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The effect of using mind maps on the development of maths and science skills

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Abstract

The aim of this study is to examine the effect of mind mapping activities on the maths and science skills of children 48 to 60 months of age. The study was designed using an experimental model with a pre-test post-test and a control group. Accordingly, the hypotheses of the study was that there would be meaningful differences in the values obtained from the pre-test and post-test scores in favor of the children working with mind maps compared to the ones who did not work with mind maps. In the examination of the development of mind maps, it was observed that as the children engaged in preparing mind maps, they used skills requiring high-level mind organization. Mind maps, which can be used in all areas of life, are believed to be supportive of children's development areas and to be an important strategy for children to adopt and experience during the time of childhood.

Keywords: mind maps, maths skills, science skills.

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1. Introduction

Children of the Information Age should be equipped with basic math and science knowledge and skills and know how to access new information. Reconstruction of knowledge plays a key role in learning new information in a meaningful and permanent way. During this process of reconstruction, creativity, memory development, and the use of multiple senses and basic cognitive skills within the area of maths and sciences are elements that can be effectively used for an individual's capacity development. Young children are capable of acquiring everyday maths skills in a surprisingly fast and comprehensive manner (Ginsburg, Lee & Boyd, 2008). It is well-established that children between the ages of 1 and 3 generally learn maths using their bodies (Franzen, 2015). While a good pre-school education has been shown to increase the capacity of a child's ability to learn arithmetic and maths (Melhuish, Quinn, Sylva, Sammons, Siraj-Blatchford & Taggart, 2013), nursery school has been demonstrated to affect the development of maths skills in nursery school-aged children (48 to 60 months old), and education received prior to attending nursery school (36 to 48 months) has been reported to better enhance the development of maths skills (Skibbe, Hindman, Connor, Housey & Morrison, 2013).

The maths skills that are dealt with in the maths skills development of pre-school children are classification, matching, comparing, and ordering (Aktas-Arnas, 2012; Unal, 2014). Numbers and counting, calculation (operation), geometry and spatial thinking, measurement and graphics (data processing), pattern and function, and problem solving through deductive reasoning are sub-skills of the general body of maths skills (Aktas-Arnas, 2012; Ginsburg, Lee & Boyd, 2008; Haylock & Cockburn, 2014; Klein, Starkey, Clements, Sarama & Iyer, 2008; Unal, 2014; Yılmaz, 2014). It is believed that maths skills will develop in children by exposing them to mathematical thinking and introducing them to the use of mathematical language (Dunphy, 2014). At the close of the National Maths Counseling Panel, which was held in the USA in 2008, it was concluded that the maths skills of children receiving pre-school education could be empowered by integrating maths concepts into other activities of education programs (Austin, Knabe & Lokteff, 2013). Furthermore, in the report produced by the Ireland National Council for Curriculum and Assessment, it was stated that games, art and physical activities, and story reading activities had a significant role in the development of maths skills in pre-school children (Dooley, 2014). Games and teacher-student interaction have also been shown to contribute to the development of mathematical thinking, which is a part of the development of maths skills (Trawick-Smith, Swaminathan & Liu, 2015). Projects, environmental planning, and new or package programs can be added to these activities (Ginsburg, Lee & Boyd, 2008).

Pre-school children have the capacity to acquire maths and science skills and are naturally curious (Piasta, Pelatti & Miller, 2014). The common aim of the science programs prepared for pre-school children is to help them acquire scientific literacy (Yurt, 2014). It is important for the children of this age group to learn by doing in terms of the development of scientific skills. Paying attention, asking questions, wondering, observing, doing research, examining, exploring, collecting data, and searching for answers are the main activities to be carried out in this process (Uyanık-Balat, 2011; Yurt, 2014). Providing activities appropriate to the developmental features of children as a way to enhance their sense experience is critical (Armga, Dillon, Jamseg, Morgan, Peyton & Speranza, 2002). These activities should support such skills as predicting, observing, analyzing, classifying, comparing, interpreting findings, communicating, and using simple science tools (Armga, Dillon, Jamseg, Morgan, Peyton & Speranza, 2002; Kinzie, Whittaker, Williford, DeCoster, McGuire & Kilday, 2014).

There are various methods and programs available to teachers to facilitate math and science skills in pre-school children (Piasta, Pelatti & Miller, 2014). Included among these programs are "Let's Count" , "Let's Think", "Big Maths for Little Kids" , "The Number Worlds" , "Building Blocks", "The Pre-K Maths Curriculum", "Storytelling Sagas" , "High Scope-Number Plus (Maths education program for young children)" (Aunio, Hautamaki & Van Luit, 2005; Ginsburg, Lee & Boyd, 2008; Perry & MacDonald, 2015; Presser, Clements, Ginsburg & Ertle, 2015) "Science Start!" , "Scientific Literacy Project" , "Wings of Discovery", and "Tool Kit for Early Childhood Science Education" (Alabay, 2011;

Mantzicopoulos, Patrick & Samarapungavan, 2008; Peterson, 2009), all of which aim to develop science skills. Examples of the programs that support the development of both science and maths skills are “Preschool Pathways to Science” and “My Teaching Partner” (Gelman & Brenneman, 2004; Kinzie et al., 2014). Maths, science, and scientific thinking and language skills are the main critical success factors of children's education lives and have long-term effects (Anders & Rossbach, 2015; Mantzicopoulos, Samarapungavan & Patrick, 2009). It is important that teachers consider the individual characteristics of children and apply various methods to better enable children to learn. Developed by Tony Buzan, mind maps are an important tool for the support of learning, memorizing, and creativity in individuals (Buzan & Buzan, 2015). Mind mapping is a method that relates imagination with structure and pictures through reason, and it is a tool that is able to increase success in education and provide individuals a meaningful encounter with maths and the change process (Brinkmann, 2003b).

In mind maps, the target theme is presented as a picture drawn in the middle, with branches extending out from this picture. The main themes branch out from the picture, with sub-themes branching off from the main themes. A key word or picture is used in each branching. Mind maps always feature branches that spread out from an image positioned in the centre. Each word or image functions as a secondary centre of association and proceeds in an endless chain of relationships that branch off from the centre or extend out to a mutual centre (Buzan & Buzan, 2015). Mind mapping is a strong, unique method for stimulating all the different functions of the brain into action (words, imagination, numbers, reason, rhythm, pictures, lists, details, colours, and spatial awareness) (Buzan & Buzan, 2015; Buzan, Dottino & Israel, 2012). As a visual and graphical integrative thinking approach, mind mapping is an appropriate technique for exercising different brain functions, including memory, creativity, and learning (Buzan & Buzan, 2015). Many components, such as attention, coordination, reason and identifying reasons, thinking, analyzing, creativity, imagination, memory, planning and implementing skills, reading, numbers, letters, visualization, hearing, motion sense, and feelings, are all related to each other simultaneously in mind maps (Wen-Cheng, Chung-Chieh & Ying-Chien, 2010).

All of the words and pictures associated with one mind map can potentially serve as the centre of another mind map and thereby lead to new associations. These new associations are developed through each new word and picture, and many variations will be added. Mind maps are based on associations rather than on time. They capture all angles of an idea and extend out in every direction. By adding more pictures and building second-, third-, and fourth-level idea steps, connection points, codes and schemes, the mind mapper completes the association network, demonstrating the eternity of the creative nature of brain associations (Buzan & Buzan, 2015).

A mind map (Buzan, Dottino & Israel, 2012);

- Can give a short summary of a large theme or problem
- Enables strategic planning
- Shows a primary position and the direction to which it leads
- Shows the connections and summarizes large amounts of data in one page
- Encourages imagination and problem solving by exploring creative courses
- Enables the mind to be active
- Is a fun way to prepare, examine, read, think about, and remember

The rules governing mind maps aim to boost rather than to limit mental freedom. These rules are specified by Buzan and Buzan (2015) and are shown below in the mind map prepared by the researchers.

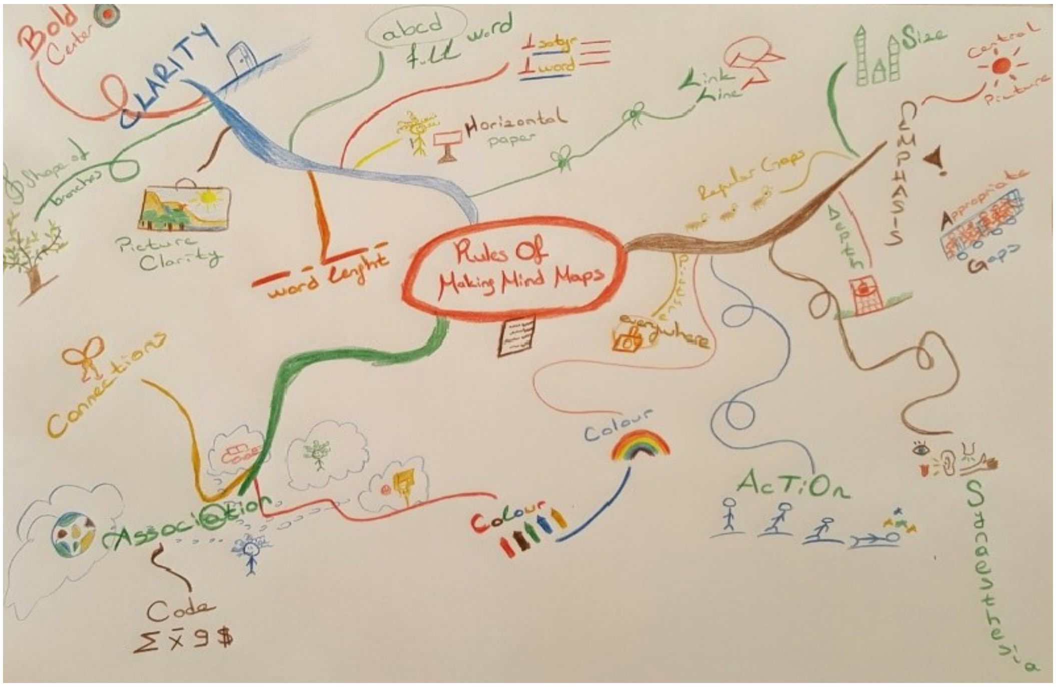

Figure 1.Rules for Making Mind Maps

- When preparing a mind map, place a blank white sheet of paper in front of you and use color pencils to draw a main theme in the centre of the sheet. Take 15-20 minutes in total to create your map. The first-level branches spreading out from the main theme at the centre are your ideas. Proceed clockwise when drawing the branches of your map, as this will help to stimulate your brain to produce new ideas. Prepare the sub-themes by drawing and relating them to the first-level branches. Second-level branches will be followed by relationships between third and fourth-level branches and connections among sub-themes (Buzan & Buzan, 2015; Buzan, Dottino & Israel, 2012; Buzan, 2011).

Mind maps can be used by everyone in every area of life and can be prepared individually or by groups (Buzan & Buzan, 2015). When young children are first learning this fun system of thinking, they will need support and modeling. Howitt (2009) supports the idea of creating three-dimensional maps, accompanied with realia, as opposed to two-dimensional maps, as the preferred method of studying with mind maps in the early childhood period. In researcher-led mind map implementations done with children it has been observed that when children between the ages of 48 and 60 months watched the creation of a mind map and were informed about the reason behind the mind map, they were able to learn how to do it. If they are given support as needed in their first try, it will be easy and fun for them to create their own mind maps. The contributions to cognitive development that the preparation of mind maps provides to individuals have been stated above. Given these contributions, it is believed that the preparation of mind maps, which is a unique method, with pre-school children will affect their development in a positive way. In this sense, the aim of this study is to examine the effect of mind mapping activities on the maths and science skills of children 48 to 60 months of age. The questions formulated for the study are as follows:

- Do the maths and science skills' pre-test scores of children in the experiment and control group differ?

- Do the maths and science skills' post-test scores of children in the experiment and control groups differ?
- Is there a difference between the maths and science skills' pre-test and post-test scores of children in the control group?
- How are the mind maps created by the children in the experiment group distributed for each theme by scoring levels?
- What are the total scores obtained by levels and distribution frequency of level branches in the mind maps created by children in the experiment group?

2. Method

This study, which has aimed to examine the effect of mind mapping activities on the maths and science skills of children, was designed using a mixed method, involving qualitative and quantitative screening. In the first part of the study, the pre-test and post-test design for the control group was also planned. Accordingly, the hypothesis of the study was that there would be a meaningful difference, in favor of the children who worked with mind maps, between the values obtained from the pre-test and post-test scores of children who worked with mind maps and of children who did not work with mind maps. The study group of the research included a total of 30 children, 15 of whom were placed in the control group and 15 of whom were placed in the experiment group, who attended different classrooms in the nursery school of a primary school. Class teachers of the experiment and control groups participated in the research-developed pre-school curriculum and implemented the same course using the same activities in order to control for the pre-school curricula that could possibly affect the children's maths and science skills development apart from using mind maps.

Themes of the mind maps used in the study were determined by the researchers, and five field experts were consulted. After the expert views were obtained, the themes were identified as "water, clothes, food, toys and dinosaurs". In the beginning phase, the implementer created a mind map themed "school", together with the children, in order to teach them how to make a mind map. At this phase, the implementer guided the children on what, why and how they did and described the details of creating a mind map. Following this phase, the real implementation phase was commenced, where children were responsible for creating their own mind maps. The implementer helped the children only during the writing part, in which children were to write on their mind maps what the picture they drew was.The maths and science skills' sub-scales of the Application Form of the Marmara Primary School Readiness Test developed by Polat Unutkan (2003) were administered to both groups. The mind map study carried out with the experiment group lasted 10 weeks in total. During the application, the children in the control group were asked to draw pictures only. At the end of the process, the maths and science skills' sub-scales of the Application Form of the Marmara Primary School Readiness Test were administered as post-test.

The part in which children created mind maps was designed using a quantitative method, and for the scoring of the mind maps created by the children, the mind map evaluation system developed by Evrekli, Inel and Balim (2010) was used as a model for the researchers to create their own mind maps evaluation system for use on the pre-school children. While the mind map evaluation system for pre-school children was being developed, the mind maps that the children created for the "water" and "clothes" themes were coded by two separate reviewers. The coding was evaluated using a relevant statistics program, which showed the cohesion co-efficiency between the reviewers to be .93. Accordingly, the mind map evaluation system for pre-school children was found to be a valid and reliable evaluation system for use in this study. In this evaluation system, the children's mind maps were examined according to first level sub-branches, second-level sub-branches, third-level sub-branches, and fourth-level sub-branches, and to establishing cross correlation, exemplifying, and establishing relationship. Scores were calculated following this evaluation.

2.1. Data Collection Tools

Research data were collected via the Marmara Primary School Readiness Scale developed by Polat Unutkan (2003) and the mind maps created by the children. The Marmara Primary School Readiness Scale developed by Polat Unutkan (2003) is composed of two separate forms: the development form and the application form. In this study, the Maths and Science Skills sub-scales of the application form were used. Factor analysis was performed as part of the validity study and the tool and factor structure was examined. The internal coherence co-efficients (Cronbach's alpha) calculated for Maths Skills and Science Skills were ($r = .96$, $p<.01$) and ($r = .86$, $p<.01$), respectively (Unutkan, 2003).

2.2. Creation of Mind Maps and Mind Map Evaluation System for Pre-school Children:

In the mind map themed "school", which was created together with the children at the beginning phase, the theme was drawn in the centre of the sheet, and the children were provided help visually and verbally. Each object, action, and suchlike which evoked "school" were placed around this drawing in the shape of small pictures or symbols with different colours. For each main branch (First-level sub-branches), second-level sub-branches related to this main branch were created using the same colored lines. Third- and fourth-level sub-branches were created in a similar manner. By using statements such as "................. and .... are related to each other", a line with a different color was drawn from the main branches that were related, and the implementer wrote down the relationship on this line.

This relationship functions as a cross link. The relationships between the second-, third-, and fourth-level sub-branches were linked together using different colored pencils. The associations regarding the theme of the mind map were organized in sub-branches, and examples were provided for some sub-branches. During the data collection process, all the children participating in the study were administered the sub-scales of the Maths and Science Skills of the Marmara Primary School Readiness Test as a pre-test, after which a mind map themed lesson was prepared with the children in the experiment group. This was carried out to enable the children to understand how a mind map is prepared. Following the provision of the lesson, mind maps on water, clothes, food, toys, and dinosaurs were prepared by the children. To perform the implementation, each child from the experiment group was placed with the researcher in a silent room in the school where the child would not be distracted. Once inside the room, the child was given colored pencils and a blank piece of white paper turned horizontally, and then asked to draw a picture in the middle of the paper. The researcher wrote down the theme under the drawing. The child was supposed to visually imagine the main ideas related to the theme by drawing arrows outwards from the drawing in the centre. Different colours for each arrow were encouraged to be used. The researcher wrote down what the drawings were under each drawing. When the child drew sub-branches or established relationships among branches, these were shown through lines, and the researcher wrote down the names under the drawings. As the child prepared the mind maps, she/he could create first-, second-, third-, or fourth-level sub-branches, or give examples, and determine relationships and cross links. The making of a mind map continued until the child stated that she/he was finished. Upon completing the task, the child's name and surname were written on the back of the paper and placed into her/his file.

During the implementation process, topics thought to be known by children should be chosen, and the children should start out from the first-level branches and continue in order. After the organization of each sub-branch is finished, the child should move on to the next sub-branch. It is believed that by presenting children the second-, third-, and fourth-level sub-branches of the mind map in a sub-branch organization, going separately from easy to complex, learning is made easier for children.

2.3. Data Analysis

Scoring of the mind maps was based on the evaluation system prepared by Evrekli, Inel and Balim (2010). However, because writings are scored as well in this system, the use of another evaluation system was necessary to score the pre-school children's mind maps. In this context, an evaluation system appropriate for mind maps prepared by pre-school children was developed by the researchers. Each part of the mind map is scored separately. According to the mind map evaluation system for pre-school children developed for this study, the scoring is as follows:

First-Level sub-branches: 2 Points

Second-Level sub-branches: 4 Points

Third-Level sub-branches: 6 Points

Fourth-Level sub-branches: 8 Points

Cross links: 10 Points

Relationships: 2 Points

Each Example: 1 Point

The scoring system explained above was used for evaluating mind maps. According to this scoring system, each child obtains a certain score for each mind map. Children's scores from each category in the five mind maps and total scores were evaluated via percentage-frequency analysis. With the pre-test post-test implementations of the study, the difference between children's scores obtained from the sub-scales of the Maths and Science Skills of the Marmara Primary School Readiness Test prior to starting work on the mind maps and scores obtained after working on the mind maps for a ten-week period was examined using variant analysis via a statistical package program.

3. Findings

The main aim of the study was to examine whether there was a difference between the experiment group and the control group, in terms of maths and science skills' development, after applying the mind maps to the experiment group. Because the number of the children in the experiment and control groups was less than 30 (n<30) combined, assumptions of non-parametric tests were investigated, and therefore, in the analysis, Mann Whitney-U and Wilcoxon tests were administered and percentage and frequency calculations were performed.

The prerequisite of the study was that both the experiment group and the control group have similar maths and science skills' levels. In order to assess this, Mann Whitney-U test was used to determine whether there was a difference between the groups according to the pre-test scores, and the results are shown in Table 1.

Table 1. Results of the Mann Whitney-U Test performed to determine whether there was a difference in pre-test scores of MRPS Scale Maths Skills' and Science Skills' Sub-Scales of Experiment and Control Groups

	Groups	N	$\bar{x}_{sira}$	$\sum_{sira}$	U	z	p
Maths Skills	Experiment	15	16.17	242.50	102.500	-0.416	.678
	Control	15	14.83	222,50			
	Total	30					
Science Skills	Experiment	15	18.50	277.50	67.500	-1.889	.059
	Control	15	12.50	187.50			
	Total	30					

p>.05

The results of the Mann Whitney-U Test show that there was not a meaningful difference between the pre-test scores obtained on the Maths Skills sub-scale (U= 102.500 p>.05) and Science Skills sub-skill (U= 67.500 p>.05). Therefore, it was concluded that the related skill levels of the children in both groups were not statistically different.

In order to determine whether there was a difference between the pre-test and post-test scores of the children in the experiment group (those who worked with mind maps during the research), Wilcoxon test was used, with the results shown in Table 2.

Table 2. Results of the Wilcoxon Test performed to determine whether there was a difference between the pre-test and post-test scores of the children in the experiment group

	Groups	N	$\bar{x}_{sira}$	$\sum_{sira}$	z	p
Maths Skills	Increasing	0	.00	.00	-3.424	.001*
	Decreasing	15	8.00	120.00		
	Equal	0				
	Total	15				
Science Skills	Increasing	1	1.50	1.50	-3,214	.001*
	Decreasing	13	7.96	103.50		
	Equal	1				
	Total	15				

*p<.01

Table 2 shows that there was a meaningful difference between the scores obtained by the children in the experiment group on the sub-scales of the MRPS Maths Skills (z= 3.424 p<.01) and Science Skills (z= 3.214 p<.01) before and after the study.

When mean rank and totals of the difference scores were taken into account, it was seen that this difference favored the post-test score. According to these results, it is possible to say that working with mind maps has a significant effect on children's development of maths skills and science skills.

In order to determine whether there was a difference between the pre-test and post-test scores of the children in the control group, Wilcoxon test was used, and the results are shown in Table 3.

Table 3. Results of the Wilcoxon Test performed to determine whether there was a difference between the pre-test and post-test scores of the children in the control group

	Groups	N	$\bar{x}_{sira}$	$\sum_{sira}$	z	p
Maths Skills	Decreasing	0	.00	.00	-3.413	.001*
	Increasing	15	8.00	120.00		
	Equal	0				
	Total	15				
Science Skills	Decreasing	2	4.50	9.00	-2.746	.006*
	Increasing	12	8.00	96.00		
	Equal	1				
	Total	15				

*p<.01

The results of Table 3 show that there was a meaningful difference between the pre-study and post-study scores obtained on the MRPS sub-scales of Maths Skills (z= 3.413 p<.01) and Science Skills (z= 2.746 p<.01) by the children who solely did the activities presented in the daily syllabi prepared in line with the 2013 pre-school education curriculum. Mean rank and totals of the difference score show that this difference favored the post-test score. According to these results, it is possible to say that the activities prepared by the teachers for the children in the control group had a significant effect on the children's development of Maths Skills and Science Skills. At the end of the 10-week research process, it was found that there was a meaningful difference between the pre-test and post-test scores of both the experiment group and the control group. Therefore, the differentiation of the Maths Skills and Science Skills sub-scales of the MRPS Scale according to post-test score was analyzed via Mann Whitney-U Test, with the results given in Table 4.

Table 4. Results of Mann the Whitney-U Test performed to determine whether there was a difference in the post-test scores obtained on the MRPS Scale Maths Skills' and Science Skills' Sub-Scales by Experiment and Control Groups

	Groups	N	$\bar{x}_{sira}$	$\sum_{sira}$	U	z	p
Maths Skills	Experiment	15	19.00	285.00	60.000	-2.183	.029*
	Control	15	12.00	180.00			
	Total	30					
Science Skills	Experiment	15	22.40	336.00	9.000	-4.371	.000*
	Control	15	8.60	129.00			
	Total	30					

$p < .05$

Table 4 shows that there was a meaningful difference between the experiment group and the control group in terms of the MRPS Maths Skills sub-scale ($U= 60.000$ $p<.05$). When mean rank was taken into consideration, it was understood that the children who worked with mind maps had better Maths Skills compared to the children who did not.

There was a meaningful difference between the experiment group and the control group in terms of the MRPS Science Skills sub-scale ($U= 9.000$ $p<.01$). When mean rank was taken into consideration, it was understood that children who worked with mind maps had better Science Skills compared to the children who did not. These findings show that working with mind maps had a positive effect on the children's maths and science skills development. The sub-objective of this study was to examine the mind maps prepared by the children in the experiment group during the 10-week-process. The mind maps were scored in terms of sub-branches, relationships, examples, cross links, and total scores. Total scores by the themes and elements of the mind maps prepared by the children during the implementations carried out with the experiment group are presented in Table 5.

Table 5. Total Scores by Themes and Elements of Mind Maps

Themes	Level1	Level2	Level3	Level4	Cross link	Example	Relationship	Total
Water	86	176	30	0	0	0	0	292
Clothes	118	88	18	0	0	0	0	224
Food	214	168	102	48	0	2	10	544
Toy	120	176	36	32	0	0	2	366
Dinosaurs	76	140	138	80	30	0	16	480

Examining Table 5, it can be seen that the children obtained the highest scores in the themes of "Food", "Dinosaurs", "Toys", "Water", and "Clothes". In terms of the elements of the mind maps, it can also be observed that the children created only first, second, and third levels in the Water and Clothes themes, whereas they were able to establish relationship in the Dinosaurs, Food and Toys themes. A striking finding of the study was that children could only create a cross link regarding the Dinosaurs theme, and they could only give examples about the Food theme. Numbers, total scores, frequency, and percentage values of the elements of the mind maps prepared by the children during the applications carried out with the experiment group are shown in Table 6.

Table 6. Total Scores, Frequency, and Percentage Values of Mind Maps by Elements

Elements of Mind maps	*f*	%	Total Score	Total Score %
Level 1	307	52.299	614	32.214
Level 2	187	31.856	748	39.244
Level 3	54	9.199	324	16.998
Level 4	20	3.407	160	8.394
Cross link	3	0.511	30	1.573
Example	2	0.340	2	0.104
Relationship	14	2.385	28	1.469
Total	587	100	1906	100

The results in Table 6 show that children drew Level 1 branches the most, followed by Level 2 branches and Level 3 branches. However, when mind maps were assessed by their scores rather than by their numbers, it can be seen that children scored highest in Level 2 branches, followed by Level 1 and Level 3 branches, respectively. Figure 2 shows the distribution of elements of mind maps in pie chart form.

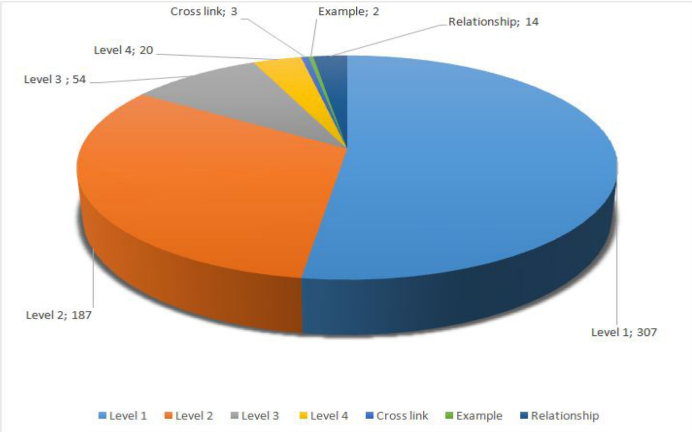

Figure 2. Percentages of Mind Map Elements by the Children

4. Results and Discussion

From the data analysis carried out to examine the effect of mind mapping activities on the maths and science skills of children between 48 and 60 months of age, it was found that children working with mind maps were more successful in developing maths and science skills compared to the children who did not engage in mind mapping. A review of the literature showed that intervention programs which emphasize various features to support the development of maths skills (Aunio, Hautamaki & Van Luit, 2005; Kinzie et al., 2014; Klein, Starkey, Clements, Sarama & Lyer, 2008; Missal, Hojnoski, Caskie & Repasky, 2015; Presser, Clements, Ginsburg & Ertle, 2015) and science skills (Gelman & Brenneman, 2004; Hong & Diamond, 2012; Mantzicopoulos, Samarapungavan & Patrick, 2009; Nilsson, 2015; Peterson, 2009; Peterson & French, 2008) in children and which include teacher supported education and family participation have a positive impact. Although we did not find any studies in the literature that examine the development of maths and science skills in pre-school children through the use of mind maps, it is nonetheless known that preparing mind maps gives children the opportunity to implement many skills, such as counting, establishing cause-effect relationships, rhythm, classifying, detailing, using colours and shapes, and spatial awareness (Buzan & Buzan, 2015; Buzan, Dottino & Israel, 2012). Moreover, the visual structure of mind maps facilitates the use of cognitive skills, such as memory and creativity, and thinking, establishing relationships, analyzing, and focusing (Buzan & Buzan, 2015; Wen-Cheng, Chung-Chieh & Ying-Chien, 2010). In examining support programs and evaluation methods, it was found that there are programs which take into account individual differences, aim to make use of available conditions in an efficient way, direct children to understand related skills and foster the active participation of children. In terms of these features, mind map activities satisfy them all, as they allow children to be active, take into account individual differences, include activities related to understanding the relevant skills, and take advantage of the available conditions in the most efficient way possible, as clear from the fact that only paper and pencils are needed.

Although the themes of the mind maps prepared by the children in the study were not taken from the maths or science curricula, the development of maths and science skills was supported, insofar as the children made classifications, established relationships among concepts, and recalled and used the available information. Brinkmann (2003a) stated that mind maps were effective tools for learning and supported mathematical thinking. According to Entrekin (1992), using mind maps in mathematical processes is a fine method for recalling relationships and places (as cited in, ThinkBuzan Ltd. Summary Report). Haylock and Cockburn (2014) stated that by simply relating a new experience with an old one, we fail to gain a thorough understanding of the new experience; instead, a more effective way is to relate the new experience with the network of experiences previously linked with each other. According to Haylock and Cockburn, understanding is forming cognitive connections. Accordingly, it is thought that the increase of relationship networks in the mind maps created by children represents their increasing cognitive connections and supports their development.

In another study on mind maps, it was stated that thanks to mind maps, participants framed their recalling levels, organizing information skills, and reflections of experiences, and they could visualize things more clearly (Wheeldon, 2011). In one study carried out with children (Farrand, Hussain & Hennesy, 2002), the use of mind maps was shown to facilitate recalling and enabled more information to be recalled. The efficiency of using mind maps in verbal lessons was also examined, and it was stated to be a successful method in various studies (Merchie & Van Keer, 2012; Karadeniz, Tangulu & Faiz, 2013). Wheeldon (2011) even stated that mind maps could be used as a collection tool in qualitative research.

Mind maps have generally been used in the secondary stage of primary school and examined in terms of their efficiency. Cakmak, Gurbuz and Oral (2011) and Keskinkilic-Yumusak (2013) worked with 7th graders; Abi-El-Mona and Abd-El-Khalick (2008) worked with 8th graders; and Dhindsa, Makarimi-Kasim, and Anderson (2011) worked with seven students between the age of 13 and 15, as part of a science lesson, and they all found that children working with mind maps were more successful than the others. Contrary to these findings, Evrekli, Inel and Balım (2012), in their study, reported that working with mind maps did not create a meaningful difference in terms of science topics.

When the features of the mind maps created by the children were examined, it was seen that in terms of the number of level branches, there were more Level 1 branches, which was an expected result, given that Level 1 branches start out immediately from the theme in the centre. In the mind map scoring system, total scores were calculated by co-efficients of level branches and comparisons were made. It was found that children scored highest in Level 2 branches, followed by Level 1, Level 3 and Level 4 branches, cross links, relationships, and examples.

Mind maps, which provide a visual of the information structure of the learner (Brinkmann, 2003b), can be used as teaching resources to enhance learning (Edwards & Cooper, 2010). Considering its many features, it is believed that experiencing mind maps, which can be used by everyone in every field of life, starting from the early years of childhood, would support development areas.

2. Suggestions

According to the study results, preparing mind maps positively contributes to the development of maths and science skills. Hence, in pre-school settings where a constructivist approach has been adopted, it is important to use mind maps as an effective method to support children's cognitive development and learning. In this sense, pre-school education teachers should be trained in how to prepare mind maps and encouraged to use these in their education settings. In a class setting where small group studies are carried out, mind maps created by groups may serve to reveal the different learning styles of the participants and thereby allow plans to be developed that will enable and support cooperation (Budd, 2004). In this context, in cases where mind mapping activities are not carried out individually, small group activities are believed to contribute to children's development.

Moreover, it is important that additional studies be carried out with the aim of determining the difficulties children experience in using mind maps and discovering a way to implement mind maps more easily, being sure to include the difficulties experienced by children and their views on mind maps. Lastly, it is suggested that a longitudinal study on the academic success of children who work with mind maps be conducted and that the effect of mind maps on the permanency of their learning and thinking skills and on their application of cognitive functions be examined.

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