Investigating the teacher's roles for the integration of science learning and play in the kindergarten

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ABSTRACT
This article builds on data from an action research project concerning a play-based intervention on magnetic phenomena that took place in a kindergarten classroom in Patras-Greece. By analysing the teacher's diary and following step by step the way she addressed a science intervention with the main intention to build on children's ideas, interests, and questions, we aimed to develop knowledge of the teacher's role to science learning in early childhood education, when free and guided play activities are implemented and mutually interchanged. The results indicated four main roles, which are enacted in various contexts by the teacher, and four resources she drew upon for addressing the integration of science learning with play.

KEYWORDS
Early childhood education, science teaching, free/guided play, teacher's role

RÉSUMÉ
Cet article s'appuie sur les données d'un projet de recherche-action concernant une intervention sur les phénomènes magnétiques. La recherche-action s'est déroulée dans une classe de maternelle à Patras-Grèce et l'équipe de recherche comptait deux personnes: une enseignante de l'école maternelle et une chercheur-facilitateur. L'analyse qualitative du contenu a été utilisée et le processus d'analyse a été appliqué par les deux membres de l'équipe de recherche. En analysant le journal de l'enseignante et en suivant pas à pas la manière dont elle a mis au point l'intervention scientifique, visant principalement à développer les idées, les intérêts et les questions des enfants, nous avons cherché à mieux comprendre le rôle de l'enseignant dans l'apprentissage des sciences dans le contexte de l'éducation préscolaire. Des activités de jeu libre et structuré ont été mises en œuvre et mutuellement interchangées. Les résultats ont indiqué quatre rôles principaux de l'enseignante, mobilisés dans différents contextes, et quatre ressources sur lesquelles elle s'appuie en essayant de mettre en œuvre l'intégration de l'apprentissage des sciences avec des activités de jeux. La limite principale de la recherche concerne le choix

méthodologique de l'étude de cas. Les données provenant d'autres classes et enseignants pourraient enrichir les résultats actuels.

MOTS-CLÉS
Education préscolaire, enseignement des sciences, jeu libre/structuré, rôle de l'enseignant

INTRODUCTION

As research has shown, early childhood education (from now on ECE) teachers are not systematically stimulating children's science learning. When they try to teach science, they are facing challenges such as feelings of discomfort (Pendergast, Lieberman- Betz & Vail, 2017), lack of content knowledge and appropriate pedagogical strategies (Kallery, Psillos & Tselfes, 2009; Kambouri, 2016; Kavalari, Kakana & Christidou, 2012). They do not always elicit children's ideas prior teaching (Kambouri, 2016), and when they do so seem unsure of how to use this information for planning next science activities, while they often hold a traditional and romantic view of children's thinking, instead of considering them as competent learners (Papandreou & Kalaitzidou, 2019). Lack of time and science materials or lack of confidence to use effectively the materials is another factor that constrains teachers from implementing science teaching in their classrooms (Nayfeld, Brenneman & Gelman, 2011; Tu 2006). Previous research also suggests that the way teachers teach science in ECE is influenced by both their assumptions for the young child and their general pedagogical practices (Fleer, 2009) which actually include institutional, social and cultural features (Areljung, 2018; Ljung-Djärf, Magnusson & Peterson 2014). These practices often constrain teachers from allowing children to develop scientific thinking. For example, traditional empiristic pedagogies, which have been revealed in Greek kindergarten classrooms (Kallery et al., 2009; Kavalari et al., 2012), may influence teachers to focus on transferring scientific knowledge to children's thinking and maintain 'a strong leadership role' (Ravanis, 2017, p. 285). Instead, traditional play pedagogies featured in Scandinavian and Australian EC settings which promote children's own exploration usually fail to maintain the children's focus on the object of learning and make explicit the scientific meaning of their investigation (Areljung, 2018; Fleer 2009; Gustavsson, Jonsson, Ljung-Djärf & Thulin, 2016). These findings may imply as Fleer (2009, p. 1074) highlights, that "science content knowledge alone is not the only contributing factor" for teaching science effectively in ECE, while she added that this issue is quite complex and depends on various "important factors".

As many initiatives related to early science teaching are rapidly expanding, nowadays, (i.e. the related research is growing, science is part of the national ECE curriculums, ECE teacher degrees, and professional development projects), many ECE teachers' qualifications in science teaching are enhanced and the challenges these teachers face may be more refined and diversified than the previous ones (Areljung, 2018). Thus, except of investigating generally teachers' practices, attitudes and views towards teaching science in ECE, as many studies have already done, another way to address both the well-known and the current challenges they confront when they teach science is to additionally study in depth how experienced teachers, experts in science teaching, deal with it in their classrooms. Thus, in this study, by analysing a teacher's diary and following step by step the way she developed a play-based science intervention related to magnetic phenomena, we seek to enhance our knowledge of the different roles a teacher may enact and the resources she draws on in order to handle various challenges during such play-based teaching.

THEORETICAL BACKGROUND

Available research demonstrates that early science learning can occur not only through prescribed curriculum and teacher-led activities, but also in other forms and contexts not always pre-planned, which integrate play-based pedagogies. Literature on science play-based teaching and learning integrates two main research fields, play pedagogies and early science teaching and learning. Although, traditionally play and learning have been separated for various reasons, nowadays scholars from around the world increasingly criticize this polarized perspective by considering their relation through the perspective of cultural-historical theory. For establishing this dialectical relation, they foreground critical features of play and investigate how these contribute in learning. Play gives meaning to everyday actions, objects and concepts, includes authentic interactions and multimodal communication, triggers imagination and creativity, generates interest, emotional and conceptual involvement, reveals experience and knowledge, and motivates investigation and problem-solving (e.g. Broström, 2017; Fleer, 2010; Ridgway, Quinones & Li, 2015; van Oers, 2013).

In line with this perspective and based on Vygotskian ideas for the formation of concepts (Vygotsky, 1978), scholars suggest approaches for conceptual learning in science through play. Play is considered as the leading activity for young children (Bordova & Leong, 2015), in which they bring among others a variety of everyday concepts related to science (Larsson, 2013; Sikder & Fleer, 2015). Therefore, in this context, where children's funds of knowledge provide a framework for meaningful learning, there are opportunities for creating links between everyday and scientific concepts (Fleer & Pramling, 2015). In that sense, science teaching can emerge from children' free play activities, spontaneous queries and incidental discoveries, and thus science learning can be built on their perspectives and interests, everyday knowledge and experience by the thoughtful teacher's involvement (Fleer, 2009; Larson, 2013).

However, researchers who investigate open approaches for teaching and learning science in ECE focus their attention to the crucial role the teacher has (Cutter-Mackenzie, Edwards, Moore, & Boyd, 2014; Fleer, 2009; Gustavsson et al., 2016). From this point of view, the teacher except of knowing science needs to know more importantly how children's everyday knowledge is related to scientific concepts and more importantly however, how, following their perspectives, to create bridges for allowing children to connect these two kinds of knowledge. Thus, for early science teaching, "the challenge goes beyond content knowledge to teacher beliefs and pedagogy practices" (Fleer, 2009, p. 1074).

This actually raises important questions, including: How teachers can monitor and use children's ideas and interests stimulated by available materials or children's incidental observations of natural phenomena? How they can follow children's perspectives and enhance their participation and interest, and at the same time, direct and maintain children's attention to the learning object, and allow them to develop their scientific thinking?

Aim of the study

This study aims to develop knowledge of the teacher' role to science learning in ECE, when free and guided play activities are implemented and mutually interchanged. We seek to identify how an experienced ECE teacher who integrates contemporary aspects of play-based pedagogies plan science learning in her daily practice and what are the features of her roles throughout an entire play-based science intervention. The research questions are formulated as follows:

- How the teacher's roles of planning, implementing, and assessing are situated in the specific context of play-based science interventions?

- How those roles are related to the specific resources of the teacher?

METHODOLOGICAL FRAMEWORK

Research design and participants

This study stemmed from an action research project, which has been designed collaboratively by a researcher and an ECE teacher with the purpose to challenge and develop the teacher's practices related to science teaching and learning. The action research design was guided by two key questions. What are the required changes in the teacher's science educational practice, so as to respond intentionally to the children's specific everyday ideas and interests? How she could enhance children's autonomy and allow them to co-guide the flow of free and structured play activities, and simultaneously, keep their focus on the object of learning?

The ECE teacher had 18 years of teaching experience, postgraduate and doctoral studies related to science teaching in the kindergarten school. This was the third time she participated in an action research project (the two previous ones concerned different topics). She systematically integrates science teaching into her curriculum, which is intentional and includes, among others, practices for eliciting children's ideas, explicit objectives, play activities and investigations, multimodal forms of communication and parents' participation.The teacher worked in a kindergarten school situated in an area near the center of Patras (city in the south Greece) with 21 students, 10 girls and 11 boys, 16 children from 5-6 years old and 5 children from 4-5 years old.

The intervention

The intervention lasted approximately four months. The main teaching objectives concerned children's facilitation to get familiar with three teaching contents related to magnetic phenomena: a. materials attracted and not attracted to the magnets, b. magnetic forces (attraction-repulsion), c. the magnetic field. Four phases can be distinguished in the teaching intervention: 1. investigation of children's initial ideas, 2. the learning center "the box with the magnets", where free-play activities were dominant, 3. a sequence of structured-play activities, and 4. final assessment.

Data gathering

Data included field notes, photographs and video-taping, which were provided by the teacher's observation and documentation of children's play, as well as the teacher's diary. The diary includes the detailed description of the whole intervention, her discussions with the facilitator, her thoughts, decisions and choices taken before, during and after the intervention (related to the specific learning objects, her pedagogy and teaching strategies, her knowledge of the content, of her students' ideas etc.). In this paper, we examine only the teacher's *voice* as it was expressed in her diary.

Data analysis

A qualitative content analysis (Cohen, Manion & Morrison, 2007) was used and the analysis process was applied by the two members of the research team (the teacher and the facilitator) according to the following process:

- they independently studied the teacher's diary aiming at identifying the different roles enacted by the teacher (they came to an agreement on identifying four roles),

- they independently studied the data and divided the text into passages according to the main teacher's role identified in each specific passage (they came to an agreement on dividing the text into 60 passages to each of which only one role was attributed),
- they studied the data again in order to identify different categories of contexts in which the roles were mobilized and different resources to which the teacher referred while describing the intervention,
- they decided on the main categories and subcategories,
- they restudied the data in order to codify them according to these categories and subcategories.

Thus, two different procedures were followed: an open codification in the beginning of the analysis and a closed one at the final steps (Corbin & Strauss, 2008; Flick, 2009).

RESULTS AND DISCUSSION

The analysis of the texts from the teacher's diary led to the formation of four roles. Thus, while developing and implementing the science intervention on magnetic phenomena with free and guided play activities, the kindergarten teacher: a. *planed*, b. *introduced*, c. *observed* / *listened and reflected on*, and finally d. *responded to critical incidents* (see Table 2, column 1). These roles alternated throughout the four-month course of the program, in a way that two consecutive passages share very rarely the same role. A pattern that appears quite often is the following succession of the teacher's roles: "plans" and/or "introduces", "observes/listens and reflects on" (see Table 1), indicating that the intervention was designed and implemented through a step by step process, that focused on teacher's observations and reflections.

TABLE 1

Pattern of the succession of the teacher's roles

Passage n.1-3:	Plans	Introduces	Observes/listens & reflects on
Passage n.4-5:		Introduces	Observes/listens & reflects on
Passage n.8-10:	Plans	Introduces	Observes/listens & reflects on
Passage n.11-13:	Plans	Introduces	Observes/listens & reflects on
Passage n.18-19:		Introduces	Observes/listens & reflects on
Passage n.20-21:		Introduces	Observes/listens & reflects on
Passage n.23-24:		Introduces	Observes/listens & reflects on
Passage n.25-27:	Plans	Introduces	Observes/listens & reflects on
Passage n.31-32:		Introduces	Observes/listens & reflects on
Passage n.33-34:		Introduces	Observes/listens & reflects on
Passage n.47-48:		Introduces	Observes/listens & reflects on
Passage n.50b-52:		Introduces	Observes/listens & reflects on
Passage n.53-55:	Plans	Introduces	Observes/listens & reflects on
Passage n.57-59:	Plans	Introduces	Observes/listens & reflects on

The teacher enacted the four roles according to eleven contexts: for example, she planed *the course of the educational program*, or she introduced *a guided play activity*, she observed and reflected on *children's reasoning*, or she immediately responded at *children's lack of interest* (see Table 2, column 2). At the same time, and according to the teacher' descriptions in her diary, when she enacted the different roles in each specific context, she mobilized different resources

that can be grouped into four categories: a. her *pedagogical profile* (her teaching experience & pedagogical practices, the practices she uses for professional development, her disposition to try new teaching strategies), b. her *knowledge of science Didactics and/or of the specific teaching content* (her experience and knowledge of science Didactics in general, of the specific content and of teaching magnetism), c. *data obtained from her own students* (regarding her students relevant experiences, their prior ideas, their usual reactions, or the learning profile of specific students), d. *discussion with the research facilitator* (see Table 2, column 3). The roles, contexts and resources identified in the teacher's diary are presented in Table 2.

TABLE 2

The teacher's roles identified in the teacher's diary, the specific contexts in which these roles are enacted, and the recourses upon which the teacher draws

Teacher's roles	**…mobilized in these specific contexts**	**Teacher's resources*** **
The teacher **plans** (12)*	…the teaching content (2)** ...the flow of the intervention (7) ...the formalization of children's experiences (4) …guided play activities (4)	Teacher's pedagogical profile (14)** Teacher's knowledge of science Didactics & the teaching content (12) Data about her pupils (6) Discussion with the Facilitator (2)
The teacher **introduces** (18)	…guided play activities (12) …a learning center (1) …a routine/process e.g. of formalization (5)	Teacher's pedagogical profile (5) Teacher's knowledge of science Didactics & the teaching content (14) Data about her pupils (4) Discussion with the Facilitator (-)
The teacher **observes/listens & reflects on** (22)	…children's reasoning (16) …children's respond (15) …parents' respond (1) …her practices (5)	Teacher's pedagogical profile (12) Teacher's knowledge of science Didactics & the teaching content (18) Data about her pupils (34) Discussion with the Facilitator (2)
The teacher **responds in critical incidents** such as (8)	...a crisis in children's relations (1) ...children's suggestions for activities (4) ...an opportunity for teaching science content (1) ...the lack or presence of children's interest (2)	Teacher's pedagogical profile (4) Teacher's knowledge of science Didactics & the teaching content (7) Data about her pupils (6) Discussion with the Facilitator (1)
*The text of the teacher's diary was divided into a total of 60 passages, according to the four teacher's roles identified. The total number of the text passages in which these roles were identified is presented in parenthesis. **In some passages more than one context or teacher's resource, were identified. ***A total of 141 teacher's references to different resources were identified in the 60 passages of the diary.		

The role the kindergarten teacher mobilizes most often is the one entitled "*the teacher observes/listens & reflects on*" (in 22 text passages of a total 60, Table 2). The title of this category shows that whenever the teacher describes in her diary the children's reasoning and/or respond, the parent's respond or her practices, she associates these descriptions with self-reflective comments. In Table 3 we present an exemplary excerpt of this category showing also that the teacher often refers both to the children's respond and their reasoning (in half of the cases both contexts were identified in the same passages). The excerpt shows what the teacher observed: the children' endeavors to invent new constructions with the material provided and their responds after making their creations (Table 3, a). More importantly however, it demonstrates what follows this observation: the teacher reflects on children's reasoning noting the fact that some children did not focus on the object of learning (Table 3, b). They simply described the external features of their constructions (for example, fixing various plastic parts

from a toy with some magnets, P. presents her construction saying that "this is a carousel for the baby" and when asked how she made it she repeats the construction and says "I put this here and this here…"), without referring to the magnets, or the magnetic properties, and the teacher seeks how to deal with this challenge. Another fact, related to the reflective attitude of the teacher on children's respond and reasoning is the resources she mobilizes in order to decide her next actions. As it is shown in Table 2, the most frequent resource in which the teacher drew upon when she enacted the role "*observes/listens & reflects on*" was the "*data about her pupils*" (34 in total). It seems that, aiming at changing her practice to incorporate more student initiatives into science teaching, this teacher mainly took up a process of observation and reflection focusing on her students' individual characteristics.

TABLE 3

Exemplary excerpt from the teacher's diary regarding the role "*Observes/listens & reflects on*"

Excerpt 17 from the teacher's diary	**Teacher's role**	**…mobilized in these specific contexts**
a [Gradually they began to run after me to tell me what they discovered, to ask me persistently to take pictures of their constructions, to ask if they could play with the box of magnets. After a while they decided on their own about whom they would play with.] **b** [I was troubled by the fact that some children while talking to me about their constructions they did not mention the magnets, or the magnetic properties, or anything else about the materials. They seemed to reason exclusively on a imaginative level and did not enter the field of natural sciences. Their reasoning had nothing to do with the materials and their properties. I discussed it with M. (i.e. the facilitator) and she suggested to try formulating questions on "how they made it", the airplane, the garage ...]	The teacher observes/listens & reflects on	…children's respond(**a**) …children's reasoning(**b**)

In general, the teacher seems to refer more often to resources coming from the main categories b. "*teacher's knowledge of science Didactics & the teaching content*" and c. "*data about her pupils*", less frequently form category a. "*teacher's pedagogical profile*", and only five times to resources concerning category d. "*discussion with the facilitator*" (see exemplary text excerpts in Table 4). The resource she mainly used was "*her knowledge & experience in teaching the specific content-magnetic phenomena*" (45 in a total of 141, see Table 4). It seems that referring to her knowledge and experience in teaching the specific content, was essential for the kindergarten teacher in order to organize and comment on the implication of the play-based intervention. This evidence, expressed actually by the teacher's voice, confirms the importance which has been assigned by the science education community to the teachers' content knowledge for effective science teaching and learning (e.g. Hedges & Gullen, 2005; Kallery et al., 2009; Saçkes, 2014). However, this resource does not include only her knowledge of the specific content. It also encompasses her knowledge of teaching magnets in early science, since as Broström (2015, p. 111) highlights "the how and what question are united and cannot be separated".

The "*teacher's experience and pedagogical practices*" and "*her disposition to try new teaching strategies*" were resources to which the teacher referred quite often (18+12, Table 4), but her knowledge of her students' ideas and the way they usually respond and reason

(17+18+10, Table 4), seem to have a priority in her writings. This evidence is of great importance as it reveals two issues, which are in accordance with current suggestions of eminent researchers from the field of early science teaching (Fleer, 2009; Larson, 2013; Sikder & Fleer). First, except of content knowledge, it seems that the ECE teacher needs a strong pedagogical foundation, which constantly should to be enhanced with new approaches. Second, this kind of responsive teaching, which is grounded in children's cultural knowledge, their perspectives and initiatives, builds actually -using Vygotsky's terms- on children's everyday concepts and promotes their conceptual learning.

Only 5 references to discussion with the facilitator, all of which on teaching methodology issues, is not a surprising evidence, since the teacher was experienced in science teaching and her main purpose was exactly to make changes on her teaching methodology by incorporating free play in the science teaching.

TABLE 4

Exemplary excerpts from the teacher's diary regarding some of the teacher's resources

Categories of teacher's resources*	**Teacher's resources (subcategories)**	**Exemplary excerpts from the teacher's diary*****
Teacher's pedagogical profile (35)**	her teaching experience & pedagogical practices (18)	[the teacher introduces …a learning center]**** *I have set some safety rules (we do not throw the magnets), rules for material protection (we play only on the rug) and for the children's cooperation (we share), along with those they already know from the play in the other learning centers.*
	the practices she uses for professional development (5)	
	her disposition to try new teaching strategies (12)	
Teacher's Knowledge of science Didactics & the teaching content (51)	her knowledge & experience in science Didactics in general (6)	[the teacher observes/reflects on …children's respond] *In the past years I suggested to the students to make statues with magnets, but this time the children made masterpieces. I could not have thought about such constructions.*
	her knowledge & experience in teaching the specific content-magnetic phenomena (45)	
Data about her pupils (49)	her knowledge of her students' family-school experiences (4)	[the teacher observes/reflects on …children's respond & …children's initial ideas] *It was a great success because they were eager to become magnets, all wanted to play, and it seemed they had no longer difficulties in recognizing which objects were attracted by the magnets and which were not.*
	her knowledge of her students' initial ideas on magnetic phenomena (17)	
	her knowledge of her students' usual respond (18)	
	her knowledge of specific children's reasoning (10)	
Discussion with the Facilitator (5)	on teaching methodology (5)	[the teacher plans … the flow of the intervention] *I was anxious to start with the structured play activities, but I discussed it with M. (the facilitator) and she suggested me to prolong the phase of the free play and not to rush.*

*Total references to different resources forming the 4 categories: 141.
**The total number of the text passages in which these resources were identified is presented in parenthesis.
***Excerpts of the text in column 3 refer to the teacher's resources that are shaded gray.
****The role of the teacher and the context identified in each case are provided in brackets.

CONCLUSIONS

Conceptual learning through play pedagogies is a rather current approach for teaching and learning in early science, which focuses mainly on the integration of open forms of play, where the children have the control of the activity. This trend is guided by an essential argument for the role of play for content learning. In the context of play the child brings her everyday knowledge and experience, which among others includes various everyday concepts related to science. Because of that, play provides a dynamic context for meaningful learning in school, and thus, may allow children to make links between everyday and scientific concepts, though with the appropriate teacher's involvement (Cutter-Mackenzie et al., 2014; Larson, 2013; Fleer & Pramling, 2015). This could imply for classroom practice in science, the interchange of structured and free play activities.

In line with this viewpoint, our implicit purpose in this study was to form a model for integrating such a play pedagogy with science teaching and learning in ECE. We tried to address this issue, by investigating the voice of an experienced kindergarten teacher illustrated in her diary, on how she handled the integration of science learning with play during a four-month action research project.

We identified four main roles, which are enacted in various contexts by the teacher. As our findings indicated the teacher altered these roles, so as to follow step by step her children's responding and reasoning through careful observations and reflection. This practice showed a kind of responsive teaching, which kept a striking balance during the whole project between the roles of "*planning*" and "*introducing*" from the one side, and the roles of "*observing-reflecting children's actions*" and "*responding in critical incidents*" on the other side.

Another noteworthy evidence revealed in the teacher's practice is the strong link between observation and reflection. This demonstrates the intentional use of observation and documentation by her, which scarcely is encountered in ECE classrooms. It seems that the teacher in order to use children's everyday knowledge and experience, enhance their participation and interest, and at the same time, maintain their attention to the learning object, deliberately monitors their actions and reflects upon them, at each phase of the project.

Except of highlighting the features of the teacher's thoughtful practice, this study also revealed three essential resources, which seem to be the foundation that allowed the teacher to orchestrate the science intervention by performing and altering carefully the four main roles. The teacher drew equally upon her knowledge of a. her students and b. the teaching of magnets, while she also mobilized, though less frequently, features of her c. pedagogical profile. In the past, a great deal of research highlighted these factors as important for teaching science, but this study showed the way that these resources are articulated with each other by an experienced teacher during her practice in the classroom and how each component of the teacher's knowledge contribute to the enactment of the different roles during the science intervention.

Although the research findings broaden our knowledge of the integration of science learning with play and allow us to analyze how the teacher can accomplish such an endeavor in ECE, the study has specific limitations. The main one could be its narrow range as it was a case study. Data from other classrooms and teachers would enrich the present findings. Additionally, since in this article we did not present data from children's achievements during the project, it would be fruitful to examine in parallel both the teacher's and the children's actions. Last but not least, the analysis of how the teacher planned, introduced, observed and reflected on the different forms of play (free and guided) during the intervention would strengthen the results of the study.

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