, and in the 2019 TIMSS exam they scored 523 and therefore above the TIMSS mid-scale point of 500. For the purpose of supporting this momentum, this qualitative study was initiated to provide valuable information regarding the similarities and differences between the Turkish mathematics curriculum and that of the Republic of Ireland. More specifically, the current study aims to provide a comparative exploration of learning goals included in the first to fourth-grade Turkish and Irish mathematics curricula, with its focus on the following research questions:

- What is the distribution of learning goals for Turkish and Irish mathematics curricula from the first to fourth grades in terms of the TIMMS mathematics cognitive domains?
- What can be revealed from the learning goal differences in terms of the first to fourth grade Turkish and Irish mathematics curricula content?

Data gathering

For this study, the researcher aimed to compare the Turkish mathematics curriculum with that of another country. Fourth-grade Irish students' mathematics achievement results from the two most recent TIMSS exams exceeded 540 points, and the similarity between the general structure (e.g., learning goals strand units) of the Turkish and Irish mathematics curricula were the two main criteria for having selected the Republic of Ireland as a comparative benchmark for the current study. Information about TIMSS results, the definition of the TIMSS mathematics cognitive domains, and Turkish and Irish curricula were directly gathered from official websites of the respective countries and organisations.

Turkish mathematics curriculum

The mathematics curriculum in Turkey provides information about the aims and general perspectives of mathematics education in modern-day Turkey. It also addresses the connection between individual learning and educational curricula, defines desired assessment and the evaluation process for teaching, describes the general competencies that students should acquire, and showcases descriptive information according to learning strands and learning goals. The structure of the mathematics curriculum in Turkey is designed around 229 learning goals (first to fourth grades) and four learning strands: (1) numbers and algebra; (2) shapes and space; (3) measure; and (4) data. Moreover, 10 core values that students should develop through education are identified as fairness, friendship, integrity, self-control, patience, respect, love, responsibility, patriotism, and benevolence (Milli Eğitim Bakanlığı [Turkish Ministry of National Education], 2018a).

Irish mathematics curriculum

The Irish mathematics curriculum defines some of the key concepts of mathematics teaching through the aims and objectives of mathematics teaching, highlighting the use of constructivist teaching activities and mathematical skills, and in discussing the use of mathematical equipment. The structure of the Irish mathematics curriculum is developed around 271 learning goals (first to fourth grades) and five learning strands, which are (1) number; (2) algebra; (3) shape and space; (4) measure; and (5) data. Moreover, the curriculum also identifies mathematical skills that students should develop as applying and problem-solving, communicating and expressing, integrating and connecting, reasoning, implementing, and understanding and recalling (National Council for Curriculum and Assessment, 1999).

Data analysis

This qualitative research was designed around the descriptive and content analysis methods as the means for investigating the learning goals within the Turkish and Irish mathematics curricula. For this purpose, the TIMSS' mathematics cognitive domains were utilised as a theoretical framework to explore and classify a list of 500 learning goals from the first to fourth grades of both curricula. Appendix A presents the verbatim definitions of the TIMSS' mathematics cognitive domains (Lindquist et al., 2019).

During the first phase of the study's qualitative analysis, the learning strands and goals of the Turkish and Irish mathematics curricula were descriptively analysed in order to represent their general structure. In the second analytical phase, the learning goals were independently analysed by two experts according to the TIMSS' mathematics cognitive domains. Then, the independent results of the content analyses were compared using Miles and Huberman's (1994) formula [Number of the agreements / (number of the agreements + disagreements) x 100] to calculate the inter-rater reliability level between the two experts, which was established as being .87. The experts then worked together to explore and discuss any areas of disagreement regarding the learning goals in order to reach a 100% unified agreement on the learning goals' classification. In the final phase of the qualitative analysis, the content of the learning goals from both curricula were analysed comparatively.

During the content analysis it became clear that many of the learning goals were constructed with multiple educational objectives; thus, some of the learning goals could have been classified with more than one cognitive domain. For instance, the learning goal of '*The child should be able to explain and interpret the information shown in shape and real-object graphs, and to transform the graphical information to tally and frequency tables'* was constructed around multiple educational objectives. While being able to read and interpret data showcased in a graph would be classified as an educational objective under the *knowing* domain, being able to transform knowledge into equal representations would be classified under the *applying* domain. In such cases, the experts chose to classify the learning goals according to the appropriate hierarchical order by choosing the cognitive domain where it showcases a higher level of cognitive skill.

Findings

The findings of this research were constructed via qualitative exploration of the Turkish and Irish mathematics curricula. While the structures of both curricula were described according to the learning strands and goals, the TIMSS' cognitive domains were utilised in order to comparatively present the content of the learning goals. Table 1 presents the general distribution of the learning goals according to the learning strands.

As Table 1 indicates, the distribution of learning goals according to learning strands in the Turkish mathematics curriculum was n = 114 (49.8%) for numbers and algebra, n = 36 (15.7%) for shape and space, n = 70 (30.6%) for measure, and n = 9 (3.9%) for data, while the distribution of learning goals in the Irish mathematics curriculum was n = 113 (41.7%)

Table 1: Distribution of learning goals according to learning strands

Learning strands	Turkish	Irish
Numbers and algebra*	114 (49.8%)	113 (41.7%)
Shape and space	36 (15.7%)	59 (21.8%)
Measure	70 (30.6%)	82 (30.2%)
Data	9 (3.9%)	17 (6.3%)
Total	229 (100%)	271 (100%)

* Numbers and algebra learning strands were combined in both curricula

for numbers and algebra, *n* = 59 (21.8%) for shape and space, *n* = 82 (30.2%) for measure, and *n* = 17 (6.3%) for data. Moreover, the Irish mathematics curriculum has 42 more learning goals in total than the Turkish mathematics curriculum. When the percentage distributions of both curricula were explored, it became clear that a higher percentage of the Turkish mathematics curriculum was devoted to the numbers and algebra learning strand than in the Irish mathematics curriculum. On the other hand, in the Irish mathematics curriculum, a higher percentage of learning goals were found to be dedicated to the shape and space and data learning strands. The percentage distribution of the learning goals for the measure learning strand were shown to be very similar for both curricula.

Table 2: Distribution of learning goals according to grade

Learning strands	Turkish				Irish			
	Grade 1	Grade 2	Grade 3	Grade 4	Grade 1	Grade 2	Grade 3	Grade 4
Numbers & algebra*	19 (52.8%)	25 (50.0%)	36 (50.0%)	34 (47.9%)	24 (43.6%)	23 (38.3%)	30 (41.7%)	36 (42.9%)
Shape & space	6 (16.6%)	8 (16.0%)	10 (13.9%)	12 (16.9%)	11 (20.0%)	13 (21.7%)	17 (23.6%)	18 (21.4%)
Measure	10 (27.8%)	16 (32.0%)	23 (31.9%)	21 (29.6%)	18 (32.7%)	21 (35.0%)	19 (26.4%)	24 (28.9%)
Data	1 (2.8%)	1 (2.0%)	3 (4.2%)	4 (5.6%)	2 (3.6%)	3 (5.0%)	6 (8.3%)	6 (7.1%)
Totals	36 (100%)	50 (100%)	72 (100%)	71 (100%)	55 (100%)	60 (100%)	72 (100%)	84 (100%)
% of Grade 1-4 goals	15.7%	21.9%	31.4%	31.0%	20.3%	22.1%	26.6%	31.0%

* Numbers and algebra learning strands were combined in both curricula

As can be seen from Table 2, the distribution of learning goals according to grade in the Turkish mathematics curriculum was *n* = 36 (15.7%) for the first grade, *n* = 50 (21.9%) for the second grade, *n* = 72 (31.4%) for the third grade, and *n* = 71 (31.0%) for the fourth grade, while the distribution of learning goals in the Irish mathematics curriculum for the first to fourth grades were *n* = 55 (20.3%), *n* = 60 (22.1%), *n* = 72 (26.6%), and *n* = 84 (31.0%), respectively. The Irish mathematics curricula had higher numbers of learning goals for the first (*n* = 55) and fourth (*n* = 84) grades, whilst the numbers of learning goals for the second and third grades were similar across both curricula. As Table 3 indicates, the percentage distributions of the learning strands for the first to fourth grades were found to be similar in both the Turkish and Irish mathematics curricula.

Table 3: Classification of TIMSS cognitive domains according to learning strands

TIMSS cognitive domains	Turkish	Irish
Knowing	145 (62.3%)	162 (59.8%)
Applying	56 (24.5%)	72 (26.6%)
Reasoning	28 (12.2%)	37 (13.6%)
Total	229 (100%)	271 (100%)

According to Table 3, the learning goal classification according to the TIMSS cognitive domains in the Turkish mathematics curriculum resulted in *n* = 145 (62.3%) under the knowing domain, *n* = 56 (24.5%) under applying, and *n* = 28 (12.2%) under the reasoning domain, whilst the classification of learning goals in the Irish mathematics curriculum placed *n* = 162 (59.8%) under the knowing domain, *n* = 72 (26.6%) under applying, and *n* = 37 (13.6%) under the reasoning domain. Although the percentage distributions of TIMSS cognitive domains were seen to be similar for both curricula, it could be said that while the Turkish mathematics curriculum devotes a higher percentage of learning goals to the knowing cognitive domain, the Irish mathematics curriculum dedicated has a higher percentage of learning goals to the applying and reasoning cognitive domains.

Table 4: Classification of TIMSS cognitive domains according to grade

Cognitive domain	Turkish				Irish			
	Grade 1	Grade 2	Grade 3	Grade 4	Grade 1	Grade 2	Grade 3	Grade 4
Knowing	28 (77.8%)	30 (60.0%)	45 (62.5%)	42 (59.1%)	37 (67.3%)	40 (66.7%)	38 (52.8%)	47 (56.0%)
Applying	3 (8.3%)	14 (28.0%)	18 (25.0%)	21 (29.6%)	11 (20.0%)	11 (18.3%)	24 (33.3%)	26 (30.9%)
Reasoning	5 (13.9%)	6 (12.0%)	9 (12.5%)	8 (11.3%)	7 (12.7%)	9 (15.0%)	10 (13.9%)	11 (13.1%)
Total	36 (100%)	50 (100%)	72 (100%)	71 (100%)	55 (100%)	60 (100%)	72 (100%)	84 (100%)

When the classification of the TIMSS cognitive domain was explored as depicted in Table 4, it could be clearly seen that the distribution of the cognitive domains according to grade were mostly homogenous. The knowing domain constituted approximately 60% to 77% of learning goals for each grade in the Turkish mathematics curricula, whilst in the Irish mathematics curricula comprised approximately 52% to 67% for each grade. Distribution for the applying domain was heterogeneous in the Turkish mathematics curriculum for each grade since only 8.3% of first-grade learning goals were in the applying domain, whilst distribution of the same domain across the other three grades were between approximately 25% to 30%. For the Irish mathematics curricula, the distribution for the applying domain was 20% for the first and second grades, and around 30% for the third and fourth grades. Distribution for the reasoning domain learning goals was seen to be similar for both mathematics curricula, and varied from 11% to 15% in the first to fourth grades.

Table 5: Classification of TIMSS cognitive domains according to learning strands

TIMSS cognitive domains	Turkish				Irish			
	Numbers & algebra	Shape & space	Measure	Data	Numbers & algebra*	Shape & space	Measure	Data
Knowing	80 (70.2%)	21 (58.4%)	41 (58.6%)	3 (33.3%)	62 (54.9%)	31 (52.5%)	60 (73.2%)	9 (53.0%)
Applying	19 (16.7%)	12 (33.3%)	19 (27.1%)	6 (66.7%)	28 (24.8%)	21 (35.6%)	19 (23.2%)	4 (23.5%)
Reasoning	15 (13.1%)	3 (8.3%)	10 (14.3%)	0 (0.0%)	23 (20.3%)	7 (11.9%)	3 (3.6%)	4 (23.5%)
Total	114 (100%)	36 (100%)	70 (100%)	9 (100%)	113 (100%)	59 (100%)	82 (100%)	17 (100%)

* Numbers and algebra learning strands were combined in both curricula

As indicated in Table 5, when the distribution of the TIMSS cognitive domains for learning strands was explored, it became clear that the numbers and algebra, shape and space, and measure learning strands were constructed mostly around the knowing dimension, ranging from 52.54% to 70.18% for both country's mathematics curricula. Only the data learning strand from the Turkish mathematics curriculum had a higher percentage of learning goals for the applying domain than the knowing domain. Moreover, very limited numbers of learning goals were classified under the reasoning domain for the shape and space learning strands (n = 3, 8.33%) in the Turkish mathematics curriculum and the measure strands (n = 3, 3.66%) in the Irish mathematics curriculum. Surprisingly, the data learning strand the Turkish mathematics curriculum did not have any learning goals in the reasoning domain.

When the content of the Turkish and Irish mathematics curricula were explored, it became apparent that they were each composed of very similar learning goals for each learning strand, since the fundamental knowledge about each learning strand such as numbers and algebra, shape and space, measure, and data is universally similar. For instance, both of the curricula aimed to teach students to use numbers to order, completing additions with and without a remaining value, exploring and understanding reasoning behind arithmetic operations, and calculating fractions. As can also be seen in Table 6, both curricula are composed of learning goals with a focus on using vocabulary related to spatial relations, completing the missing half of a symmetrical shape, and exploring the features of 3-D shapes. In the measuring data strand, both the Turkish and Irish mathematics curricula incorporated knowledge of making transformations between

Table 6: Examples of similarities between Turkish and Irish learning goals

	Turkish	Irish
Numbers and algebra	Uses numbers up to and including 20 to indicate the order.	The child should be enabled to use the language of ordinal number, first to tenth.
	It performs the addition with and without remaining up to 100.	The child should be enabled to add numbers without and with renaming within 99.
	Explains that multiplication means repeated addition.	The child should be enabled to develop an understanding of multiplication as repeated addition and vice versa.
	Determines a specified simple fraction of a given quantity (started with models, then students can do the calculations).	The child should be enabled to calculate a fraction of a set using concrete materials
Shape and space	Expresses vocabulary of spatial relations (situation, place, direction).	The child should be enabled to explore, discuss, develop and use the vocabulary of spatial relations.
	Completes a given part of a symmetrical figure according to the vertical or horizontal symmetry line.	The child should be enabled to use understanding of line symmetry to complete missing half of a shape, picture or pattern (4th grade).
	Recognises and distinguishes cube, cylinder, sphere, square, rectangular, and triangular prisms on models.	The child should be enabled to describe, compare and name 3-D shapes, including cube, cuboid, cylinder, sphere, and cone.
Measure	Explains the relationship between ton-kilogram, kilogram-gram, gram-milligram, and makes transformations between these units.	The child should be enabled to rename units of weight in kg and g.
	Selects a suitable non-standard measuring tool to measure a length and makes a measurement.	The child should be enabled to estimate, compare, measure, and record length using non-standard units.
	Reads and shows hours, half-hours, and quarter-hours.	The child should be enabled to read time in hours, half-hours, and quarter-hours on a 12-hour analogue clock.
Data	Interprets and makes conversions from graph to tally and frequency tables by explaining the information shown in the figure and object graphs.	The child should be enabled to collect, organise and represent data using pictograms, block graphs and bar charts.
	Solves problems that require addition and subtraction by using the information given in the graphs or by creating graphs.	The child should be enabled to use datasets to solve and complete practical tasks and problems.
	Examines and makes comments and predictions on a bar-line graph.	The child should be enabled to read and interpret bar-line graphs and simple pie charts.

various measuring units, utilising non-standard measuring tools, and successfully reading the time. Both curricula also shared similarities in data learning strands since they aimed to teach students how to transform information between tables and graphs, solve problems by gathering information from tables and graphs, and to interpret and comment on data that stems from tables and graphs.

Table 7: Examples of differences between Turkish and Irish learning goals

	Turkish	Irish
Numbers and algebra	Determines and writes the number of objects in a collection of up to 20 objects.	The child should be enabled to estimate the number of objects in a set 0-20.
	Solves problems that require division with whole numbers.	The child should be enabled to solve and complete practical tasks and problems involving division of whole numbers.
	Not identified.	The child should be enabled to order decimals on the number line identify the number with the greatest value.
Shape and space	Recognises line, ray, and angle.	The child should be enabled to recognise an angle in terms of a rotation.
	Explains the relationship between perimeter and side lengths of a square and rectangle.	The child should be enabled to understand, estimate, and measure the perimeter of regular 2-D shapes.
Measure	Solves problems with kilograms and grams.	The child should be enabled to solve and complete practical tasks and problems involving the addition and subtraction of units of weight.
	Specifies where millimetres are used, as one of the standard units of measurement.	The child should be enabled to rename units of length using decimal or fraction form.
Data	Not identified.	The child should be able to use vocabulary of uncertainty and chance: chance, likely, unlikely, never, definitely.

Although the fundamental understanding around the learning strands were shown to be similar for both countries' mathematics curricula, their approach to the numbers and algebra, shape and space, measure, and data learning strands varied. For example, in the numbers and algebra learning strands the Turkish mathematics curriculum requires students to count numbers of objects up to 20, whilst the Irish mathematics curriculum expects students to display higher cognitive skills by estimating the numbers of objects up to 20. In another example, the Turkish mathematics curriculum promotes solving division-related problems, whilst the Irish mathematics curriculum additionally connects division-related problem-solving skills with practical tasks. As Table 7 indicates, while the

Turkish mathematics curriculum focused on the recognition of concepts concerning shapes and spaces such as lines and angles, some of the learning goals in the Irish mathematics curriculum focused on the creation of such concepts.

In another example, while the learning goals in the Irish mathematics curriculum were concerned with the estimation and calculation of the perimeter of a shape, the learning goals in the Turkish mathematics curriculum additionally encouraged students to explore the relationship between perimeter and sides of a shape. It was seen that while the learning goals in the Turkish mathematics curriculum focused solely on knowing and using measuring units, the Irish mathematics curriculum also connects the measuring learning strands with the topics of fractions and decimals. Moreover, while both mathematics curricula aimed to connect ability and knowledge of measuring with problem solving, the Irish mathematics curriculum additionally aimed at connecting these learning strands with practical tasks that students might encounter in their daily lives.

Finally, while the majority of the learning goals in the data learning strand were found to be similar and were concerned with transformation, acquisition, and representation of the data, the Irish mathematics curriculum also included learning goals that focused on the use of vocabulary to describe uncertainty. Additionally, the topics concerning decimal numbers did not address the use of language for the subject of probability and was not connected to the data learning strand in the first four grades of Turkish mathematics curricula, unlike the mathematics curricula of the Republic of Ireland.

Discussion

Although the cognitive domain target percentages for the TIMSS exams are not official regulations for either Turkey or Ireland, they are seen as important factors to be considered whilst creating mathematics curricula, since both countries acknowledge TIMSS as an affective international exam and opt to participate regularly. The findings of the current study indicated that the learning goals of both the Turkish and Irish mathematics curricula have similar distributions around the TIMSS cognitive domains of knowing, applying, and reasoning, while both curricula were found to have somewhat homogenous distributions within grade levels. However, the percentage distribution of the TIMMS exam is different as it devoted 40% to the cognitive domain of knowing, 40% to applying, and 20% to reasoning (Milli Eğitim Bakanlığı [Turkish Ministry of National Education], 2020). It is clear that both countries' curricula devoted more than the necessary numbers of learning goals to the knowing cognitive domain, whilst placing less emphasis on both the applying and reasoning domains. Although the learning goal distributions across the cognitive domains were mostly homogenous within the grades and learning strands for both curricula, it was startling that the first-grade mathematics curriculum in Turkey has only 8.3% of its learning goals within the applying domain, and none in the reasoning domain for the data learning strand.

Defining limited numbers of learning goals under the applying cognitive domain in the first-grade mathematics curriculum could pose significant problems for the teaching of mathematics, since first-grade students might not encounter the appropriate level of opportunity to implement much of the abstract mathematical knowledge that they are targeted to acquire at their grade. Time constraints to implementing the applying and reasoning levels of learning goals might be why curriculum developers decided to limit the numbers of these cognitively more challenging learning goals, because (for example) calculating two-fifths of a number takes up far less time than attempting to create two-fifths of an item using concrete materials. However, when the first to fourth-grade students' limited ability on abstract thinking (Kandemir, 2015) is considered, the need becomes clear to transform some of the knowing domain learning goals to the applying domain, when curriculum developers in Turkey and Ireland create mathematics curricula or changes to the existing curricula in the future.

Moreover, curriculum developers in Turkey should place a greater emphasis on increasing the percentage of learning goals in the applying domain for first graders, whilst adding to the level of reasoning domain learning goals such as in the data learning strands in order to create a more cognitively homogenous mathematics curriculum. Consideration of student-centred and problem-based learning approaches whilst designing curricula might also help curriculum developers and instructors to create greater opportunities for students to apply and develop their mathematical reasoning skills (Laurens et al., 2017; Merritt et al., 2017).

The findings of the current study also revealed that the learning goals of both the Turkish and Irish mathematics curricula have similar distributions around the learning strands of numbers and algebra, shape and space, measure, and data. However, the percentage distributions of the TIMSS learning strands were found to differ for the measure and data strands since the TIMSS exams devote 50% of learning goals to the numbers and algebra learning strands, whilst 30% is dedicated to the measure and shape and space learning strands, and 20% to the data learning strand (Milli Eğitim Bakanlığı [Turkish Ministry of National Education], 2020). The high level of emphasis on the data learning strand in the TIMSS exams may be caused by the nature of the exam itself; however, when the amount of topics that embedded the measure and shape and space learning strands are considered, the distribution of learning goals in both the Turkish and Irish mathematics curricula become more apparent. Since the mathematical information that students should acquire are defined globally, it is understandable that both the Turkish and Irish mathematics curricula have similar, or in some cases identical, learning goals (Johansson & Hansen, 2018). However, some of the nuances in the learning goals might be one of the reasons behind the higher levels of Irish students' achievement in the TIMSS exams. For example, the learning goal, '*The child should be able to translate an addition or subtraction number sentence with a frame into a word problem*' in the Irish mathematics curriculum is clearly aimed at supporting students to establish connections between number sentences and word problems, whilst there is no specific learning goal in the Turkish mathematics curriculum created solely for this purpose.

While the learning goals in the Turkish mathematics curriculum attempt to draw connections between measurement and problem solving, the Irish mathematics curriculum pushes this notion further by also connecting these concepts with situations in daily life. The greater emphasis on improving students' numeracy skills under the Irish educational reforms (Department of Education and Skills, 2011) can be clearly observed in the learning goals included in the Irish mathematics curriculum. Therefore curriculum developers in Turkey could consider a greater level of integration of the students' numeracy skills in prospective Turkish mathematics curricula, in order to help strengthen the connections made through the application of mathematical knowledge in daily life situations. Moreover, both countries' mathematics curricula include learning goals that concern the gathering, categorisation, and presentation of data, while the Irish mathematics curriculum furthers these abilities by connecting them to the vocabulary of uncertainties. TIMSS learning strands integrate the vocabulary of chance or uncertainty to the data learning strand at the eighth grade (Milli Eğitim Bakanlığı [Turkish Ministry of National Education], 2020); thus, to enhance connections between the fourth-grade and eighth-grade mathematics curricula, curriculum developers in Turkey should add learning goals that address the vocabulary of chance in data learning strands, just as seen in the Irish mathematics curriculum. Overall, placing greater emphasis on creating learning goals that help students to establish connections between various mathematical concepts and daily life could be considered as a means to enhancing the effectiveness of prospective Turkish mathematics curricula.

Recent studies in Turkey have highlighted elementary school teachers' time-based struggles in teaching the required mathematical curriculum content and have reflected upon the teachers' suggestions regarding decreasing the number of learning goals in the Turkish mathematics curriculum (Cil & Sefer, 2021; Karakoç, 2019; Turan & Tabak, 2021). The descriptive investigation of Turkish and Irish curricula in the current study revealed that the Irish mathematics curriculum contains a higher number of learning goals than in the Turkish mathematics curriculum, and especially in the first and fourth grades. When the higher numbers of learning goals in the Irish curriculum and the greater success in the TIMSS exams by students from Ireland are considered, it becomes imperative to ascertain serving teachers' opinions on simplifying the current Turkish mathematics curriculum. Thus, educators, researchers, and policymakers should increase their discussion and exploration of factors that influence the effectiveness of in-class teaching activities, rather than simply and superficially suggesting a decrease in the numbers of learning goals in the Turkish mathematics curriculum (Gür et al., 2012). Moreover, the Turkish Ministry of National Education could take additional steps by generating an educational ebvironment for elementary school teachers in order to profoundly investigate and discuss the current Turkish mathematics curriculum. This would enable elementary school teachers to have more opportunities to generate in-depth solutions to effectively teach mathematical concepts, rather than simply suggesting a broad simplification of the current mathematics curriculum.

Although the primary purpose of the current study is not the exploration of the structural composition of curricula learning goals, during the study's qualitative analysis it became clear that both the Turkish and Irish mathematics curricula were composed of intensive and complex learning goals. For instance, the learning goal, *"Child should be able to estimate, compare, measure, and record length using non-standard units'* in the Irish mathematics curriculum requires educators to prepare and implement lessons that focus on four different educational abilities regarding measurement, in a single learning goal. When Demirel's (2015) suggestions regarding creating measurable and observable learning goals that only focus on one educational gain at a time are considered, the complexity of such learning goals becomes readily apparent. Similarly, in the Turkish mathematics curriculum, all of the learning goals that were focused on problem solving also had a sub-learning goal focused on problem posing. For example, the learning goal, '*Students should solve problems that require completing addition. Problem-posing activities should also be included',* guides educators to prepare lesson plans that focus upon teaching both how to solve and create addition-related problems.

When the vast differences between mathematical information and the skills required to solve or create mathematical problems are considered (English, 2001), it becomes clear that the merging of problem-solving and problem-posing mathematical abilities into one single learning goal might in fact skew the implementation process, by focusing more upon one ability than another. Moreover, since problem-posing ability is considered more cognitively demanding and comprehensive than problem-solving ability (Çıldır & Sezen, 2011), defining problem-posing ability as a sub-learning goal of problem solving could decrease the effectiveness of the educational process designed around these learning goals. The implementation of such intensive learning goals might unnecessarily complicate the learning process, and educators might therefore ineffectively allocate educational time between multiple educational gains such as estimation, measurement, and/or problem solving. Thus, curriculum development experts should place the greater emphasis on creating comprehensible learning goals that focus on one educational gain, at the expense of increasing numbers of learning goals in the curriculum, in order that prospective Turkish and Irish mathematics curricula may become more applicable.

Conclusion

The current study provides a comparative perspective by examining the TIMSS' cognitive domains within the Turkish and Irish mathematics curricula in order to identify some of the key differences that might lay behind consistently high international mathematics achievement scores for Ireland's students (Martin et al., 2020; Milli Eğitim Bakanlığı [Turkish Ministry of National Education], 2016), while purposely avoiding previously explored topics such as gender, socioeconomic status, technology integration, and test books (Cheema & Sheridan, 2015; Chirkina et al., 2020; Mejía-Rodríguez et al., 2021; Mersin & Karabörk, 2021). Additionally, Turkish and Irish science curricula could be analysed comparatively according to the TIMSS' mathematics cognitive domains in order to showcase similarities and differences between the two curricula, and to provide suggestions for potential improvements.

Further studies could be designed to separately explore and analyse Turkish and Irish mathematics curricula according to the TIMSS' mathematics cognitive subdomains such as recognise, retrieve, determine and justify, to present a more detailed cognitive distribution of learning goals in the Turkish and Irish mathematics curricula. Moreover, the current investigation of the learning goals in each curricula triggered the researcher's interest on the complexity of the learning goals in each curriculum. Thus, further studies could focus on unnecessarily dense and complex learning goals that include more than three educational aims, or where they require the teaching of more than one high-level cognitive skill, and to explore the effects of these learning goals on teachers' in-class practices. The investigation of such research topics could provide valuable information and a stable direction for curriculum development processes in the future for both Turkey and Ireland.

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Appendix A: TIMMS mathematics cognitive domains

Knowing	Recall definitions, terminology, number properties, units of measurement, geometric properties, and notation (e.g., a × b = ab, a + a + a = 3a).
	Recognise numbers, expressions, quantities, and shapes. Recognise entities that are mathematically equivalent (e.g., equivalent familiar fractions, decimals, and percentages; different orientations of simple geometric figures).
	Classify numbers, expressions, quantities, and shapes by common properties.
	Carry out algorithmic procedures for +, –, ×, ÷, or a combination of these with whole numbers, fractions, decimals, and integers. Carry out straightforward algebraic procedures.
	Retrieve information from graphs, tables, texts, or other sources.
	Use measuring instruments; and choose appropriate units of measurement.
Applying	Determine efficient/appropriate operations, strategies, and tools for solving problems for which there are commonly used methods of solution.
	Display data in tables or graphs; create equations, inequalities, geometric figures, or diagrams that model problem situations; and generate equivalent representations for a given mathematical entity or relationship.
	Implement strategies and operations to solve problems involving familiar mathematical concepts and procedures.
Reasoning	Determine, describe, or use relationships among numbers, expressions, quantities, and shapes.
	Link different elements of knowledge, related representations, and procedures to solve problems.
	Evaluate alternative problem-solving strategies and solutions.
	Make valid inferences on the basis of information and evidence.
	Make statements that represent relationships in more general and more widely applicable terms.
	Provide mathematical arguments to support a strategy or solution.

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