

Preschool Inquiry-Based Mathematics in Practice: Perspectives of Teachers and Parents*

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Abstract: An Inquiry-Based Mathematics Activities Module (IBMAM) consisting of integrated and child-centered activities was developed. IBMAM provides preschoolers 60-72 months of age with the opportunity to develop mathematical and inquiry skills and use them actively to construct their own learning. The present study aims to investigate the effects of IBMAM on preschoolers. Teachers' and parents' views were obtained, and long-term observations (16 weeks) were performed. Phenomenology, which is a qualitative research design, was used in this study. The study sample consisted of a pre-school teacher of a kindergarten (Sincan, Ankara) and her children's parents in the academic year of 2016-2017. Semi-structured interviews were conducted with the teacher to assess the post-IBMAM process, changes in their views of math and math education, the effects of IBMAM on preschoolers' math skills and changes in the classroom. Preschoolers' parents' were also interviewed to evaluate changes in preschoolers at home. To support the results of the interviews, unattended and structured classroom observation was conducted twice a week for four months on certain dates. Instant field notes were taken during each observation, which was also videotaped. Data were analyzed using inductive content analysis. Results showed that IBMAM contributed to all areas of development by providing a fun and educational setting that increased preschoolers' motivation. In the observations, it was understood that the applied module gave pre-school children different perspectives, encouraged active participation, enabled learning to continue, and help enabled pre-school children to use their scientific process skills more frequently. Moreover, parents noticed positive changes in their children, and therefore, were optimistic about the future.


Keywords: Pre-school mathematics education, inquiry-based education, mathematical skills, parents, teachers


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Introduction

Environment and resources can help children develop math skills on their own. In the early years of life, children discover mathematical facts through games. For example, they compare the number of fruits in plates or heights of block towers, discover patterns and create new patterns using real objects and sustain or extend them and detect and analyze their shapes or deal with real-life situations, such as sharing a bowl of biscuits with a playmate fairly (Seo & Ginsburg, 2004). Although such math education in natural settings is useful at early ages, it is still limited. Children need more than natural settings to learn math and abstract thinking better. In other words, children need systematic and developmental math education programs prepared by adults to help them develop math skills and learn math concepts (Lewis Presser et al., 2015). Suppose a math education system aims to help children understand the world and provide them with a solid foundation for success. In that case, it should encourage active engagement, facilitate the establishment of a link between prior knowledge and math, allow for deduction and inquiry through reasoning and development of comprehension skills (National Association for the Education of Young Children [NAEYC], 2002).

Developmental and cognitive theories suggest that early math skills are associated with academic achievement in the future (Anders & Rossbach 2015; Aunola et al., 2004; Clements et al., 2004; Gersten et al., 2009; Jordan et al., 2009). Basic math concepts (one to one correspondence relationship, grouping, comparison, counting, ordering, and making simple operations) develop in the preschool period. Math skills, therefore, play a critical role in academic achievement and professional career (Anders & Rossbach 2015; Clements & Sarama, 2005, 2014). Math skills developed in the preschool period provide children with a foundation for future academic achievement. Preschool math activities should teach basic skills that can be transformed into advanced math because they form the basis for additional life skills. Research highlights that early years are critical, especially for the development of math knowledge and skills (Gifford, 2004; Clements & Sarama, 2014). Experimental studies show that children who start primary school differ in math skills and that that difference increases during and even after school life (Anders et al., 2012; Sammons et al., 2004).

According to the National Council of Teachers of Mathematics [NCTM, 2000] and NAEYC (2002), quality and thought-provoking and accessible math education a vital role future learning of children aged 3-6 years. According to the NCTM (2000), a high-quality math education program requires self-confident and well-informed teachers, educational policies that encourage and enrich learning, ready-to-use education settings and objectives of equality and excellence. Children deserve and need the best possible math education. Children should experience effective, research-based curriculum and teaching practices, which require political and organizational support and adequate resources. Therefore, children develop math skills through

strategies and techniques integrated with rich resources, and those skills are the basis of other academic skills. Research shows that people who are good at math are more likely to be successful in other fields (Duncan et al., 2007; Geary, 2000).

Since it is an undeniable fact that children acquire math knowledge in the first six years of life through physical actions, games and materials, everyone involved in the education of preschoolers should know and apply the methods that encourage them to think, enquire, ask questions and explore. Events, experiences, discussions and questions play a big role in the development and enrichment of math skills (Clements, 2001; Moomaw, 2011; Umay, 2003; Unutkan, 2007). When children start questioning at early ages (0-6 years), they also start defining objects and events, asking questions, using current scientific knowledge to make and test explanations and communicating their opinions to others. Afterward, they define assumptions and consider alternative explanations when using critical and logical thinking skills. In this way, children actively use their thinking and reasoning skills to develop an understanding of math (National Research Council [NRC] & Mathematics Learning Study Committee [MLSC], 2001). Therefore, math programs with systematic activities should be used to provide children with the opportunity to develop and practice skills at school or home (Starkey et al., 2004). Inquiry-based math education is based on sense-making processes by interpreting events and situations (Clements, 2007). Many researchers argue that inquiry-based math education enables preschoolers to achieve in-depth conceptual learning, develop an understanding of mathematical processes and learn scientific inquiry processes (Katz, et al., 2014; NRC, 2004). In this study, an Inquiry-Based Mathematics Activities Module (IBMAM) consisting of integrated and child-centered activities was developed. IBMAM provides preschoolers 60-72 months of age with the opportunity to develop mathematical and inquiry skills and use them actively to construct their own learning. The present study aims to investigate the effects of IBMAM on preschoolers' math skills. To that end, a teacher's and her children's parents' views were obtained, and long-term observations were performed. Doing this, this study approached the same phenomenon from different perspectives and showed consistency in the results. The main question of this study is, "What is the relationship between interviews and observations regarding IBMAM activities? To this end, this study sought answers to the following sub-questions:

- What does "mathematics" mean to the teacher and parents?
- How do the teacher and parents think math education should be like?
- What kind of effects does the teacher think IBMAM has on preschoolers?
- What does the teacher think about changes in children?
- What are the data obtained from the observation?
- What kind of effects do parents think IBMAM has on preschoolers?

- What do parents think about changes in children?

Methodology

Design

Phenomenology, which is a qualitative research design, was used in this study. People's perceptions of the world originate from their sensory experiences of things and personal interpretations of those experiences. Phenomenological research deals with how we bring together the facts that we experience in understanding the environment (Patton, 2014). Phenomenology is a research design that aims to highlight perspectives, perceptions and experiences (Ersoy, 2016). Phenomenology was the design of choice in this study as it aims to have a better understanding of a teacher's and parents' views of a new module develop for preschool math education and interpret the relationship between activities and analyze changes in children's lives.

Participants

The study sample consisted of a preschool teacher of a kindergarten (Sincan, Ankara) and her children's parents in the academic year of 2016-2017. Participants were recruited using a purposive sampling technique, which is a non-probability sampling technique involving selecting participants who have experienced a specific phenomenon and meet certain inclusion criteria (Patton, 2014). Participants were recruited using criterion sampling. The basic concept of criterion sampling is to include appropriate situations according to predetermined criteria (Merriam, 2013; Yildirim & Simsek, 2012). The study sample consisted of the preschool teacher of the classroom in which IBMAM was administered and her children's voluntary parents. Parents were interviewed at three different times. There were 6, 8 and 12 participants in the first, second and third interviews, respectively. The teacher had a bachelor's degree and nine years of professional experience. The parents were all housewives and their age ranged from 27 to 43 years. Eight of them had a primary school degree, three a secondary school degree and one a high school degree.

Inquiry-Based Mathematics Activities Module (IBMAM)

The experimental group children performed the 30-activities IBMAM for three days a week for ten weeks. IBMAM consists of four sets of skills (arithmetic, numeracy, addition and subtraction) but focuses, especially on numbers and operations skills designed to be developed by activities prepared in an eclectic and spiral structure. Acquisitions and indicators were handled separately for each skill. "Initial Stage," "Initial Inquiries," "Saving the Problem," "First Remarks and Possible Answers/Solutions," "Method Selection," "Planning and Implementing Research,"

“Comparison of initial ideas and Results” and “Writing and Sharing through Mathematical Expressions” were used for each activity (Bayram, 2015). IBMAM was designed as a process that requires high-level thinking, organization and planning for both educators and children (please see for detailed knowledge about IBMAM; Karademir & Akman, 2017).

Data Collection

Data were collected using a semi-structured interview developed by the researcher and approved by experts. Data were supported by field observations and records. The aim of qualitative research in which phenomena (individual, process, activity, program, and environment and related themes are defined in detail through in-depth analysis using multi-source data collection tools (interviews, and observations (Creswell, 2012), is to highlight experiences and perceptions and meanings attached to them regarding a phenomenon or a case. Interviews provide people with the opportunity to express their behaviors, feelings and insights in their own words, which allows us to understand their world views, perspectives and experiences (Merriam, 2013; Patton, 2014). Observations help us obtain a comprehensive and longitudinal image of behaviors and phenomena in determined environments (Yildirim & Simsek, 2012).

All mathematic activities werperformed by the researcher during this study, and the teacher was in the classroom. Semi-structured interviews were conducted with the teacher to assess the post-IBMAM process, to determine changes in her views of math and math education, the effects of IBMAM on preschoolers’ math skills and changes in the classroom. Preschoolers’ parents’ were also interviewed in three sessions to assess changes in their children at home. There were 6, 8 and 12 participants in the first, second and third sessions. It was made sure that the items were easy to understand, open-ended, unbiased, one-dimensional and logical (Merriam, 2013; Patton, 2014).

Observations were performed to support the results of the interview. Non-participant and structured classroom observations were conducted twice a week for four months on certain dates. Instant field notes were taken during each observation. Classroom observations were also videotaped, and each recording was repeatedly reviewed to enrich the field notes.

Data Analysis

Data were analyzed using inductive content analysis. To obtain a general idea for data encoding, all interview transcriptions and field observation notes were read several times and video recordings were examined again and again. Interview and observational data were coded in the light of the sub-objectives of this study. Sub-themes and themes were developed, and findings were defined and interpreted. For reliability, a third expert reviewed the codes and themes. Data were presented in table and figures after a consensus was reached.

Data were analyzed using inductive content analysis, which involves data categorization and theme and sub-theme development based on categories to understand the symbolic world of participants (Patton, 2014). Themes are associated, interpreted to make future predictions (Yildirim & Simsek, 2012). To have a general idea for data encoding, all interview transcriptions and field observation notes were read several times and video recordings were examined again and again. Interview and observational data were coded in the light of the sub-objectives of this study. All views and records thought to respond to the research question were combined under the same code. Sub-themes and themes were created from the codes. All themes and sub-themes were reviewed and those associated with each other were combined. Cites and codes in the sub-themes and codes were read to check their suitability for the codes, sub-themes and themes. Data were coded using QSR-NVivo 8.

Findings and Discussion

This study investigated the teacher's and parents' views on the effects of IBMAM on preschoolers' math skills and lives. This section will present the implementation process and its aftermath in all aspects and will provide in-depth interview analysis supported by observation and field records.

Teacher's and Parents' Views of Math

Pre and post-IBMAM in-depth interviews were conducted with Ceren (teacher) to elicit information on how she defined math, what kind of activities she used in her classroom and how her views changed after IBMAM (see Figure 1).

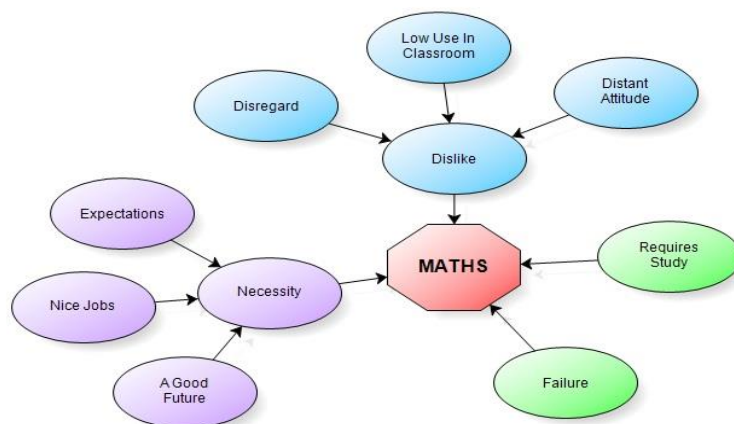


Figure 1. Opinions about maths

Ceren emphasized that math is an important branch of science in every field of life. She stated that she did not attach importance to math activities as other activities and associated her negative attitudes towards math with her negative experiences in the past. There are studies supporting this finding. The more negative the teachers' past

experiences with math, the fewer math activities they perform in their classrooms (Karakus, 2015). People continue to do what they love and succeed. Therefore, if children enjoy learning math, they develop a positive attitude towards it in the future (Aydin, 2009; Tarim & Bulut, 2006).

For parents, there are many reasons that make math important. Most parents stated that math is necessary for every sphere of life and children will need it throughout their lives. One of the parents stated that *"Math is important for my kid as well as a friend's kid. Math has an important place in our lives, in every sphere of our lives. We cannot afford not to know it. Every child needs to understand and use math"* In this way, she emphasized that math is in every aspect of life, that it is crucial for every child and that children should understand and use it. Another parent stated that *"School life is not just about here, these kids are going to go to different schools and have to use math there, so it is important"*, emphasizing that education is an ongoing process and that math is an important lesson in this process.

Another parent expressed her views on the importance of mathematics as *"My husband is a construction worker. There is no construction work in Ankara during this period, you know, we are in the winter. I mean, we work hard to make money. We couldn't go to school, so we want our daughter to get a proper education. We want her to learn math, science, Turkish etc., so that she would not have to work as hard as we do to make money,"* while another parent stated that *"If you want to have a good job, you have to know math."* These statements suggest that parents think that their children should learn math to avoid financial problems in the future suggest that parents think that their children learn math to avoid financial problems and that having a decent job depends on math knowledge. Some parents stated that math is important as it helps children develop skills. One of them stated that *"knowing math is not only knowing the numbers, you have to use math at home, at the grocery store, in the market, that is, in life. You have to know how to do math and calculation and whatnot."* This mother drew attention to the that math is not only about numbers and that one has to use numbers and develop reasoning skills.

Parents think that math is important because *"it helps people have a higher income, it is in every sphere of life and it is needed at other educational levels."* Many studies are suggesting that developing math skills in early childhood improves math performance in advanced ages (Clements & Sarama, 2008; Celik & Kandir, 2013; Shophian, 2004; Starkey et al., 1999). There are also studies showing that there is a positive relationship between socio-economic status and math skills (Aslan & Aktas Arnas, 2015; Baroody & Lai, 2007; Baroody et al., 2008; Jordan et al., 2006; Kandir & Orcan, 2010). In general, research shows that qualified, child-centered and constructivist programs should be implemented to help economically disadvantaged people develop math skills. Our participants associated math knowledge with a better life and a higher income, which might be because they are socioeconomically disadvantaged parents. The literature and our results show that IBMAM can be used to fill the gap in children's math knowledge.

Parents stated that math education should make children love math and that math education should be simple and include toys. It is reported that children develop math skills through play in early childhood; therefore, researchers have focused on the issue in recent years (Fleer, 2009; Nayfeld et al., 2011; Yoon & Onchwari, 2006). Some researchers argue that play should be integrated into math activities because gamified math activities enable children to develop math skills in a fun and natural way (Clement & Sarama, 2005; Cohrssen et al., 2014; DeGoot, 2012; Sirin, 2011; Zaslow et al., 2010). The observations and the teacher's responses show that the gamified math activities in IBMAM increased children's interest and motivation for learning math.

Some parents also stated that mathematics content should be supported by daily life skills. One of them stated that *"math teachers used to scare us. We simply can't love it. We use it but only when we need it. They could actually have taught it in a simple way. Teachers should make sure that our kids learn to love math. I don't know; they could use toys or activities, I mean, they should somehow do it."* With this statement, the parent emphasized that toys and activities should be integrated to make sure that children enjoy learning math. Another parent stated that *"It is only worth learning if you can use it in daily life. I mean, you should be able to use it at the grocery or on the bus,"* suggesting that math knowledge should be put into practice on a daily basis.

After IBMAM, Ceren was asked the question *"how should math education be?"* to which she responded as follows (see Figure 2):

After IBMAM, Ceren's views changed positively. She realized that classical math teaching approaches were not useful and therefore decided to use different methods. She also thought that children should be provided with math education integrated into daily life. Ryan and Laurent (2016) addressed the benefits of inquiry-based approaches to educators and reported results similar to ours. They stated that although educators had more responsibility, children were more willing to learn, ensuring smooth classroom management. Walker and Shore (2015) stated that inquiry-based approaches led to changes in roles and attitudes between educators and children, which made the latter more inquisitive and enthusiastic. Similarly, Vandermaas-Peeler and Pittard (2014) conducted a study of socioeconomically disadvantaged children four years of age and their parents and provided the latter with training on associating math with daily life, gamification and active use of mathematics at home. They concluded that training parents positively affected children's development of math skills. Our results showed that the gamified and rich activities of IBMAM helped children enjoy learning math and apply it to the home environment quickly.

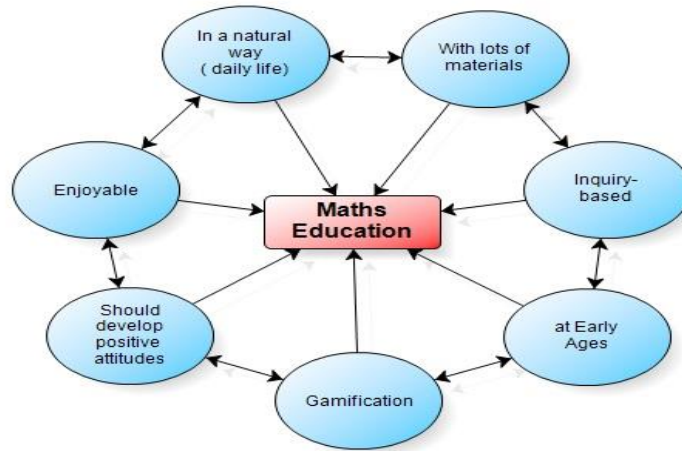


Figure 2. Maths education

Impact of IBMAM on Teacher

Ceren was asked to evaluate the IBMAM process in general. Her responses were grouped under the sub-themes as presented in Figure 3: *“creativity, material, relating with daily life, retention, the difference from other activities, attention, communication with children, classroom management, communication with parents, applicability, likes and dislikes, and reflections on children.”*

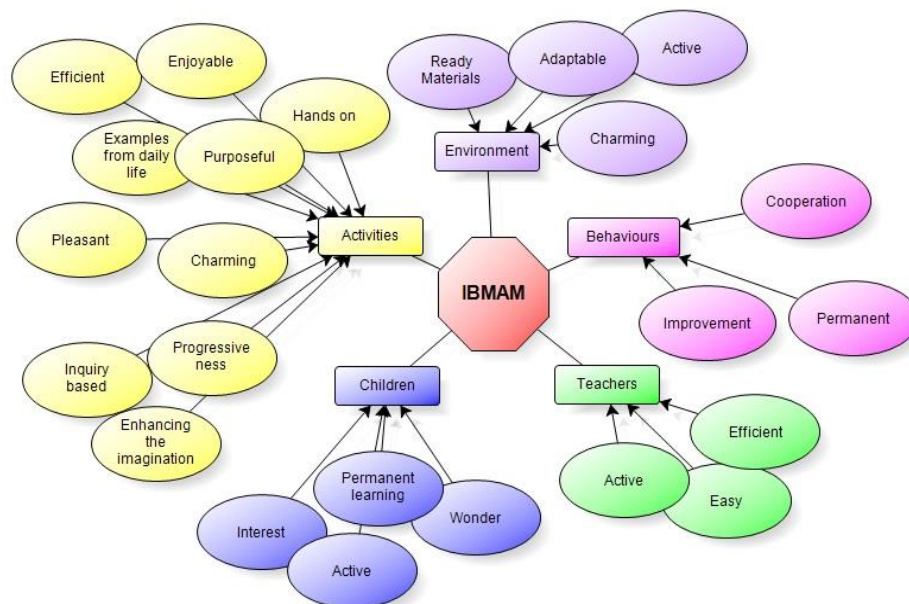


Figure 3. Inquiry-based mathematics activities module (IBMAM)

Ceren stated that IBMAM was fit for its purpose and prepared in advance, which provided great convenience. She also stated that IBMAM was a fun and efficient module that drew children's attention provided them with the opportunity to learn by living, and therefore, facilitated active engagement and learning retention. She also suggested that IBMAM consists of creative and fun activities that are appropriate for children's developmental characteristics and age, making them more willing to engage in learning.

The researcher prepared the materials in IBMAM himself and brought them into the classroom. She knew that a rich educational setting was required by inquiry-based approaches (NRC, 2000). Therefore, he placed a "math center" in the classroom, which provided children with access to over a hundred ready materials developed and replaced with new ones once a week for 10 weeks by the researcher. The materials provided children with the opportunity to experience math in an active way and the teacher with the opportunity to execute activities comfortably and easily. They were all recyclable materials. Children were asked to think about the materials and were expected to make similar materials with parents' help at home.

The literature also supports Ceren's views of IBMAM. Inquisitive activities should be carried out in learning environments that are appropriate to their developmental stages in order for children to develop high-level thinking skills (Clements & Sarama, 2004, 2007, 2008; Delacour, 2016; Karademir & Akman, 2019; Karademir et al., 2020). Skills should be supported by concrete materials so that children can experience and make sense of them. According to Nelson (2005), supportive classroom and home settings that are rich in materials encourage engagement and improve learning and contribute to their cognitive and social development in the preschool period. In this way, school activities can be put into practice in daily life and increase learning retention (Niklas et al., 2016). IBMAM materials triggered children's curiosity and extended their attention span. The enjoyable activities of IBMAM increased children's interest and provided learning by living and doing and learning retention. This result is consistent with that reported by Ryan and Laurent (2016), who investigated the effects of inquiry-based approaches on children's success. They concluded that the approaches that provided children with the opportunity to construct their own knowledge led them to cooperation and improved learning retention and that activities designed in this manner stimulated more interest and curiosity than did traditional applications. IBMAM provided children with ready-made materials, more interaction, active experience and learning retention. Such opportunities help children develop skills. Ceren emphasized IBMAM's ability to provide learning retention and to relate to daily life and its difference from other activities.

Ceren emphasized that IBMAM facilitated active engagement and provided children with daily life examples, which helped achieve learning retention and that it consisted of active and collaborative activities that achieved learning retention instead of passive pen-and-paper activities that bored children. These statements that Ceren considers activities that keep children active and extend their attention span to be important for

their development. Walker and Shore (2015) have stated that inquiry-based activities provide teachers and children with the opportunity to change roles. IBMAM also provided children and the teacher with the opportunity to change roles. Children assumed a researcher's role and established close relationships with their peers to inquire. Ceren's statements also show that the positive relationship with parents facilitated the follow-up of children at home, which also positively impacted the implementation of IBMAM activities. This suggests that new information is put into practice out of school, i.e., at home. The fact that the researcher sometimes failed to adhere to the schedule did not negatively affect the teacher. The use of interesting and attention-grabbing materials facilitated learning retention. Research shows that preschool teachers are likely to have negative attitudes towards math activities in the first years of teaching but adopt new constructivist math teaching methods in the following years (Aslan et al., 2013; Aydin, 2009; Karakus, 2015; Tarim & Bulut, 2006).

Ceren also expressed her observations on the effects of IBMAM on children. She was asked to indicate the contribution of IBMAM to children's learning. Her responses were grouped under the subthemes as presented in Figure 4: "social emotional field, cognitive domain, language field and psychomotor field."

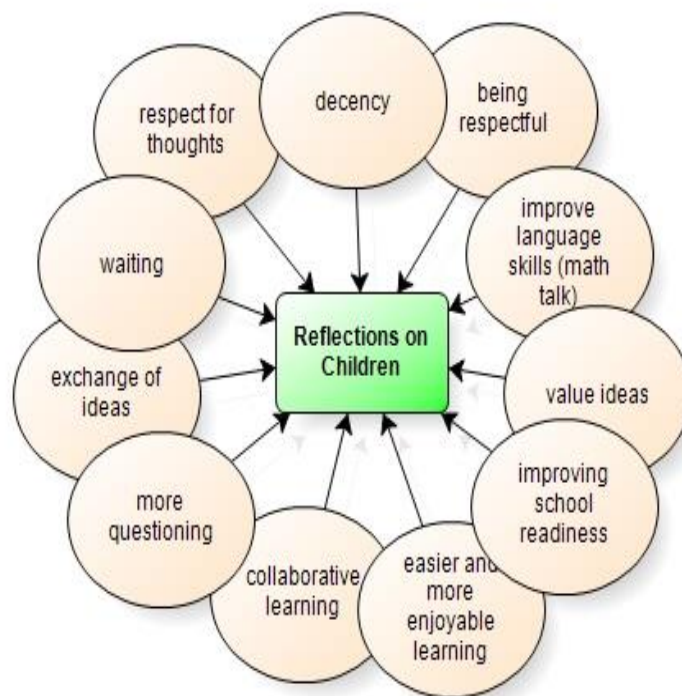


Figure 4. Reflections on children

According to Ceren's statements, IBMAM helped the children develop skills in all areas at different levels. She stated that the children developed social and emotional skills as well as language and questioning skills. They also developed the skills to exchange

ideas and use them even in routine activities. Linn and Jacobs (2015) examined the effects of the inquiry-based approach on the interaction between teachers and children and reported that the interrogation approach contributes positively to the improvement of teacher-child interaction and the development of language skills. Taskin (2013) also stated that there is a positive relationship between children's math achievement and language skills. In thirty activities, children interacted with their peers and adults and had to use math language. Children were in communication with adults and peers to perform both school and home tasks. It can be stated that adult-child communication and language used at home have a significant effect on academic skills. IBMAM provided the parents with the opportunity to perform math activities and use math expressions with their children. Dialogues and activities performed during IBMAM increased the children's ability to use math expressions. Susperreguy and Davis-Kean (2016) found that math expressions used at home are closely related to math skills that children use in school. Our results are, therefore, similar to those previously reported. We can state that the activities and tasks in IBMAM improved the children's interaction and language skills. Inquiry-based approaches require the use of communication and language skills. This is thought to be the component that helped the children develop math talk and communication and language skills.

These statements show that the children tried to use new forms of inquiry through peer interaction and involved math in their language use. They associated the math concepts and skills they learned from daily life activities, indicating that they internalized math. Children used new information at home, which is important for family engagement and school collaboration. This result is consistent with the result reported by Begum (2007) reported that family engagement and enriched home activities are associated with the development of children's math skills. Baker (2015) also highlighted the role of family engagement and environmental regulation in facilitating early childhood math skills development. Through tasks and activities, the children also put the new knowledge learned from IBMAM into practice at home. IBMAM activities facilitated the development of fine and large muscle skills and provided the teacher with the opportunity to learn different activities for fine muscle development.

These statements show that the integration of IBMAM into preschool education curriculum can contribute to education. IBMAM will help children develop positive attitudes towards math and make their transition to primary school easier. Research shows that early childhood education facilitates the transition to the next education levels (Aslan & Aktas Arnas, 2015; Clark et al., 2013). Clements and Sarama (2013) found that math skills developed in early childhood predict future high levels of literacy and math skills. From this point of view, the quality of math activities and the adoption of different approaches directly affect children's future life. Learning opportunities, a variety of methods and content, the level of interaction between the teacher and the child in early childhood math education help children develop the belief that they can comprehend and achieve math. The literature and our results show that an inquiry-

based and qualified math education program minimizes the loss of math skills in children.

IBMAM has inquisitive processes for every activity. Therefore, the children used language skills more than usual during IBMAM activities. Let us examine in detail all the stages of the activity "Does it float or sink?" and see how the children actively used language skills. In the first step, "Initial Stage," children listen carefully to the teacher's interesting and attention-grabbing narratives, which increases their willingness to discover and participate in the activity. In the second step, "Initial Inquiries," children begin to question their own lives and knowledge and have to use the language actively. In this way, they have to share their opinions with others and form groups with like-minded peers. This process helps them develop self-expression skills and teach them to listen to others. What is the relationship between the weights of objects and their sinking or floating? Are there other factors affecting their sinking or floating? What are the common characteristics of objects that sink? In the third step, "Saving the Problem," children try to establish a relationship between the language of speech and the language of painting or writing. Children illustrate a problem to save it and try to put their ideas on the paper and show them to their group friends.

Meanwhile, the teacher goes from group to group and learns about children's drawings and records it. In the fourth step, "First Remarks and Possible Answers/Solutions," children express their guesses regarding their solutions to the problem. For the activity "Does it float or sink?" they express their opinions as "The objects that are lighter than water float because [...] the objects that have air in them float because [...] large objects sink because..." In the fifth step, "Experiments and Observations," children conduct experiments and observations actively and interactively. In the sixth step, "Method Selection," children determine strategies and methods. In the seventh step, "Comparison of initial ideas and Results," children compare their initial opinions with their experimental or observational results. If the difference/conclusion confirms their assumptions, they explain why their hypotheses were accurate. If not, then the inquisitive process should be repeated. In the last step of the interrogation and activity, experimental and observational data are combined. It is then recorded in a clear manner using mathematical expressions. Analysis results are shared with other friends and groups at this stage. As you can see, children use language skills effectively in all steps of inquiry-based activities.

According to the NCTM (2000), learning math knowledge and concepts is as important as sharing and using them to communicate and discuss. Using inquiry-based approaches with preschool activities provides experiential tools that allow children to actively develop language skills (Austin et al., 2013). Almost all of IBMAM activities encouraged the children to develop language skills and actively use the language. Group activities helped them develop language, listening and understanding skills and decision-making and collaboration reflexes. In this process, they learned new concepts and words. Bicakci (2009) examined the effects of project approaches on preschoolers and concluded that small group activities supported all

developmental areas. The project approach resulted in a significant difference in language skills between the listener and speaker. It is similar to our results. Uyanik and Kandir (2014) also investigated the effects of an educational program on preschoolers' academic and language skills aged 61 to 66 months. They reported that preschoolers in the experimental group had higher vocabulary, numbers, letters, pronunciation and expressive language scores than those in the control group and that the difference between the two groups was permanent.

Observations for IBMAM

The researcher periodically observed Ceren's classroom to determine the interview data's consistency. Table 1 presents the effects of IBMAM based on long-term observations.

Table 1.

Observations Notes

Theme	Subtheme	Codes	Notes from 4-Months Observations
Creativity Preschooler	Dimensions	Fluidity	Children's fluidity, which is a dimension of creative thinking, improved. They developed more options and ideas to solve problems than they did before. They discussed with their peers. Our observations confirmed Ceren's views on this subject.
		Flexibility	IBMAM enabled the children to face different situations and events. In the first days, they had difficulty adapting to the questions of inquiry and active learning. However, in the following days, they broke away from preconceptions and tried to adopt the new approach. They thought about and developed different forms of recyclable materials used in activities. Many of them tried to design math materials from recyclable materials at home, such as egg cases or shoeboxes and presented them in the classroom.
	Stages	Elaboration	They focused longer, paid attention to details and developed different perspectives. For example, they learned to see the magnet not only as a magnet but also as a speckle for a ladybug, a stone inside the water, a number on a board, or a line attached to a stick.
		Preparation	Inquiry-based activities that support critical thinking helped children develop creative thinking. They approached cases and situations from different perspectives. Material-rich activities encouraged them to collect data on problems and aroused their interest and curiosity.
		Incubation	Children combined their views of situations presented in the previous weeks with their experiences and conveyed them in the following weeks, indicating that they were mentally preoccupied with that case or situation within

			the incubation stage. They tried to use new ideas and products to solve problems, suggesting that IBMAM activities increased their attention and motivation.
		Epiphany	When children found a solution to a problem alone or in a group, they exclaimed with excitement as "We've cracked it!" or "I've figured it out!" and showed their solutions to the researcher and their classmates.
		Conclusion and Development	Children tested their thoughts and tried to determine whether they satisfied the needs identified in the first place. They were constantly involved and interested in applying the solutions they tested for accuracy. They found solutions to some problems after a few weeks and went through the repetition process, indicating that they were interested and enthusiastic about IBMAM activities.
Classroom	Educational Environment	Materials	The classroom was designed to facilitate inquiry and positively affect the duration and quality of IBMAM activities. Inquisitive materials aiming to keep children's perceptions dynamic triggered learning by touching, discovering and having fun.
		Math Center	The math center allowed children to access math materials at any time. Even in the transition periods of the activities of the Ministry of Education 2013, children tried to amuse themselves with inquisitive materials. They integrated math into their lives whenever they liked, and therefore, had the opportunity to use it more often than before. The educational environments where the intrinsic motivation of the teacher supported learning made learning easier and permanent.
	Interaction / Atmosphere	Teacher-child	IBMAM helped the teacher develop new skills, which resulted in changes in her classroom management. She became really interested in the activities and supported her children's efforts. IBMAM provided children with more choices and decisions, resulting in more teacher-child interaction than usual. The exchange of ideas between the teacher and her children enabled the latter to develop thinking skills, make decisions, and solve problems. IBMAM made the teacher-child interaction more open, bi-directional and warmer and made the classroom atmosphere healthier.
		Child-child	Children interacted with other their peers while selecting materials from the math center and playing with them. They used math as the language of communication. They combined math talk and inquiry and tried to find more creative and realistic solutions to problems.
Children	Retention	Internal Motivation	Children were not forced to participate in any of IBMAM activities and were expected to participate in them voluntarily. They participated in IBMAM materials with curiosity and interest. The teacher and children themselves expressed it many times that they looked forward to IBMAM activities. Children noticed the change in themselves and were enthusiastically involved

		in IBMAM activities.
	Active Engagement	As IBMAM was based on constructivism, children assumed an active role in the process. They were directly involved in learning by living and doing. IBMAM let children regain confidence and encouraged them to grow up to be people who can think, participate, plan and put their ideas into practice.
	Gamification	Children enjoyed IBMAM activities and learned new things from them. They wanted to perform the activities again and again. For example, they wanted to play the activity "Fish of Numbers" over and over again for three weeks, indicating that IBMAM is fun.
	Spirality (Repetition)	Another feature of IBMAM activities is that they contain repeatable acquisitions. Different activities focus on the same acquisitions at different times, achieving learning retention. Most children reached new solutions by using the strategies and methods they had previously learned from spiral repetitive activities. For example, a student who learned the strategy "counting multiples of 10" used it in an activity related to addition.
Learning Processes	Attention Problem-solving, Making a connection, Communication, Relating to daily life	The Initial Stage presented interesting materials and cases associated with daily life. Environment and daily life examples were used for children to gain new knowledge. IBMAM enabled them to develop the skills of researching, inquiring, predicting, practicing, interpreting and communicating with peers. They were more skeptical and asked more questions than their peers, which can be considered a learning outcome of IBMAM.
Thinking Skills	Convergent Thinking	Children had initially used easy and previously learned ways to solve questions. However, they abandoned that habit towards the middle of the IBMAM process.
	Divergent Thinking	IBMAM encouraged children to use different ways of thinking, intuition and imagination to reach solutions. They began to focus more on unstructured problems and chose to predict different factors and try different ways.
	Inquisitive Thinking	Children sought to be more reflective during IBMAM. They tried to understand the logic of problems and solve them. Those who developed reasoning skills entered an active process to understand their peers' opinions. Those who developed different perspectives began to learn how to put their math knowledge to use in other fields.
Teacher	Task	On IBMAM days, the teacher was as passive as possible and observed the process and recorded the important parts of the techniques and activities. At the end of the day, she helped the researcher assess IBMAM and gave some hints to make the activities more effective.
	Classroom Management	The teacher used IBMAM knowledge and skills in her own activities as well. She replaced her classroom management skills with the preventive and holistic model in IBMAM. She sought to provide children with

		the opportunity to express themselves more and create a freer classroom environment where decisions were more respected.
	Views	The teacher didn't like the fact that IBMAM was only 3.5 months long. She thought that teachers should be provided with in-service training on the inquiry-based approach. However, she was very pleased with the positive impression that IBMAM left on children and their parents. Her children stated that they would use the inquiry steps of IBMAM in math and other types of activities. She also believed that the knowledge acquired by her children was permanent.
Parents	Parental Engagement	Parents closely monitored the change in their children throughout the process. They witnessed their children use math more in home activities or daily life. They performed math games and training with their children, especially on weekends according to the researcher's instructions. They tried to encourage their children to do what they wanted to do about math in daily life.

IBMAM led to changes in the class, children, teacher and parents for four months. IBMAM activities rich in materials (*math center*) provided the children with a more enjoyable and long-lasting learning experience. Discovery-based learning improved their motivation and communication with peers and teachers and made the classroom atmosphere warmer and healthier. IBMAM enabled the children to use cognitive processes more actively and the dimensions of creativity (fluidity, flexibility and elaboration) more frequently. During IBMAM, they abandoned convergent thinking and adopted divergent thinking. They established logical connections between subjects and problems and tried to relate them to daily life. They were actively engaged in IBMAM activities and achieved learning retention through inquiry. During IBMAM, the teacher assumed an observer/guide's role, which facilitated classroom management while making the children feel freer. Although the teacher found IBMAM a bit too short, she was pleased with the permanent changes that she noticed in her children and herself. IBMAM provided the teacher with the opportunity to learn new things and increased her confidence so much so that she stated that she would use the inquiry-based approach for all her activities. The parents followed the whole process closely and were pleased to see changes in how their children approached math and used math skills in daily life. They considered the change promising for their children's future education.

IBMAM helped the children develop and use observing, comparing, classifying, measuring, recording, communicating, estimating, and concluding skills. It also led them to use inquiry steps that cover many scientific process skills. It can be stated that the whole IBMAM process involves activities that require active use of process skills. For example, if we examine the skills used in the activity "We are playing dart," we see that children are expected to start using "Thinking Skills" in the Initial Stage. In the Initial Inquiries, they are expected to "compare" their opinions with their peers' and "classify"

and restructure them accordingly. This stage also helps them develop “problem-solving skills.” They should also be able to predict possible solutions to the problems they may encounter. They are then asked to compare their predictions with those of their peers. Prediction and comparison skills are two critical steps that should be taken to perform inquiry (NRC, 2000, 2004). Observing cases and changes directly helps children develop observation skills and make inferences regarding activities to develop “inference” skills. Moreover, sharing results with peers helps them develop “communication and display” skills. As can be seen, inquiry skills are also intertwined with scientific process skills. Inquiry-based activities that are appropriate for developmental characteristics contribute to the multidimensional development of children.

Inquisitive processes are required for high-level thinking skills in math education (Clements, 2007). According to Harlen (2013), we should use scientific process skills to dwell on problems, understand and structure information, and assess results. There are many studies reporting that inquiry-based teaching method has a positive effect on math learning, thinking skills, attitude towards math and retention (Henningsen, 2013; Hollingsworth & Vandermaas-Peeler, 2017; Ryan & Laurent, 2016). We believe that IBMAM made positive contributions to the children's math and scientific process skills thanks to two important factors. First, IBMAM encouraged them to learn, think, enquire and explore actively, increase their sense of curiosity, and support learning by living and doing. IBMAM activities provided the children with the opportunity to define problems, generate assumptions, collect data and use the data to draw conclusions. Second, IBMAM is based on a constructivist approach, and therefore, includes constructivist methods and strategies. Learning by living and doing involves structuring knowledge in the mind through the experience and incorporating small parts. IBMAM enabled the children to construct reality both in terms of living and discovering facts.

Impact of IBMAM on Parents

The researchers conducted interviews with parents in three different sessions to find out about their views on preschool math education. This section will present their responses. Interview findings were given under themes (see Figure 5).

Figure 5 shows that the parents observed many changes in their children. Most parents stated that IBMAM increased their children's interest in math and enabled them to take a liking to it. These statements show that children began to share with their parents what was going on in school, continued to use such skills as counting numbers and had a growing interest in math. The children adopted IBMAM activities and tried to prepare materials to carry out similar activities at home with their parents' help. The parents also observed their children more clearly and expressed their views on many changes in their lives. They focused on integrating math into everyday life and speech, an increase in recognition and use of numbers and improvement in inquiry skills and self-confidence.

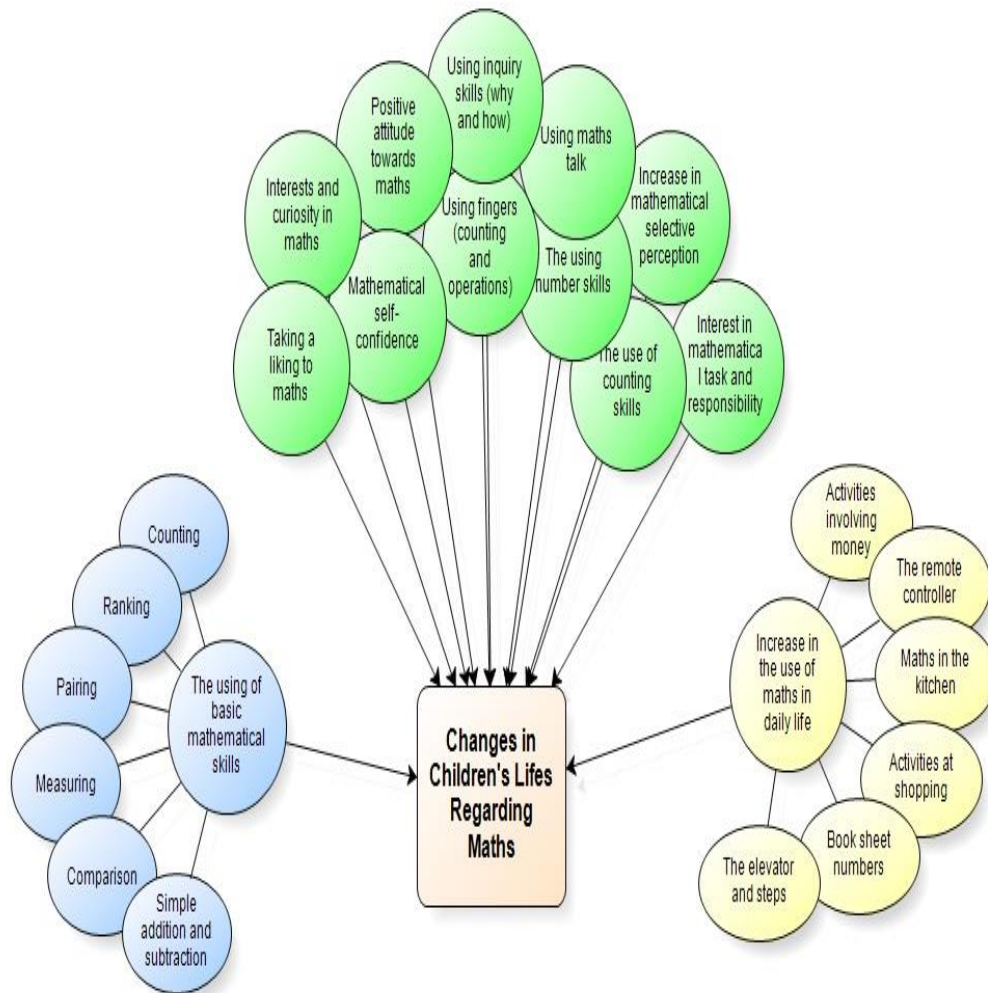


Figure 5. Changes in children's life

These statements showed that the children recognized and used numbers, countedcount fingers, establishedestablish a cause-effect relationship and put numerous skills into practice. They also showed that they developed inquiry skills and began to integrate math into their language. This finding was consistent with the finding that was reported by Susperreguy and Kean (2016), who conducted a study on 40 mothers and reported that parent-child interaction contained much more mathematical content than previously thought. They also found a positive relationship between math expressions and math skills. They stated that children tend to put their daily expressions into use in their education life. They suggested that parents used math expressions that could be supported by home activities.

IBMAM encouraged the children to use language during each activity. The parents' views also confirmed the observed changes. Parents stated that IBMAM enabled their kids to use math concepts and words more frequently and in different ways in daily life.

It also encouraged them to use new math expressions at home and associate them with their daily skills. This also suggests that inquiry-based approaches, which are constructivist approaches, achieve learning retention.

Figure 6 shows that children's change led parents to feel surprised and happy and made them more optimistic about the future. These statement shows that the children are able to put math knowledge into practice, which surprises and pleases their parents.

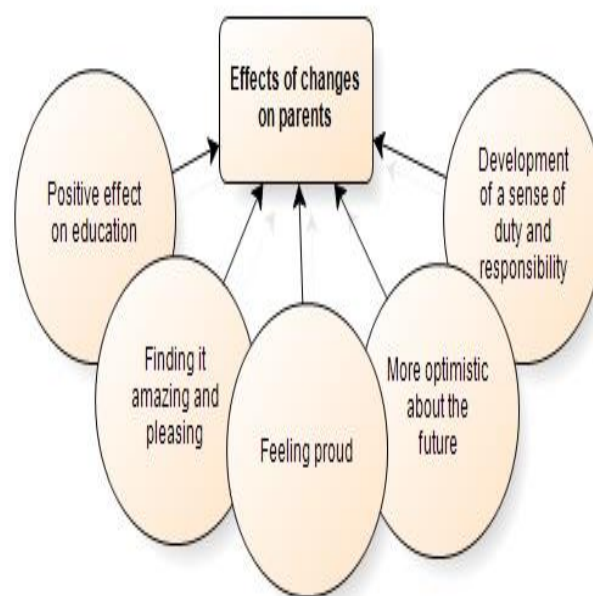


Figure 6. Effects on parents

Some of the parents were more optimistic about the future and expected their children to be supported in this way in the future as well. Another parent stated, *"The weekly tasks that you assign to children are useful. My kid consulted with us about the assignments and worked on them every Friday and Saturday. His motivation got us as well, so we bought some more books"*, suggesting that IBMAM increased the sense of responsibility of the child and the parents and raised the latter's awareness.

Guided inquiry-based IBMAM was designed and implemented to improve children's mathematical skills aged 60-72 months. IBMAM enabled the children to better understand the concepts of "Numbers and Operation," use them more actively, put them into practice and use math more frequently. It helped them develop more positive attitudes towards math, collaborate, and discuss with their peers. The interviews and observations both supported the results and provided detailed information about the IBMAM process and the experiences of children. Few studies are analyzing inquiry-based learning processes and instructional models for early childhood math, which

has remained under-researched. We, therefore, believe that our results will guide researchers.

Conclusion and Suggestions

This study examined a classroom teacher's and her children's parents' views on the effects of an Inquiry-Based Mathematics Activities Module (IBMAM) on children. The teacher and parents were asked to assess the IBMAM process in all respects, and in-class observations supported the data.

Interview with Teacher

The teacher was asked to assess the overall IBMAM process. According to her, IBMAM is an interesting and easy to use module that enhances creativity, provides rich material, active engagement and learning retention, helps to relate new knowledge with daily life, focuses on communication with children and facilitates classroom management skills. She stated that IBMAM affected four developmental areas. To her, IBMAM helped her children develop social and emotional skills, encouraged them to exchange ideas, and positively impacted their language skills both at home and in the classroom. IBMAM changed the way they reach information and encouraged them to develop high-level thinking skills, such as observation, comparison, classification, recording, estimation, and conclusion. IBMAM's activities supporting fine and large muscular development contributed to psycho-motor development.

Results of Observations

IBMAM enabled the children to use cognitive processes more actively and the dimensions of creativity (fluidity, flexibility and elaboration) more frequently. It helped them use preparation, incubation, epiphany, conclusion, and development (stages of creativity) more effectively. It provided a rich, stimulating classroom environment, made the children active learners and enabled them to incorporate math into games whenever they wanted to. The inquisitive materials of IBMAM provided learning retention. The classroom's positive and warm atmosphere improved both teacher-child and child-child interaction, encouraging the children to exchange ideas and involve themselves in decision-making processes. In this way, they had the opportunity to make more creative and critical decisions and reflect on their solutions. IBMAM's spiral-designed gamified and fun activities increased the children's motivation and active engagement and made learning outcomes, knowledge and skills more permanent. IBMAM encouraged them to abandon convergent thinking, adopt divergent thinking, develop different perspectives, and apply them to everyday life. After IBMAM, the teacher made her classroom management skills and thinking system more child-centered and facilitated active learning. She valued her children's ideas more and

started using inquiry steps to design activities. Lastly, IBMAM met the parents' expectations and facilitated their active engagement in the process.

Interviews with Parents

According to the parents, math is important because it is used in every sphere of life, helps children throughout their educational life, keeps them away from financial problems and enables them to have decent jobs. To them, math education should make sure that children love math, be fun enough not to bore them, and use toys. One and a half months after the onset of IBMAM, the parents notice the following changes in their children: (1) IBMAM increased the children's interest in math and taught them to love it, (2) provided them with the opportunity to expand their knowledge and skills of numbers, (3) increased their sense of responsibility for math tasks and assignments and (4) improved their communication with their parents regarding school activities. Three and a half months after the onset of IBMAM, the parents notice the following changes in their children: (1) IBMAM increased the children's ability to put math knowledge into practice and (2) recognize and use numbers, (3) enabled them to use math expressions more often and (4) increased their self-confidence and inquisitive skills. The parents' feelings about the change in their children were as follows: (1) they were amazed by skill development, (2) hopeful for the possible positive effects of the change on their children's education life, (3) pleased that their children developed a sense of responsibility for math tasks and assignments and (4) proud of their children's achievement.

The recommendations of this study are as follows: (1) Different disciplines can be integrated to expand the scope of the inquiry-based approach, (2) IBMAM activities can be extended over a longer time to increase their effectiveness, (3) materials or settings can be prepared in schools to facilitate children's experience with math, (4) Alternative programs can be developed to help children develop math skills, and possible effects of the programs can be investigated, (5) Longitudinal studies can be conducted to monitor changes in children's academic achievement and math skills and (6) national inquiry-based education projects involving teachers and preservice teachers can be designed to provide the target audience with the opportunity to learn about inquiry-based approaches.

Parental engagement should be designed to ensure that children's attitudes and skills through inquiry-based math activities become permanent. Parents should be involved in inquiry-based math learning processes to support the development of children in the framework of school, teacher and parent cooperation. Parental engagement can also facilitate the integration of IBMAM to the home setting, which can also be designed to facilitate the development of math skills. Further research can also focus on the impacts of IBMAM on other areas of development in children.

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