https://doi.org/10.53656/math2021-6-6-pre

PRESCHOOL TEACHERS' KNOWLEDGE, PERSPECTIVES AND PRACTICES IN STEM EDUCATION: AN INTERVIEW STUDY

Dr. Lyubka Aleksieva, Assoc. Prof., Prof. Dr. Iliana Mirtschewa, Snezhana Radeva, PhD Student
Sofia University "St. Kliment Ohridski" (Bulgaria)

Abstract. Early STEM education has a great potential to support children's development in constructing their own knowledge, in designing, discussing and testing ideas and finding solutions to different problems. Significant role in achieving the goals of STEM education is played by the teacher, who scaffolds the learning process, builds a creative learning environment, provokes children with open questions and guides them to test their hypothesis as young scientists, mathematicians, engineers and technology users. Preschool teachers' knowledge and perspectives could seriously influence their practices in STEM education and respectively, the fulfilment of STEM learning outcomes. It is very important to explore in depth teachers' views and experiences thus to plan and provide appropriate courses for their academic preparation or continuous professional development. While reviewing some popular misconceptions for STEM education amongst teachers, this paper presents the results of pre- and post-interviews conducted with teachers from Bulgaria in the framework of the European multilateral Erasmus+ project №2018-1-TR01-KA203-059568 "STEM for Pre-schoolers and Their Families" (PARENTSTEM) (2018–2021). The overall goal of this project was to increase family involvement in the STEM education process of early childhood children specifically coming from low socio-economic status. As a part of this goal implementation, the project aimed to extend conceptual and pedagogical knowledge of early childhood teachers on STEM. In the frame of the project the preschool teachers-participants in the study were provided with three teacher trainings (two international and one national) and were additionally supported with the intellectual outputs of the project. This paper attempted to identify teachers' preliminary knowledge, awareness and attitudes towards STEM conceptualization and pedagogy and to describe the relative influence of the project teacher trainings and activities on them. The results of the research unambiguously demonstrated the need for training of preschool teachers in terms of STEM education, outlining the main focuses to be considered when constructing STEM courses intended for preschool teachers.

Keywords: STEM Education; early STEM; preschool teachers

Introductions

The Convention on the Rights of the Child (United Nations 1989) emphasises on the importance of early childhood development claiming that a child has a right to develop to "the maximum extent possible" (Article 6). Early childhood starts from birth and continues up to 8 years of age and it is a critical period "for cognitive, social, emotional and physical development" (UNICEF 2019). During this period the use of integrative STEM approaches in early education creates opportunities to make children become young researchers, who construct their own knowledge by inquiry, hypothesis testing, discussing and finding different solutions and making decisions. A great role in achieving the goals of STEM education is taken by the teacher, who creates the scaffolding of the learning process, builds a creative learning environment, challenges children with open questions and guides their attention to problems they can solve as young scientists, mathematicians, engineers and technology users. To succeed in this initiative, the teacher should have certain competences and realistic views regarding STEM.

A variety of methods – surveys, interviews, case studies, etc. are used to determine the attitudes of teachers for early STEM education since these are an important component of successful STEM integration in kindergartens and schools. The academic discourse reveals many misconceptions related to teachers' understanding of STEM which has the potential to influence their practices and the quality of STEM education they provide. One of the main issues found in practice is the tendency of teachers to disintegrate STEM. Recent studies demonstrated that "teachers struggled with integrating subjects…" (Arnonee & Hanuscin 2018, 170) and some educators even "regard STEM as any of the individual STEM disciplines" (Moomaw 2013). These perspectives emerge as a problem and lead to a fragmentation of the overall picture of the world that children receive. Some teachers admitted that they do not know how to integrate the STEM disciplines (Arnone & Hanuscin 2018). A research by Education Development Center also revealed that they "are not well prepared to teach STEM to young children in developmentally appropriate ways" (Pasnik & Hubert 2016, 5) and they "underestimate what young children are capable of learning" (Pasnik & Hubert 2016, 5). That explains why teachers reported that they are using websites where they could quickly find a lesson (Arnone & Hanuscin 2018), which leads to a formal conduction of STEM education and does not allow its positive potential to develop.

Another misconception of STEM education is related to the role of the teacher in the learning process. There are two extreme points of view on teachers' role in it. On the one hand, there is a prioritized teacher centered instruction which is "much different from the STEM learning environment where the teacher is more of facilitator" (Gatling 2016, 364). Teacher's role involves helping students to process information, facilitating students' thinking and modelling the learning process (Anderson 2002) rather than being the only authority who provides learning. Kinder-

garten should not become a school which would distract children from their natural desire to make discoveries in STEM and being natural scientists. Thus the National Science Foundation stated that: "What we need to do to encourage children to learn is not to put them in the equivalent of school, tell them things or give them reading drills or flash cards ... What we need to do is to put them into a safe, rich environment where these natural capacities for exploration, for testing, for science, can get free rein" (National Science Foundation 2012, cited by McClure 2017, 23). On the other hand, some professionals assume that children do not need a teacher at all and should explore the world on their own. But the teacher is a significant factor in the implementation of early STEM education (Pasnik & Hubert 2016, 5) where "children need adults to develop their "natural" STEM inclinations" (Early Childhood STEM Working Group 2017, 12). The teachers should organise the process, prepare the study arrangements, consider the provision of the necessary resources, provoke the children with appropriate questions, delicately guide children to test different hypotheses and find different solutions.

Very popular practice in kindergartens in some countries, is using mainly worksheets and books to fill in when working on STEM topics. Problems in mathematics and science are mainly presented and solved in such a format which is probably related to a misunderstanding that some STEM elements like mathematics will "be learned most effectively by rote memorization in traditional, book-based classroom setting" (McClure 2017). It is assumed that the children will work quietly and acquire the necessary knowledge through a lot of drills. It is thought that working with textbooks and paper learning aids will prepare them better for school. Behind these practices stays the belief that children will memorize new information but in fact, the memorization of "empty knowledge" does not lead to understanding. As it is revealed in the literature, the learning at the conceptual level is also of a great importance (Moomaw 2013) and only through memorizing children cannot understand the natural phenomena and the existing relationships between them. "While teachers may count on objects with children or read counting books, they often do not engage in discussions and problem-solving activities that expand children's thinking." (Moomaw 2013, 2). Moomaw (Moomaw 2013,2) also pointed out that "teachers should encourage children to solve problems through their own thinking rather than supplying them with answers" and emphasised that many preschool teachers did not succeed in using the science opportunities that their classroom offers.

Another misinterpretation of the early STEM education is that the focus is on the final product/artefact of the activity, and not on the process. The nice looking and skilfully made product is perceived as a successful fulfilment of the learning goals. The significant fact that in the process of STEM education children learn from their own experience (by trying different materials, making discoveries about their properties, designing, prototyping and looking for solutions to problems) is ignored. A recent study demonstrated that in many lessons, emphasis is placed on the

fun side of STEM, without focusing on the content (Arnonee & Hanuscin 2018). The same researchers found that teachers very often use STEM lessons as ice breakers or for team building activities without striving to acquire any knowledge and skills (Arnonee & Hanuscin 2018). Indeed, it is very important for children to be engaged in the process and it is beneficial if the learning process is fun. The problem emerges when this is the main focus of a STEM lesson – it would then not lead to effective learning as it does not provide enough opportunities to enrich the knowledge and the experience of the children.

Additionally, teachers have a lot of prejudices about STEM education – some teachers believe that STEM education is only suitable for gifted children (Arnone & Hanuscin 2018, 170; McClure 2017, 53); other think that it is more important for boys who show greater talent than girls (McClure 2017, 14) or that it is suitable only for elder children (McClure 2017, 14). These attitudes, which unfortunately are also widespread in society, could influence and limit the opportunities for unleashing the potential of early STEM education.

Moreover, many studies demonstrated the uncertainty of some teachers regarding the STEM content and their perturbation to questions posed by children (McClure 2017; Pasnik & Hubert 2016). The problem is exacerbated by the fact that "science and math are often seen as difficult, complex and confusing subjects" (Aaron & Valle 2016, 3). Survey from 2013 found that only 39% of elementary teachers feel very well prepared to teach science (Horizon Research 2013, p. 7, cited by Jeanpierre 2018). Teachers' lack of confidence in teaching STEM is also demonstrated in the abovementioned Jeanpierre longitudinal study (Jeanpierre 2018). This data raises serious questions about the academic preparation of teachers which should be addressed. Furthermore, these issues are additionally complicated by the misunderstanding of technology integration in STEM. As Pasnik & Hupert (2016) noted, technologies cannot replace the teacher (especially a young children's teacher) as it is believed by some professionals, rather they are an important tool that supports learning of STEM. There is another misconception about technology which some educators understand as computing (Sanders, 2009). In fact, early STEM education does not require any complex devices, computers or robots. It is enough to use affordable appliances, tools or technologies from everyday life.

As can be seen from the above, there are many misconceptions and misinterpretations of STEM education by teachers that could seriously influence the integration of STEM in the practice. This implies a requirement for revision of teacher training programmes (in terms of university academic preparation or in courses for continuous professional development) which should be appropriately addressed by the higher educational institutions (HEIs). In response to these issues, the Erasmus+ project PARENTSTEM (STEM for Pre-Schoolers and Their Families) №2018-1TR01-KA203-059568[1)], which main goal was to increase low-income families' involvement in their early childhood children's STEM education process, aimed also to

extend conceptual and pedagogical knowledge of early childhood teachers on STEM, including in a family involvement perspective. Thus in the frame of the project three preschool teacher trainings (LTTs – Learning/Teaching Trainings) were provided from which two international (with partners from 5 countries – Turkey, Spain, Denmark, Germany and Bulgaria) and one national training for each country. This paper focuses on the Bulgaria case in which Sofia University "St. Kliment Ohridski" in partnership with two Bulgarian kindergartens (one metropolitan and one rural with low socio-economic status children) conducted face-to-face STEM National Teacher Training in June 2019. In September 2019 the same Bulgarian preschool teachers took part in the international face-to-face teacher training in Manresa and Barcelona (Spain), and in March 2021 in the last international online LTT with a leader – the project partner from Germany. The duration of all LTTs was four days according to the preliminary schedule. The trainings aimed to increase preschool teachers' pedagogical content knowledge of STEM, to develop and improve their skills in designing STEM lessons, as well as in terms of parent involvement. To support their learning, teachers were provided with the PARENTSTEM Guidebook[2)] which addresses the key points for STEM in early childhood education (the first intellectual output of the project). To measure the results of those trainings pre- and post- semi-structured interviews with teachers were conducted. They explored teachers' knowledge, attitudes, practice and self-efficacy in STEM education both in designing and implementing STEM lessons and activities and in terms of parents' involvement in early STEM education. This paper focuses on the study of teachers' knowledge, attitudes, practice and self-efficacy in STEM education and how it changes after the appropriate trainings were provided to the teachers-participants. The prior knowledge and attitudes of teachers about early STEM education provided important guidelines for considering the structure and content of teacher training. Establishing the preliminary knowledge and attitudes of the teachers is of great importance for planning and implementing teacher trainings. The results and the effect from the trainings (found in post-interviews analysis) could serve as a basis for designing and improving teacher training programmes in HEIs.

Bulgarian Context

In Bulgaria the children start school at the age of seven. A recent educational reform from 2020[3)] imposed a three-year compulsory preschool education before that. At the age of 4 years, each child should be enrolled in a preschool group in one of the two approved by the government options – a preparatory preschool group in a school or a preschool group in a kindergarten. The preschool preparatory groups in schools have half-day organisation (3 – 4 hours per day). The kindergarten preschool groups are open during the whole working day and the children could spend up to 12 hours per day there. Typically, a preschool group consists of 20 – 25 children with one teacher. In larger cities the number of the

children in a group increases up to 35. Since there is an option for children at the age of 3 to apply for a kindergarten, many working parents use this option and thus in Bulgaria there is a very high percentage of children involved in preschool education – more than 90%.

The learning process in the kindergarten is organized in a structured and regulated format. Depending on their age, the children have 2, 3 or 4 learning units per day called "educational situations". They are organized by the teacher and are regulated by the National Educational Standard for Preschool Education. Usually the duration of these educational situations is between 15 and 20 minutes. Besides that, the children have free play time. There is a mandatory kindergarten curriculum which is subject based – the main subjects are Bulgarian language, Mathematics, Science and Social Studies, Music, Arts, Design and Technologies and Physical education. The educational situations are based on each of these subjects which are proportionally distributed during the week. For instance, the four years olds have 21 educational situations per week (4 – Bulgarian language, 4 – Mathematics, 3 – Science and Social Studies, 2 – Music, 3 – Arts, 2 – Design and Technologies, and 3 – Physical education) and it is not typical two different subjects to be integrated in one educational situation which highly contrasts with the nature of STEM.

The STEM approach is quite new for Bulgarian educational system and particularly for the kindergarten it is not well recognized. In some schools this approach is implemented as part of an innovative programmes and it is integrated mainly in the form of extracurricular activities. Some private educational centres claim that they use the STEM approach as part of their teaching methodology, however they are not monitored for the quality of the provided STEM education. Furthermore, STEM education is not widespread in the preschool teachers training programmes in the universities and in the continuous professional development courses. In the universities teacher training programmes STEM education is offered mainly as an optional course.

The Erasmus+ PARENTSTEM project had a great role in introducing the STEM approach to early educators and caregivers in Bulgaria. The intellectual outputs of the project support professionals in implementing new ways of teaching that are based on integrating multiple subjects together. LTTs in the frame of the project have a potential significant impact on preschool education in Bulgaria as serving not only for training professionals and disseminating an emerging educational approach but for a cause of positive effect on children's development.

Methodology

As a part of the PARENTSTEM project, pre and post semi-structured interviews were conducted with preschool teachers (participants in the project) aiming to identify the relative influence of LTTs, PARENTSTEM guidebook and the implementation of project activities on teachers' knowledge, awareness and attitudes towards their STEM conceptualization and pedagogy.

Interview process

Objectives of the interview

The interviews' main objective was to understand the change in preschool teachers' pedagogical and conceptual understanding of STEM due to the conducted trainings and project activities. The main research questions were related to the impact of the project activities (trainings with teachers, the implementation of STEM activities based on that, PARENTSTEM Guidebook) and were focused on the following:

- How teachers' competences, practices and perspectives in designing and implementing STEM activities has been changed due to the conducted teacher trainings?
- How capable and confident teachers feel to design and implement STEM activities properly in the beginning and at the end of the PARENTSTEM project?
- What are the potential benefits and barriers of implementing STEM activities in early childhood according to teachers?

Interview protocols were designed and prepared by the project team through collaboration between all project partners. They were the same for pre- and post-interviews and consisted of 4 main categories with leading and additional deepening questions, as follows:

- Meaning of STEM Education (this section aimed to grasp the different meanings that early childhood educators are giving to STEM education)
- STEM Education in Practice in Early Childhood Education (this section attempted to identify what is already done by teachers in STEM)
- Parent Involvement in STEM Activities at Early Childhood Education (this section tried to identify teachers' views and experience in involving parents)
- Background/personal and professional information (this section was related to teachers' professional experience and their kindergarten contexts).

This paper focuses and analyses three from those sections – meaning of STEM Education, STEM education in practice and teachers' background.

Methods

The interviews were organised as follows: pre-interviews with 7 respondents (5 preschool teachers and 2 kindergarten principals) were conducted in June 2019; post-interviews with 5 respondents (including the 2 principals) were conducted in May 2021. All the interviews were administered in face-to-face mode and were recorded through recording devices and protocols. Each interview has been taken between 15 and 20 minutes.

The interviews' records were transcribed and then analysed through deductive analysis. The teachers' responses were connected to the predefined categories according to the interview protocol. Each teacher was given an ID number and their pre- and post-answers were compared. Categories data was qualitatively analysed and the findings were discussed in terms of the predefined objectives. Relevant implications and conclu-

sions were made for each category in terms of the changes of teachers' knowledge and attitudes towards STEM due to the activities of PARENTSTEM project.

During the period between pre- and post-interviews the teachers from the two Bulgarian kindergartens-participants in the project (a metropolitan kindergarten in Sofia city and a rural kindergarten in Lehchevo (North Bulgaria) took part in the total of three LTTs (see information in the introduction), based on the intellectual outputs of the project. The first intellectual output of the PARENTSTEM project – a PARENTSTEM Guidebook was available to the teachers at the end of 2020. Additionally, the Bulgarian proposal of 12 activities for another project's intellectual output – PARENTSTEM activity book [4)], were discussed with the teachers and some of those activities were piloted with teachers and children in face-to-face mode. In July, August and October 2019 (after the National STEM LTT) three activities were piloted with parents and children in the two kindergartens in Sofia and Lehchevo. The other activities were presented to them during nine online training sessions with teachers and parents in the period February – May 2021.

Participants

In the pre-interview 7 preschool teachers took part. Two of them were also principals of the two kindergartens-participants in the project. All teachers were females. Three of those 7 respondents were from the rural kindergarten (Lehchevo) and four from the metropolitan one (Sofia). For the post-interview two teachers from Lehchevo kindergarten have dropped out from the initial number due to kindergarten redundancies. For this study only a valid data of 5 teachers who participated in both pre- and post-interviews was analysed. Data on table 1 displays the professional experience of the 5 teachers who took part in pre- and post-interviews.

Table 1. Participants' professional experience

Teacher ID #	T 1		T 2		T 3		T 4		T 5	
Interview	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Teaching experience (years)	22 years	24 years	22 years	24 years	10 years	12 years	39 years	42 years	2 years	4 years
Experience in STEM teaching (years)	None	2 years	None	2 years	None	2 years	None	2 years	None	2 years
Continuing professional development (CPD) courses attended (number)	More than 10	More than 10	More than 10	More than 10	Approx. 5	Approx. 8	More than 10	More than 10	Approx. 3-4	Approx.5
STEM CPD courses attended (number)	0	0	0	0	0	0	0	0	0	0

The kindergartens' data in terms of the type, culture and socio-economic environment in which the interviewed teachers were working is displayed on Table 2 as it is relevant information about each teacher's background and context. Teacher 3 (T3) has changed her working place during the project but yet remained a participant in the project who implemented STEM activities in her group. Therefore, the data for T3 in Table 2 differs for pre- and post-interview.

Table 2. Kindergartens environment and culture

Teacher ID	T 1		T 2		T 3		T 4		T 5	
Interview	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Kindergarten information										
Type of kindergarten (rural, metropolitan, big, small)	Rural, middle-sized		Metropolitan, middle-sized		Metropolitan, middle-sized	Metropolitan, very big	Metropolitan, middle-sized		Metropolitan, middle-sized	
School culture	Traditional		In the process of innovation		Traditional in the process of innovation	Traditional	In the process of innovation		In the process of innovation	
Socio-economic background of the pupils in the kindergarten	Low income families		Middle and low income families		Middle and low income families		Middle and low income families		Middle and low income families	

Findings

Findings about teachers' STEM knowledge, attitudes, practice and self-efficacy levels in pre-interviews

STEM knowledge

In the beginning of the project no teacher was familiar with STEM – most of the teachers did not have an idea what it was (3 teachers) or had a misconception. One of the teachers that misunderstood STEM conception suggested that this was some kind of individual work with children; and the other suggested it was something related to technology and engineering, which is closer to, but yet not the exhaustive meaning of STEM. Four of the interviewed teachers have first heard about STEM education from the initial PARENTSTEM project meeting. The fifth one has heard about it on social media.

STEM attitudes

Nevertheless, the teachers' attitudes towards STEM were very positive. Only one teacher shared that she is not sure about the importance of STEM in early childhood education: *"I cannot say – Science, Technology and Maths are important,*

but I am not sure about Engineering" (principal of rural kindergarten and teacher with 22 years' experience). At the same time, the other principal shared that STEM *"should be present because it is probably a way to a better professional development of children - we can see their talents and lead them to a relevant profession"* (principal of metropolitan kindergarten and teacher with 22 years' experience). All of the teachers (5) expressed their curiosity and interest in STEM and nature phenomena.

Also, all five teachers thought that implementing STEM in early childhood education is beneficial. They shared that it is a "great initiative" (T2) which is appropriate and very close to the children (T3), although it is a challenge (T1). They also pointed out some barriers for implementation of STEM: 1) the huge number of children in one group (T3) which could make it difficult for one teacher to conduct such activities; 2) teacher's lack of confidence and determination (T4); 3) Parents and their willingness (T2, T5).

STEM practice

When asked what kinds of STEM activities they have implemented in their classes, all teachers answered that they have not conducted such but they described their similar to STEM activities in subjects related to Mathematics, Science, Technology and Engineering – mostly activities in Mathematics and Technologies were mentioned (4 of 5 teachers), one teacher gave an example related to Arts and more than half of the teachers (3 teachers) shared that they were not sure that they do something about engineering. As a whole, the examples were related mainly to games and some workshops that teachers do with parents.

None of the teachers has experienced STEM activities, but all of them shared that they have the opportunity to do STEM with children each week (T2, T5), anytime (T3), everyday (T1, T4). As asked to define how they imagine their roles in the implementation of STEM activities, the two principals answered that their role would be active and guiding, which is not the role of a STEM teacher. T3 suggested that her role would be mainly in preparation which implies that she has a better idea of the STEM process. More neutral position had T4 who pointed out that *"At the beginning we should lead the children but later we should let them lead"* and also T5 noted that teachers should support children and if necessary to do the activity with them.

All the teachers found their community supportive and reported that they do not need anything special to integrate STEM and conduct STEM activities. Two teachers mentioned the need of a teaching assistant to support children with SEND in the groups (T2 and T5). T1 and T4 suggested that additional materials and resources would be needed, but as T3 aptly said that *"anything could be made from handy materials and even waste"*.

STEM self-efficacy

All of the teachers admitted that they do not feel confident about their knowledge on STEM. Two of them shared that they need training: *"I need some training*

to see if I understand the idea correctly and then I will be confident. I love to experiment and a lot of ideas come to my mind then", said a teacher with 10 years' professional experience.

In terms of teachers' ability to implement STEM in their classes, only one teacher admitted that she does not feel able to implement STEM. The other four teachers claimed that they are confident that they would be able but they need preparation and support. Their answers lead to the implication that indeed none of them felt able to implement STEM at that moment.

Findings about teachers' STEM knowledge, attitudes, practice and self-efficacy levels in post-interviews

STEM knowledge

As for the pre-interview, the first question to teachers was what comes to their mind when they hear the concept of STEM education. In the post-interview their answers demonstrated that they already have a sound knowledge on the topic as they suggested that this is to challenge children to experiment (T1, T4, T5), or that this is something that children create by themselves or in groups while actively participating and learning through their experience (T3).

Teachers were again asked about examples of STEM activities that they implement in their classes. They gave many interesting examples, two of them even showed pictures from some of the activities (T3 and T4) which were very creative and real STEM challenges (for example, children were challenged to create a fence to protect their playground from passer-by to cross it; or to invent a facility or another mean for crossing a river). T5 talked about how they made musical instruments and constructed boats that float, etc. The other two teachers shared that they were emphasising mainly on science in outside activities with natural materials.

STEM attitudes

In terms of the importance that teachers gave to STEM in early childhood education after their participation in PARENTSTEM project trainings, it could be said that they started to find it as something very important that all children should experience (T3, T4, T5). As the rural kindergarten principal shared: *"It is very good for children – it is very educational, interesting for them – no child has ever said: "I don't want to do that"*. Another teacher stressed on the importance of systematic and consistent STEM implementation as saying that: "*I think it is very valuable but if it is used every day. We should try to apply at least some STEM elements each day"* (T1).

All five teachers interviewed believe that STEM should be implemented as early as possible and that it is very good for children's development. The rural kindergarten principal shared that *"It is very good about thinking – children start to think outside the box. It is very valuable and it is very close to natural learning by doing."* (T1). Most of the teachers admitted that a negative factor for such earlier implementation could be mainly the teacher itself – if the teacher is unwilling and

conservative and does not want to change their traditional approach of teaching or if they do not want to allocate enough time for preparation of the activities. T1 paid attention to the fact that a positive factor for STEM implementation could be its inclusion in the National Educational Standard. The other factor considered as a positively influencing factor is the effect on children that teachers would recognise – the children would be more interested and better developing (T5).

STEM practice

After the trainings all teachers conducted STEM activities regularly. In the rural kindergarten they were once a month, and in the metropolitan kindergarten teachers did such activities "anytime, anywhere" (T3) in the kindergarten (inside and outside). They experienced such activities almost every day (T2 and T3) or at least once a week (T4 and T5).

As they have gained some experience, the teachers started to understand their role in implementing STEM activities as supportive, as a facilitator. The youngest teacher (T5) shared: *"My role is of an observer who stimulates children to create."*

It is interesting that most of the teachers (4 out of 5) indicated that there is no special environment, resources and community needed to implement STEM activities – "the willingness is enough" (T1). Of course, they recognised the need for a supportive team (T3) and that it would be better if the furniture and tools in the classroom are compliant with STEM (T2).

STEM self-efficacy

All of the teachers expressed that they feel confident in their knowledge about STEM. However, none of the teachers said they were 100% confident - two of the teachers (T2 and T5) mentioned that they still need support and the others admitted that they probably have to enrich their knowledge about STEM. It was more explicitly explained by T3 who said: *"I have to learn a lot, but I am confident enough to apply STEM."*

In terms of their ability to implement STEM in their classes, two of the teachers considered themselves 100% capable (T3 and T4), while the other three teachers still need aid in that. They explained that they need support in two directions – for ideas about appropriate STEM activities and for assistance during the activity (which they explained as a necessity of a teacher assistant to help them, because their groups are big).

Influence of the trainings and the project activities on preschool teachers' STEM knowledge, attitudes, practice and self-efficacy levels

Teachers' answers demonstrated the significant role of the project activities to refine their knowledge and attitudes in terms of STEM education. Their practices and their self-efficacy evaluation have also been improved notably.

In terms of teachers' knowledge and practice at the beginning of their participation in the PARENTSTEM project they were not familiar with STEM and have never taught STEM. This logically led to their self-efficacy assessment that they

were not confident in their preparation for teaching STEM and to the misbelief that the teacher has a leading role in STEM activities. Nevertheless, a good predisposition to change their attitudes and improve their knowledge and practices was their curiosity in STEM, their positive perspective on the implementation of STEM in early childhood education, and their supportive community.

All the explored aspects have notably changed during the project as it is seen from the post-interviews data. All of the teachers were well informed about STEM and implemented many activities which complied with the specifics of STEM activities design. They were even more positive about integrating STEM in early childhood as they define it as a compulsory experience for each child that should be implemented as early as possible. The teachers interviewed declared that they have extended their practices in terms of STEM and did it regularly in and out of the kindergarten. They started to understand better the facilitating role of the teacher which is quite different in comparison to their role in the traditional teaching approaches. All of them appreciate the fact that the main driving force in implementation of STEM activities is the teacher although a supportive role of the kindergarten team is important and some resources may be needed. Also, if in the beginning of the project no teacher felt capable of implementing STEM, at the end of it two of them considered themselves as fully capable, and the others felt capable but with some aid (from colleagues or internet resources about ideas for STEM activities).

No significant differences were found in the two contexts – rural or metropolitan kindergarten, except for the frequency of practicing STEM activities which was rarer in the rural kindergarten than in the metropolitan one.

Discussion and Conclusions

The pandemic situation due to Covid-19 has influenced all aspects of life and education was one of the most affected areas. The activities planned within the project PARENSTEM which targeted pre-schoolers and their families have also been impacted by this situation. Fortunately, the planned LTTs with teachers were not much affected (only one was conducted in online mode), but most of the preliminary planned face-to-face implementation of 12 ParentSTEM activities in the kindergarten had to be transformed to online trainings. Such were conducted online both with teachers and parents which could potentially influence the effectiveness of the interactions and fulfilment of preliminary set goals.

However, according to the analysis of interviews data, PARENTSTEM project teacher trainings has played a great role in introducing the STEM approach to Bulgarian kindergartens-project participants as it promoted teachers' knowledge and practices in terms of STEM education. Preschool teachers-participants become much more informed about STEM and its implementation, evaluating critically its potential advantages and disadvantages. The preschool teachers have demonstrated their great enthusiasm on the implementation of STEM in early childhood and even

found it as something that should be compulsory. Although at the beginning of the project many teachers expressed their doubts about the possibility of STEM to be integrated in the curriculum (which have to follow the National Educational Standards for Preschool Education), at the end of the project they realised that it is thoroughly possible and their willingness is the main factor to implement STEM. Indeed, the Bulgarian National Educational Standards for Preschool Education regulates the topics and requires the fulfilment of specific learning outcomes, but does not define any compulsory approaches or teaching methods. That is something that teachers began to understand during the National teacher training in June 2019. In relation to that, they also have started to understand their changed facilitating role in implementing the STEM approach (McClure 2017; Gatling 2016; Anderson 2002), in comparison to their leading role in the traditional setting – it could be clearly seen in the analysis of the post-interviews.

In the pre-interviews, some teachers demonstrated the described in the literature (Arnonee & Hanuscin 2018; Moomaw 2013) tendency to disintegrate STEM by defining as STEM activities some pure Mathematics or Technology activities. Nonetheless, at the end of the project two of the teachers still emphasised on the science activities which implies the need for more trainings in terms of better integration of STEM subjects. Teachers' lack of confidence in implementing STEM was obvious in the pre-interviews and it was clearly explained by their lack of experience, but after the trainings and the practice which follows them yet three out of five teachers admitted they need support. This finding proves previous studies which found that more than 60% of teachers do not feel confident in STEM (Horizon Research 2013, 7, cited by Jeanpierre 2018).

It could be concluded that post-interviews explicitly demonstrated teachers' improved knowledge, attitudes, practices and self-efficacy evaluation in terms of implementation of STEM activities as well as parent involvement in them. These results contributed to the positive tendencies outlined in the answering of the first two research questions (1) How teachers' competences, practices and perspectives in designing and implementing STEM activities has been changed due to the conducted teacher trainings? And 2) How capable and confident teachers feel to design and implement STEM activities properly in the beginning and at the end of the PARENTSTEM project?). It could be concluded with certainty that teachers' competences and capabilities in designing and implementing STEM activities has been significantly improved. Their perspectives have changed accordingly and their misconceptions were almost overcome. Regarding the third research question (3) What are the potential benefits and barriers of implementing STEM activities in early childhood according to teachers?), all teachers understand the beneficial role of STEM for children development. They defined as a barrier the possible unwillingness of the parents to take part in the activities, though they highly appreciate the supportive role of the kindergarten team and the possible need of specific resources

for each activity. They also acknowledged the negative role of the pandemic in that process. Yet, no teacher felt discouraged to apply STEM, even if some difficulties were encountered.

As it was preliminary set in the project objectives and as it could be concluded on the basis of the analysis of the conducted pre- and post-interviews with 5 Bulgarian teachers-project participants, the trainings provided to them in the frame of the PARENTSTEM project as well as the PARENTSTEM intellectual outputs have supported preschool teachers in successfully understanding and implementing STEM.

Pre- and post-interviews analysis unambiguously demonstrated the need for preschool teachers' trainings in terms of STEM education. The necessity of STEM courses for continuous professional development of preschool teachers in Bulgaria is explicit. Also the academic preparation of preschool teachers should be revised in terms of introducing STEM as a modern educational approach. The findings of the study as well as the project intellectual outputs could help course designers in constructing appropriate STEM courses intended for preschool teachers. They also could serve as a basis for further research on preschool teachers' STEM competences and attitudes. Special attention should be paid to the popular misconceptions which should be overcome, namely the disintegration of STEM subjects, the leading role of the teacher, the focus on the product and not on the process, as well as some biased concepts. Thus it is important for course designers who intend to prepare preschool teachers in STEM education approach to focus on the integration of the four pillars of STEM (Science, Technology, Engineering and Mathematics), the facilitating role of the teacher during the process and the importance of independent learning of children through inquiring, designing and testing.

Limitations of the study

This study has its certain limitations. One of them is the low number of participants, which were initially planned as seven, but due to change of their working place had to be lowered to five. The number of respondents was not representative though it gave a deep idea of the knowledge, perspectives and practices in the two kindergartens before and after the provided teacher trainings. However, the inclusion of the principals of the two partnering kindergartens provided a fairly broad picture of perspectives and practices of the kindergartens they manage.

A limitation of the study was also that at the time of analyzing the Bulgarian interviews, the data of the other project partners were not yet available for comparison. Such would be valuable for wider comparative research, which is planned in the future.

Another limitation was related to the Covid-19 lockdowns, which changed the mode of the third teacher training to online. The lockdowns also have prevented the face-to-face implementation of most of the planned STEM activities, which influenced the interaction between teachers and children. However, even in such cir-

cumstances the project trainings and follow-up activities have demonstrated their positive impact on the studied variables.

NOTES

1. Detailed information on PARENSTEM Project website: http://parentstem.kku.edu.tr/project-info/.
2. The Guidebook is open-access and could be freely downloaded from the following link: https://drive.google.com/file/d/1xDFiJXC-oSzHpHGAjmBTWqkphQcSZvi7/view?usp=sharing.
3. The Act on Amendment to the Pre-school and School Education Act (18 September 2020): https://dv.parliament.bg/DVWeb/showMaterialDV.jsp;jsessionid=6F044BE97E4F956A7800FF72CDEF6875?idMat=151650.
4. The Activity book is open-access and could be freely downloaded from this link: https://drive.google.com/file/d/164jDPfsFUS-27mAk6S-gj4706vW-ufNd/view.

REFERENCES

Anderson, R. D., 2002. Reforming Science Teaching: What Research Says About Inquiry, *Journal of Science Teacher Education*, **13**(1), 1 – 12. Available from: doi. 10.1023/A:1015171124982.

Arnone, K. A., & Hanuscin, D., 2018. An Exploratory Cross-Sectional Survey Study of Elementary Teachers' Conceptions and Methods of STEM, *Integration Journal of Research in STEM Education*, **4**(2), 159 – 178.

Early Childhood STEM Working Group, 2017. *Early STEM Matters. Providing High-Quality STEM Experiences for All Young Learners.* A Policy Report by the Early Childhood STEM Working Group. Viewed 12.08.2021 from https://d3lwefg3pyezlb.cloudfront.net/docs/Early_STEM_Matters_FINAL.pdf.

Gatling, A., 2016. Technology's Role in Supporting Elementary Preservice Teachers as they Teach: An Urban STEM Afterschool Enrichment Program. In: Urban, Michael J. & David A. Falvo. *Improving K-12 STEM Education Outcomes through Technological Integration.* Hershey: Information Science Reference.

Isabelle, A. D., & Valle, N. Z., 2016. *Inspiring STEM minds: Biographies and activities for elementary classrooms.* Rotterdam, WA: Sense Publishers.

Jeanpierre, B., 2018. Inquiry Beliefs and Practices in an Urban Low SES Elementary Classroom: A Case Study. *Journal Research in STEM Education*, **4**(2), 146 – 158.

McClure, E., 2017. *STEM starts early. Grounding science, technology, engineering, and mathematics education in early childhood*. New American & The Joan Ganz Cooney Center at Sesame Workshop.

Moomaw, S., (Ed.), 2013. *Teaching STEM in the Early Years*. St. Paul: Redleaf Press.

Pasnik, S.& N. Hupert, 2016. E*arly STEM Learning and the Roles of Technologies.* Walthman, MA: Education Development Center, Inc.

Sanders, M., 2009. STEM, STEMEducation, STEMmania. *The Technology Teacher,* December/January, 20 – 26.

UNICEF, 2019. *The formative years: UNICEF's work on measuring early childhood development*. Viewed 12.08.2021 from https://data.unicef.org/resources/the-formative-years-unicefs-work-on-measuring-ecd/.

United Nations, 1989. *Convention on the Rights of the Child*. Viewed 12.08.2021 from https://www.ohchr.org/en/professionalinterest/pages/crc.aspx.

✉ **Dr. Lyubka Aleksieva, Assoc. Prof.**
ORCID iD: 0000-0002-7877-5792
Web of Science Researcher ID: AAE-4709-2019
Faculty of Educational Studies and the Arts
Sofia University
Sofia, Bulgaria
E-mail: l.aleksieva@fnoi.uni-sofia.bg

✉ **Prof. Dr. Iliana Mirtschewa**
ORCID iD: 0000-0001-7992-3745
Web of Science Researcher ID: ABD-2748-2020
Faculty of Educational Studies and the Arts
Sofia University
Sofia, Bulgaria
E-mail: imircheva@uni-sofia.bg

✉ **Snezhana Radeva, PhD Student**
Faculty of Educational Studies and the Arts
Sofia University
Sofia, Bulgaria
E-mail: snezhanaradeva@gmail.com