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The Effect of Cognitive Development Programme (Turkish Maths / Math Modules) on the Development of Mathematics Skills of Primary School Students

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Abstract. This study was conducted to determine the effects of the Turkish Maths (Math Modules) cognitive development programme based on the PASS Theory on the mathematics skills of first grade students. In the study, unequal groups pretest-posttest experimental design, one of the quasi-experimental designs, was used. The study group consisted of 39 typically developing students attending 1st grade. The measurement tools to determine the effectiveness were the calculation performance test (De Vos, 1992; Olkun et al., 2013) and the number sense test for kindergarten and primary school students (Palabıyık & Tertemiz, 2021) developed for the first grade. To ensure social validity, semi-structured interviews were conducted with the class teacher of the experimental group and 9 parents. The quantitative data obtained were analysed manually through SPSS 27.00 package programme, and the social validity data were analysed manually through content analysis. As a result of the intervention; according to the Mann-Whitney U test results of the experimental group students and the control group students; it was determined that there was a significant difference between the scores obtained from the calculation performance test (U=99.00, p= .015 <.05) and the number sense test (U=20.50, p= .001 <.05). According to the social validity findings, each interviewee stated that the programme was beneficial for the children and the differences were observable. In line with the quantitative results and social validity findings, it is thought that the Turkish Maths (Math Modules) cognitive development programme is effective on first grade students in improving their mathematics skills.

Keywords. The PASS theory, Turkish Maths, Math Modules, mathematics skills, quasi-experimental design.

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Basic literacy and numeracy skills are the two most important outcomes that primary school children are expected to acquire. The foundations of both outcomes should be built from the preschool period onwards. As a matter of fact, it is seen that the researches conducted in the context of educational periods for the development of mathematics skills are first addressed in early childhood (Baroody, 2003; Byrnes & Wasik, 2009; Claessens & Engel, 2013; Clements, 2004; Clements & Sarama, 2007, 2009, 2011; Ginsburg & Amit, 2008; Lehrl et al., 2016; Pagani et al., 2004; Wang, 2010).

The majority of early childhood studies on the acquisition of mathematical skills aim to investigate whether there is a significant relationship between children's preschool education and their mathematics performance at that time and their mathematics achievement in later years. To give an example of these studies; in Claessens and Engel's (2013) study, students' mathematics achievement was followed from kindergarten to eighth grade. As a result of the longitudinal study, it was determined that mathematics skills acquired in the early period explained literacy, science and mathematics achievement; in addition, it predicted grade repetition in the whole process. In a longitudinal study conducted by Bachman and colleagues (2015), they tried to determine the effectiveness of the factors that are associated with students' mathematics achievement in preschool, first grade and third grade. The effects of three groups of factors, namely socioeconomic status, pre-existing mathematical disposition, and frequency of applying mathematics content, on mathematics skills were examined. As a result of the study, it was found that these three factors significantly predicted the mathematics achievement that could be reached in the following years. The mathematical disposition of the child was found to be the strongest determinant of mathematics achievement. Lehrl and other researchers (2016) determined the results with the latent linear growth model and found that basic mathematics skills in primary school starting from the first grade can be predicted by mathematics skills in early childhood and socioeconomic status of the family. In his thesis study, Guhl (2019) blended the literature on the subject and his own experiences and emphasised that early mathematics education strongly affects academic achievement in later years, especially mathematics performance. As a result, it is possible to say that all formal or non-formal training on the development of mathematics skills in the preschool period will be beneficial for mathematics achievement at different levels depending on the background of the student in the later stages of education.

When the studies dealing with mathematics skills in primary school period are examined, studies in which the effects of different variables on mathematics achievement are tried to be

determined draw attention. For example, in the study conducted by Memisevic and other researchers (2018) on mathematics achievement in primary school, students between the first and third grades were evaluated in terms of different characteristics. As a result of the study, it was found that visual functions-motor processor coordination, inhibitory control, selective attention and verbal fluency explained 70% of the variance in mathematics achievement. Another element that draws attention in the research on the primary school period is the need to be very careful in the curricula to be developed for mathematics skills. In their study, Agodini and Harris (2010) found that the effectiveness of different mathematics education curricula applied in the primary school period may produce different results regarding the development of mathematics skills. In some curriculum studies, it was observed that relatively less formal procedures were followed for mathematics skills in the preschool period, and it was emphasised that mathematics education should be carried out in a more planned and action-oriented manner in subjects and areas with defined boundaries in the primary school period (Griffin, 1997, 1998, 2000; Griffin & Case, 1995; Hook et al., 2007; Yee, 2010). When the international literature is analysed in the context of this view, it can be said that laying the foundation of mathematical skills such as correctly perceiving the concept of number, making estimations and measurements, making comparisons about magnitudes, establishing visual-spatial relationships, adding and subtracting, collecting and interpreting data, and solving problems in the first grade of primary school is critical for the development of students (Charles et al., 2005; Fuson, 2006; Larson, 2004; Memisevic et al., 2018; Russell et al., 2006). It is possible to categorise these skills under the umbrella concept of "basic mathematical skills". Again, "number sense" and "calculation performance" skills have a large share in mathematics skills. Due to their mutually supporting structures, it would be an appropriate approach to ensure the development of these two important skills together in mathematics education and to evaluate them holistically.

Number sense is the ability to understand and use numbers and to perceive number-related relationships. This concept is considered as the foundation of mathematical thinking and problem solving skills. Number sense helps children to interact with the number world and this interaction plays a critical role during their developmental processes (Jordan et al., 2006). The importance of number sense in primary school period has a multidimensional structure (Olkun, 2012). Firstly, number sense in children forms the foundations of mathematical concepts. Understanding numbers and number relationships at an early age prepares the ground for children to learn more complex mathematical operations. For example, children can learn basic operations such as addition and subtraction more easily by understanding the relationships between numbers (Clements, 2001). In

addition, number sense improves problem solving skills. Children have the opportunity to develop logic by using concepts related to numbers and quantities while solving problems they encounter in real life. This strengthens their analytical thinking skills and contributes to the development of mathematical thinking (Fuson, 2012). In a similar context, number sense enables individuals to better understand the mathematical situations they encounter in daily life. Situations such as shopping and calculating time are practical examples that develop number sense and reinforce children's real life skills (McIntosh et al., 2005). In addition, number sense increases children's self-confidence. Children with high number sense have more self-confidence when performing maths-related tasks. This self-confidence also positively affects their general academic achievement. Experiences gained through games and activities with manipulating numbers in educational processes increase children's self-confidence in this area (Gersten et al., 2005).

Calculation performance refers to the ability of individuals to perform mathematical operations quickly and accurately. For primary school children, this ability is an important factor that affects not only their approach to mathematics but also their overall academic success (Sarı & Ekici, 2018). Children who build a strong foundation in mathematics do not have difficulty in learning more complex concepts in the following years (Mix et al., 2016). Improving calculation performance at primary school age also improves children's ability to understand mathematical concepts. Geary (2011) stated that the implementation of training to improve calculation performance from an early period is very effective in improving children's mathematical skills. Improving calculation performance also has positive effects on children's social and emotional development. Children who are successful in mathematics gain self-confidence by gaining mathematical flexibility and are motivated by the feeling of competing with their peers (Newton et al., 2020). In addition, this situation creates an encouraging factor for children to reach their academic goals. As can be seen, the development of number sense and calculation performance skills during primary school is the basis for mathematics education. This has a high impact on the development of mathematical skills in the short term and overall academic achievement in the long term.

The aim of this study is to investigate the effects of the Cognitive Development Programme (Turkish Maths) on the calculation performance and number sense development of typically developing first grade students who have difficulty in acquiring mathematics skills. The study is considered important in terms of testing the hypothesis that calculation performance and number sense can be improved through cognitive skills training for primary school students and introducing an effective intervention programme to Türkiye.

The research questions of the research designed in the context of this purpose are as follows:

1. Does the cognitive development programme (Turkish Maths) have an effect on developing number sense in typically developing first grade students?

2. Does the cognitive development programme (Turkish Maths) have an effect on improving calculation performance of typically developing first grade students?

Method

In this section, the research model, participants, data collection process and tools, data analysis, validity and reliability of the research will be explained.

Research Model

In this study, unequal groups pretest-posttest experimental design was used. In this design, a group besides the experimental group is determined for comparison or control purposes. Then, measurements of the subjects in the two groups are taken about the dependent variable before the application. In the application process, the experimental procedure, the effect of which is tested, is applied to the experimental group but not to the control group. Finally, after the experimental procedure, the measurements of both groups regarding the dependent variable are taken with the same or parallel form. The design is preferred in cases where random distribution of subjects is not always possible (Thyer, 2012). Due to this feature, the design is widely used in educational research. The only difference of this design from the pretest-posttest control group model from real experimental designs is the lack of random distribution of groups (Büyüköztürk et al., 2017; Creswell, 2017).

Study Group

The study group of the research consists of typically developing children attending the 1st grade in a primary school affiliated to the Ministry of National Education in Manisa. Volunteer students from two different classes were included in the study. While the students in one class were allocated for the experimental group, the other class was determined as the control group. In this determination, the class in which the majority of parents allowed the students to receive the intervention programme and the ability to continue participation in this programme outside of school were effective. Again, the following criteria were sought in order to determine the students to be included in the experimental group:

1. To be able to read and write without help.
2. To be able to count rhythmically one forward from 1 to 10.
3. To have scored below 70 per cent in the calculation performance test and number sense test.
4. Attending school classes only; not receiving mathematics lessons from any person or institution other than the intervention programme.

Table 1.

Descriptive Statistics of the Participants

Typically Developing 1st Grade Student Groups (n=39)		
Group	**n**	**%**
Experimental Group	16	41
Control Group	23	59

Data Collection Process and Tools

Table 2.

Experimental Design Used in the Study

Group	**Pre-Test**	**Operation**	**Final Test**
Experimental Group	O_1	X	O_3
Control Group	O_2		O_4

Before starting the study, the researchers obtained research permission from the Rectorate of Dokuz Eylül University with the ethics committee decision specified in the official letter dated 02/05/2024 and numbered E-87347630-659-979824. Volunteer students from two different 1st grade classes in a primary school affiliated to the Ministry of National Education were identified and the whole process was carried out out of school. Calculation performance and number sense tests were administered to both groups of students as pretests. Since there was no significant difference between the groups as a result of the two pre-tests, the experimental group was selected from the class in which the majority of the students whose parents allowed the intervention. After the experimental group was determined, the first two modules of the intervention programme were implemented. The implementation was carried out by dividing the experimental group consisting of

16 students into two groups of 8 students each (Experiment-A and Experiment-B) and each group received 3 lesson hours per week (1 lesson lecture, 1 lesson group practice, 1 lesson one-to-one practice). After the intervention, post-tests were applied to the experimental and control groups. The opinions of the class teachers and parents of the students in the experimental groups were obtained regarding the intervention.

Table 3.

Procedure of the Research Process

Duration	**Operation**	**Test and Modules**	**Method and Duration of Application**
2 weeks	Implementation of pre-tests	Computational performance test	All Groups Individual- 1 min.
		Number sense test	Individual- 30-40 min.
7 weeks (7x6 class hours = 42 sessions)	Turkish Maths (Math Modules) Cognitive Development Programme	Module 1: Changing Patterns Module 2: Let's Learn the Number Line	Weekly Programme (Experiments A and B - Total 6 sessions) Lesson 1: Lecture Lesson 2: Group Practice Lesson 3: Practising One-on-One
2 weeks	Application of post-tests	Computational performance test	All Groups Individual- 1 min.
		Number sense test	Individual- 30-40 min.

Cognitive Development Programme (Turkish Maths/ Math Modules)

One of the cognitive intervention programmes to improve mathematics skills is the Turkish Maths (Math Modules) (Das, 2014) cognitive development programme. Turkish Maths, which is an intervention programme focused on developing cognitive skills in the field of mathematics, which forms the basis for short-term memory, long-term memory, inner speech, mathematics skills and academic learning, aims to help children learn to interpret, remember, manipulate and use information. Turkish Maths, the theoretical basis of which is the PASS Theory, focuses on the development of the

PASS processes of (P)lanning-, (A)ttention, arousal, (S)imultaneous processing and (S)uccessive processing skills throughout the education (Das et al., 1994). This programme has five modules on the themes of magnitude and value, number line, multiplicity (counting), verbal and non-verbal simultaneity, and working memory, and the modules are delivered through group instruction. It can be applied to children from preschool period. In addition to children who have been diagnosed with learning disabilities or who are at risk of being diagnosed with learning disabilities, children who have difficulty in acquiring mathematical skills for any reason or who have mild developmental delay can also benefit from this programme. Although there are international studies showing the effect of the PASS theory on mathematical skills (Cai et al., 2024; Deaño et al., 2023; Kroesbergen et al., 2010; Naglieri & Gottling, 1995; Warrick, 1989) in the literature, there is no research directly related to the effectiveness of the Turkish Maths (Math Modules) cognitive development programme in Türkiye.

Measurement Tools for Determining the Effectiveness of Cognitive Development Programme

Calculation Performance Test

Computational performance involves analysing procedural fluency in the context of speed. Procedural fluency is one of the most important predictors of mathematics achievement (Van de Walle et al., 2014). The primary school period has been emphasised as a 'critical period' in the transition from concrete representation of numbers to the formation of cognitive schemas and in the development of computational fluency (Jordan & Hanich, 2003). In this context, the level of calculation performance serves as an important criterion in determining the ability to learn mathematics.

The calculation performance test is a test developed by De Vos (1992) and adapted into Turkish by Olkun and colleagues (2013), consisting of arithmetic operations (addition, subtraction, multiplication and division) with different weighted questions for each grade level in primary school. In the test adapted for first graders, there are 20 addition operations. It is expected to solve these 20 addition operations correctly in one minute. Olkun and other researchers (2013) found the KR-20 reliability coefficients of the test, which they applied as timed and untimed, as .95 and .98.

Number Sense Tests for Kindergarten and Primary School Students

Number sense is the ability to make logical predictions about mathematical operations and numbers and to use them flexibly. In their study, Palabıyık and Tertemiz (2021) worked with kindergarten, 1st grade, 2nd grade, 3rd grade, and 4th grade students, separately for each level for preschool and primary school students, and developed five tests in total. The questions prepared in the

scales were based on the elements used to determine number sense in the literature and the achievements of each grade in the curriculum of the Ministry of National Education. In the 1st grade level number sense test, there are a total of 23 (twenty-three) questions from the areas of number line, problems requiring addition or subtraction, numerosity, money problems, visual perception, non-standard units of length measurement and non-standard units of weight measurement. The application time of the test is flexible according to the individual. The KR-20 value of the variation of the test prepared for the 1st grade is 0.878.

Measurement Tools for Determining the Social Validity of the Study

Semi-structured Interview Form for Parents to Evaluate the Effectiveness of Cognitive Development Programme

This form was prepared by the researchers in order to obtain the opinions of the parents of the children participating in the study about the intervention programme and the effect of the programme on the children in order to ensure the social validity of the study. After this form was prepared, it was sent to 3 researchers who are experts in the subject area. After the feedback from the experts, necessary corrections were made and the form was finalised. This form includes 4 open-ended questions. This form was applied to the parents at the end of the study through one-to-one interviews.

Semi-structured Interview Form for Classroom Teacher to Evaluate the Effectiveness of Cognitive Development Programme

This form was prepared by the researchers in order to obtain the opinions of the children participating in the study about the classroom teacher's intervention programme and the effects of the programme on children in order to ensure the social validity of the study. After the form was prepared, it was sent to three field experts for expert opinion. There are 4 open-ended questions in this form. After their evaluations, the form was finalised. At the end of the study, this form was applied to the classroom teacher through one-to-one interviews.

Analysing the Data

The quantitative data obtained from the study were analysed using SPSS 27.00 package programme.

Regarding the normality distribution for calculation performance in the experimental and control groups, it was determined that the data were not normally distributed by looking at the histogram curve results and skewness -.094, kurtosis -1.253 and Shapiro-Wilk Test p= .025<.05.

Regarding the normality distribution for the number sense test in the experimental and control groups, it was determined that the data were not normally distributed by looking at the histogram curve results and skewness .814 kurtosis .763 values and Shapiro Wilk Test p= .021<.05 results.

Apart from this, nonparametric analysis was preferred due to the small number of participants and the unequal number of participants in the groups.

Results

Comparative Pretest Results of Calculation Performance and Number Sense of Experimental and Control Groups Before Intervention

The Mann-Whitney U test results of the scores obtained from the calculation performance test by the experimental group students who will participate in the intervention and the control group students who will not participate in the intervention among the 1st grade students with typical development before the start of the intervention are given in Table 4. Accordingly, there was no significant difference between the scores of the experimental and control group students on the calculation performance test before the intervention (U=128.00, p<.05).

Table 4.

Mann Whitney- U Pretest Result of Number Sense

Group	**N**	**Rank Mean**	**Row Total**	**U**	**p**
Experiment	16	23.50	376.00	128.000	.109
Control	23	17.57	404.00		

(U=128.00, p<.05)

The Mann-Whitney U test results of the scores obtained from the calculation performance test by the experimental group students who will participate in the intervention and the control group students who will not participate in the intervention among the 1st grade students with typical development before the start of the intervention are given in Table 5 Accordingly, there was no significant difference between the scores of the experimental and control group students on the number sense test before the intervention (U=178.00, p<.05).

Development of Experimental Group Students Before and After the Experiment

The results of the Wilcoxon signed-rank test regarding whether there was a significant difference between the pre- and post-experiment calculation performances of the 1st grade experimental group students with typical development are given in Table 6. The results of the analysis show that there is a significant difference between the pre- and post-experiment scores of the children who participated in the intervention programme in the calculation performance test ($Z=2.48$, $p<.05$). When the rank sums of the difference scores are considered, it is seen that this difference is in favour of positive ranks, that is, the post-test score. In line with these results, it can be said that Turkish Maths cognitive development programme has a significant effect on improving calculation performance.

Table 6.

Wilcoxon Signed-Ranks Test Results of Calculation Performance Test Scores Before and After the Experiment (Experimental Group)

Pre Test - Post Test	**N**	**Rank Mean**	**Row Total**	**Z**	**p**
Negative Sequence	3	2.50	7.50	2.48	.013
Positive Sequence	9	7.83	70.50		
Equal	4				

*Based on negative ranks

Group	**N**	**Rank Mean**	**Row Total**	**U**	**p**
Experiment	16	20.38	376.00	178.000	.863
Control	23	19.74	404.00		

(U=178.00, *p*<.05)

The results of the Wilcoxon signed-rank test regarding whether there was a significant difference in the number sense development of the 1st grade experimental group students with typical development before and after the experiment are given in Table 7. The results of the analysis show that there is a significant difference between the pre- and post-experimental number sense test scores of the children who participated in the intervention programme ($Z=3.51$, $p<.05$). When the rank sums of the difference scores are considered, it is seen that this difference is in favour of positive ranks, that is, the post-test score. In line with these results, it can be said that Turkish Maths cognitive development programme has a significant effect on developing number sense.

Table 7.

Wilcoxon Signed Ranks Test Results of Number Sense Test Scores Before and After the Experiment (Experimental Group)

Pre Test - Post Test	N	Rank Mean	Row Total	Z	p
Negative Sequence	0	.00	.00	3.51	.001
Positive Sequence	16	8.50	136.00		
Equal	0				

*Based on negative ranks

Control Group Students' Development Independent of the Experiment

The results of the Wilcoxon signed-rank test regarding whether there was a significant difference between the pre- and post-experiment calculation performances of the 1st grade control group students with typical development are given in Table 8. The results of the analysis show that there is no significant difference between the pre- and post-experimental scores of the children who did not participate in the intervention programme in the calculation performance test ($Z=1.73$, $p<.05$). According to this result, it can be said that there was no significant improvement in the calculation performance of the students who continued general education in the 7-week period.

Table 8.

Wilcoxon Signed-Ranks Test Results of Calculation Performance Test Scores Independent of Experiment (Control Group)

Pre Test - Post Test	**N**	**Rank Mean**	**Row Total**	**Z**	**p**
Negative Sequence	8	9.19	73.50	1.73	.082
Positive Sequence	14	12.82	129.50		
Equal	1				

*Based on negative ranks

The results of the Wilcoxon signed-rank test regarding whether there was a significant difference in the number sense development of the 1st grade control group students with typical development before and after the experiment are given in Table 9. The results of the analysis show that there is no significant difference between the pre- and post-experimental number sense test scores of the children who did not participate in the intervention programme ($Z=.76$, $p<.05$). According to this result, it can be said that there was no significant progress in the number sense development of the students who continued general education in the 7-week period.

Table 9.

Wilcoxon Signed-Ranks Test Results of Number Sense Test Scores Independent of Experiment (Control Group)

Pre Test - Post Test	N	Rank Mean	Row Total	Z	p
Negative Sequence	11	12.77	140.50	.76	.939
Positive Sequence	12	11.29	135.50		
Equal	0				

*Based on negative ranks

Comparative Posttest Results of Calculation Performance and Number Sense of the Experimental and Control Groups After the Intervention

The Mann-Whitney U test results of the scores obtained from the calculation performance test by the experimental group students who participated in the intervention and the control group students who did not participate in the intervention among the 1st grade students with typical development after the intervention are given in Table 10. After the intervention, it was determined that there was a significant difference between the scores obtained by the experimental and control group students from the calculation performance test (U=99.00, p<.05). Accordingly, it is understood that the students who participated in the Turkish Maths cognitive development programme after the intervention had higher calculation performance than the students who did not participate in the programme. This finding indicates that the Turkish Maths cognitive development programme was effective in improving calculation performance of typically developing first grade students.

Table 10.

Mann-Whitney U Posttest Result of Calculation Performance

Group	N	Rank Mean	Row Total	U	p
Experiment	16	25.31	405.00	99.000	.015
Control	23	16.30	375.00		

(U=99.00, *p*<.05)

The Mann-Whitney U test results of the scores obtained from the number sense test by the experimental group students who participated in the intervention and the control group students who did not participate in the intervention among the 1st grade students with typical development after the intervention are given in Table 11. After the intervention, it was determined that there was a significant difference between the number sense test scores of the experimental and control group students (U=20.50, p<.05). Accordingly, it is understood that the number sense of the students who

participated in the Turkish Maths cognitive development programme after the intervention was higher than the students who did not participate in the programme. This finding indicates that the Turkish Maths cognitive development programme was effective in increasing number sense in typically developing first grade students.

Table 11.

Mann-Whitney U Posttest Results of Number Sense

Group	**N**	**Rank Mean**	**Row Total**	**U**	**p**
Experiment	16	30.22	483.50	20.500	.001
Control	23	12.89	296.50		

(U=20.50, p<.05)

Findings Related to the Social Validity of the Intervention Programme

The opinions of the classroom teacher and volunteer parents regarding the intervention programme were evaluated as positive and negative, and themes were formed through manual content analysis. Table 12 shows the themes that emerged based on parents' opinions and the ratios of positive and negative opinions.

Table 12.

Parents' Views on the Programme

	Positive		**Negative**		**Total**	
Themes	**f**	**%**	**f**	**%**	**f**	**%**
Children's Comments on the Programme	9	100	0	0	9	100
Changes Observed in Children	9	100	0	0	9	100
Reflections of the Programme on Parents	9	100	0	0	9	100
Impressions on the Programme from a Parent's Perspective	9	100	0	0	9	100

It was observed that all of the 9 parents who agreed to be interviewed presented positive opinions. In the theme of children's comments on the programme, the parents expressed their opinions with the following statements*: "Most of the time when my child came home, he eagerly told me 'we had a lesson with our teacher ..... today, we learned this and that', the activities he did at school are still on my child's lips, he wishes we had lessons like this every day, my daughter came home one day and said that addition and subtraction were actually very easy, when I asked her how she understood*

this, she showed me the exercises she did in the programme." In the theme of changes observed in children, they stated their opinions with *the following statements: "My daughter, who said that she did not understand and disliked mathematics lessons before, started to do her mathematics homework, my child could never do addition and subtraction without fingers, now he can calculate very easily mentally, my son now sees himself very successful in mathematics; he says 'I am a master of mathematics'. He says 'I am a maths master' "*. In the theme of the reflections of the programme on the parents, they stated that *"It was torture to get my child to do his mathematics homework, but since he participated in this programme, this problem is over. I noticed that my child grasped mathematics subjects very quickly after participating in this programme; in the past, he/she would not understand the same subject until his/her teacher taught the same subject for a week.*" In the theme of impressions of the programme from the perspective of the parent, the following statement was made*: "Since my child has progressed in mathematics with this programme, I think she has a good foundation; I feel comfortable about this. I always followed the exercises brought by my daughter, and even from there, I saw that this programme was very different from the education in the classroom or the education in our time. I think that the lessons were very beneficial for my child because he/she learned mathematics easily and with love.*"

The themes that emerged depending on the opinions of the class teacher of the experimental group and the ratios of positive and negative opinions are shown in Table 13.

Table 13.

Classroom Teacher's Opinions on the Programme

	Positive		**Negative**		**Total**	
Themes	**f**	**%**	**f**	**%**	**f**	**%**
Students' Comments on the Programme	1	100	0	0	1	100
Changes Observed in Students	1	100	0	0	1	100
Reflections of the Programme on Teachers	1	100	0	0	1	100
Impressions on the Programme from the Teacher's Perspective	1	100	0	0	1	100

It was observed that the classroom teacher expressed positive opinions in all themes. In the theme of students' comments on the programme, the class teacher of the experimental group stated her opinion as follows*: "My students look forward to the mathematics lessons that are taught differently every week, they ask if we have a lesson with our teacher ..... today, and when I ask them*

what they learned when they return from the lesson, they excitedly tell me about the activities they did." In the theme of changes observed in the students, *"With the programme, children's fear and boredom of mathematics disappeared. The view of "I can do this" for the mathematics lesson dominated the class. We are progressing quite fast in mathematics this term. Children come to the lesson already learnt"*. In the theme of the reflections of the curriculum on the teacher, he said, *"Children have already gained many acquisitions with this curriculum. As a result, I did not have much burden in the mathematics lesson in the classroom. We can teach mathematics lessons faster and more enjoyable."* In the theme of impressions about the programme from the teacher's point of view, *"I think this programme is very useful for children. From the first weeks, the change started to be visible. Children learnt many subjects such as counting to 100, the concept of big-small, rhythmic addition and subtraction, number line, measurements. I saw in their problem solutions that they were able to understand the subjects to be seen in higher grades beyond the curriculum. I understand from the children's expressions and exercise papers that this programme has a different functioning. I would like to receive such a training in terms of my professional development.*"

Discussion and Conclusion

Basic literacy and numeracy skills are two important skills that need to be established and developed from the preschool period onwards. The basic condition for the child to be able to leave the family and school fanus is to have acquired these two skills and to be able to transfer these skills to daily life without help. For this reason, it is very important to make efforts to acquire, develop and monitor these skills from an early age (Nelson at al., 2016; Pomalato et al., 2021). In this context, the acquisition of mathematics skills should be started from the preschool period. However, the level of preschool education in Türkiye has not reached the desired level despite the introduction of compulsory education in the 5-year-old age group. This result is influenced by factors such as the low rate of starting preschool education in early childhood (Aktan & Akkutay, 2014; Kıldan, 2010), economic inadequacies and regional opportunity inequalities that seem difficult to solve (Aydın et al., 2018; Ekici & Ekici, 2024).

The fact that access to pre-school education in Türkiye is still not at the desired level interrupts and delays the development of mathematical skills. Again, significant differences were found between the levels of school maturity in children starting primary school depending on the level of pre-school education (Cinkılıç, 2009); this situation also led to differences between the development levels of mathematical skills. For this reason, the readiness levels related to mathematics skills in

children who start first grade within the scope of compulsory education should be determined urgently and necessary interventions should be applied to children.

In this study, the effects of the Turkish Maths (Math Modules) cognitive development programme on the basic mathematics skills of first grade primary school students were examined. The findings show that the cognitive development programme made significant contributions to the development of mathematical skills in terms of calculation performance and number sense and to the strengthening of cognitive structures. The similarity of the baseline levels of the experimental and control groups before the study constituted a basic requirement for the reliability of the intervention effect, and the comparison analyses confirmed this similarity. The results obtained after the intervention revealed that significant improvements were observed especially in the areas of calculation performance and number sense. On the other hand, no significant difference was observed in the development of calculation performance and number sense on the basis of pre-test and post-tests in the control group students who continued general education. Based on these results, it is possible to say that the intervention programme can make significant contributions to overcome the learning deficiencies arising from the functioning of general education.

Mathematical education and the development of cognitive structures in early childhood and the first years of primary school positively affect children's mathematics achievement in the long term (Bodovski & Farkas, 2007; Claessens & Engel, 2013; Guhl, 2019). The findings of this study, in line with the studies in the literature, clearly demonstrate that the intervention programme supports cognitive processes and strengthens the foundation of mathematical concepts. Regarding calculation performance, Cowan and colleagues (2011), in their study with second and third grade students, found that improvement in basic calculation fluency contributed to cognitive and conceptual progress and may be partially related to mathematics achievement. The improvements observed in calculation speed and accuracy in this study indicate that mathematics modules structured on the basis of PASS theory systematically support cognitive processes such as inner speech, attention, planning and processing (Das et al., 1994). Moreover, gains in number sense are important for the development of mathematical thinking and problem solving skills (Yang et al., 2008), as understanding and using the concept of number correctly is a fundamental building block in mathematics education (Griffin, 2004; Olkun, 2012).

The results of the study were also supported by the positive opinions and observations of the stakeholders during the implementation process of the programme. Both parents and the classroom

teacher reported that children's interest and self-confidence in mathematics lessons increased, their anxiety about mathematics decreased and their motivation to learn increased. This shows that the programme is effective not only in cognitive but also in psychosocial aspects. In addition, the acceptance of the programme by different stakeholders in educational practices is an important indicator for sustainability and dissemination. However, the study has some limitations. For example, the limited sample size and the preferably short duration of the study in order to prevent the maturation effect limit the generalisability of the results. In addition, only short-term effects were examined, and the permanent effects of the programme and its effects on students with different characteristics should also be investigated. At this point, long-term follow-up studies and studies with samples with different demographic characteristics will make important contributions to the literature. In addition, a detailed examination of the effects of the programme on other cognitive and emotional development areas will pave the way for the development of holistic educational approaches.

Since this study was designed on the effectiveness of the cognitive development programme called 'Math Modules in English' developed by Prof. Dr. J. P. Das, the only comparable study is the intervention effectiveness study conducted by Deaño and other researchers (2023). In this study, the mathematics modules of the cognitive development programme were applied to 2nd grade students with typical development. The effect of the cognitive development programme on the cognitive processes of calculation, problem solving and PASS theory cognitive processes to provide mathematical norms was examined. It was observed that there was a significant difference in favour of the experimental group in these three areas. The fact that the results of these two studies, one conducted in Spain and the other in Türkiye, are compatible with each other reveals that the Math Modules cognitive development programme based on PASS theory is a valid and reliable intervention tool in the international arena.

Recommendations

The following suggestions are presented for future research on the subject:

- In order to increase the generalisability of the cognitive development programme, larger and thematic studies should be conducted. In the studies, adaptations suitable for different learning needs should be developed by taking into account the samples of students from different regions, school types and socioeconomic levels.

- In order to determine the lasting effects of the programme and its relationship with long-term academic achievement, monitoring studies should be carried out for at least 1-2 years after implementation, thus evaluating the sustainability and effectiveness of the intervention.
- While examining the effectiveness of the programme, it should not only be limited to the development of mathematical structures, but also holistic development should be supported by examining the emotional and motivational state related to mathematics.
- For the sustainability and effectiveness of the programme, support, guidance and feedback mechanisms should be established for the training of teachers and parents, thus strengthening the cooperation between teachers and families.

As a result, this study supported that cognitive development-oriented intervention programmes are one of the cornerstones of early mathematics education and that children's mathematics skills and self-confidence can be increased with appropriate content and methods applied especially in preschool and primary school period. In this direction, education programmes to be developed and disseminated will provide permanent and meaningful gains in both academic and cognitive development.

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Conflict of Interest

It has been reported by the authors that there is no conflict of interest.

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Ethical Standards

For this research, research permission was obtained with the decision of the ethics committee stated in the official letter of Dokuz Eylül University Presidency dated 02/05/2024 and numbered E-87347630-659-979824. Since the child participants were primary school students, parental permission documents were obtained from their parents. Voluntary participation consent was obtained from the adult participants.

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