

Early years teachers' late concerns and perceived needs in science: an exploratory study

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Science in early childhood is of great importance to many aspects of children's development. Planning for improvement of science instruction should take into consideration the problems teachers encounter in their performance of their task. However, exposition of problems of early years teachers, especially those with many years of experience, is somewhat rare in science education literature. The purpose of the present work was to investigate those factors that hinder experienced early years teachers in the performance of their task in science, and their needs, as perceived by the teachers themselves. The study was carried out in Greece. One take-home written task and two group interviews were used for data collection. Qualitative approaches were employed for the analysis of the data. The emergent themes related to teachers' problems, teachers' worries induced by these problems, problem consequences and teachers' perceived needs in science.

La science sur la précoce enfance est très importante pour beaucoup des aspects de la développement des enfants. Il faut que le croquis de l'instruction de la science aille considérer les problèmes que les instituteurs affrontent. Mais, dans la littérature de l'instruction de la science, il n'y a pas beaucoup des instituteurs, spécialement des expérimentes, qui exposent leurs problèmes. Le but de présent travail était l'investigation de ces facteurs qui empêchent les instituteurs expérimentes de travailler dans le secteur de la science sur la précoce enfance; et, aussi, leurs besoins, conformément a eux-mêmes. Le travail était réalisé en Grèce. Un travail, écrit à la maison, et deux interviews des groupes étaient utilisées pour la collection des éléments. les résultats concernaient les problèmes des instituteurs, les inquiétudes des instituteurs à cause de ces problèmes, les conséquences des ces problèmes et les besoins des instituteurs de la science sur la précoce enfance.

La ciencia en la primera infancia es de gran importancia en muchos aspectos del desarrollo de los niños. La planificación para mejorar la ciencia de la educación debe tomar en consideración los problemas que encuentran los profesores en la realización de su tarea. Sin embargo, la exposición de problemas de las profesores de primera infancia, especialmente la de los que tienen muchos años de experiencia, es algo rara en la literatura de la ciencia de la educación. El propósito del actual trabajo era investigar esos factores que obstaculizan a profesores experimentados de primera infancia en la realización de su tarea en la ciencia y de sus necesidades, según lo percibido por los mismos profesores. El estudio se llevo a cabo en Grecia. Una tarea escrita para realizar en casa y dos entrevistas del grupo se utilizaron para la recogida de datos. Se emplearon aproximaciones cualitativas para el análisis de los datos. Los temas que surgieron se relacionan

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con los problemas de los profesores, las preocupaciones de los profesores inducidos por estos problemas, las consecuencias del problema y las necesidades percibidas por los profesores en la ciencia.

Die Naturwissenschaften sind von großer Bedeutung im früheren Kindesalter bei vielen Aspekten der Kinderentwicklung. Beim Planen der Unterrichtsvorbereitung müssen die Probleme, mit denen sich die Lehrer auseinandersetzen, mitberücksichtigt werden. Doch die Bekanntgebung der Probleme der Vorschulerzieher, vorallem der mit langer Berufserfahrung kommt selten in der Erziehungsbibliographie der Naturwissenschaften vor. Diese Studie hatte als Ziel die Faktoren zu erforschen, die die Erzieher bei ihrer Arbeit hindern und ihre Bedürfnisse wie sie von den Erziehern selbst wahrgenommen werden. Die studie wurde in Griechenland durchgeführt. Ein schriftliches Referat und zwei Gruppeninterviews dienten der Angabensammlung. Qualitative Annäherungen wurden bei der Angabenanalyse verwendet. Die Themen, die sich ergaben, beziehen sich auf die Probleme der Erzieher, ihre Besorgnis wegen der Probleme, auf die Problemkonsequenzen und auf die Bedürfnisse der Erzieher in den Naturwissenschaften, wi sie von ihnen selbst wahrgenommen werden.

Introduction

In contemporary society, early childhood science that is meaningful and relevant to the lives of pupils and contributes to aspects of their development is considered of great importance. Modern beliefs maintain that appropriate scientific work can and should begin in infant classes (e.g. Harlen & Jelly, 1989; Chaille & Britain, 1991; Duckworth, 1996; Frost, 1997). Achieving this is not a simple task that can be accomplished with the mere introduction of new materials or technological gadgetry into the classrooms: there is growing realization of the importance of professional upgrading for teachers as well (Dass, 2001). As Sparks (1983) notes, 'Staff development offers one of the most promising roads to the improvement of instruction'.

Teachers' concerns are among the many factors that need to be investigated in order to provide a foundation upon which to base development of, or improvements to, teachers' professional upgrading programmes on the one hand, and changes in the context of teachers' work so that specific objectives are met on the other.

Fuller (1969) distinguishes teachers' concerns as 'early' and 'late'. She defines 'early concerns' as the perceived problems of student or beginning in-service teachers and 'late concerns' as perceived problems or worries of experienced teachers. Veenman (1984) sees a problem as a difficulty that teachers 'encounter in the performance of their task, so intended goals may be hindered'.

Fuller and Bown (1975) developed a model of concerns in which changes in the nature of the concerns are described as stages in the teacher's professional development. The first stage (concerns about self) is characterized by concerns about survival: mastery of content, class control, evaluation by supervisors. They are concerned about their own adequacy in fulfilling their role. In the second stage, concerns turn to teaching performance, the limitations and frustrations of teaching situations, methods and materials, explaining content to pupils, giving examples and answering questions. In the third stage, the teachers' concerns turn to pupils: the impact of their teaching on pupils' learning and their social and emotional needs.

Reviews of later research (e.g. Veenman, 1984; Kagan, 1992) on the concerns and

problems of beginning and experienced primary and secondary teachers have confirmed the Fuller and Bown (1975) model. Veenman (1984) has identified a number of problems mentioned by beginning teachers, the most common of which, in order of ranking, are: concerns about classroom discipline, motivating students, dealing with individual differences among students, assessing students' work, relations with parents, organization of class work, insufficient materials and supplies and dealing with problems of individual students. Veenman (1984) also reviewed studies (e.g. Rudd & Wiseman, 1962; Koontz, 1963; Olander & Farrell, 1970; Pharr, 1974) of problems reported by experienced primary and secondary teachers of different disciplines in several countries, which showed that experienced teachers were hampered by problems like overly large classes, unsatisfying social position, lack of parental interest, discipline problems, inadequate teaching materials, excessive administrative duties, unsatisfactory work conditions, teaching overload, student motivation, adaptation of instruction and inadequate building infrastructure. These studies show that several of the problems identified by beginning teachers were shared by experienced teachers as well.

The research reported above is of a general nature, and there have been few subject-specific studies (e.g. Zeitler, 1984; Appleton & Kindt, 1999; Bohning *et al.*, 1999) in areas such as primary teachers' science-related problems. Such studies as there are look mainly at prospective and beginning teachers and have identified concerns about science content (background knowledge, selecting interesting topics and appropriate content), about teaching performance (teaching science processes, teaching science content, answering pupils' questions), about self (self-confidence, knowledge of a variety of methods and activities, use of a variety of resources) and about pupils (pupil knowledge, number of pupils in a class).

Studies of the concerns of experienced teachers, however, are somewhat rare in science education literature. One recent study (Dass, 2001), which investigated the concerns of experienced K-8 (children ages 5-14) teachers associated with implementation of instructional innovations, identified concerns about capability, about the correctness of their work, about organizing and managing time demands, about the availability of materials and other instructional sources and about classroom management. But a search of the literature yielded no subject-specific studies of the science-related problems of early years teachers, whether prospective or beginning or experienced.

Considering the importance of science in early childhood, and the fact that early years teachers function in a complex context within which they are expected to have adequate knowledge in a number of fields, attention needs to be paid to what these teachers' problems and needs are in order to improve science instruction in the early years classroom.

It was in view of all the above that the present study was undertaken. The study was carried out in Greece and addresses the following questions:

- What problems do experienced early years teachers encounter in the performance of their task in science?
- In the context of early years science, what do experienced early years teachers

think they need in order to overcome their problems and improve science instruction in the early years classroom?

The results of this study address these teachers' perceptions of what hinders them in meeting the objectives of the proposed science curriculum and of what their needs are in overcoming these difficulties. Since the results of the present work reflect the voice of the early years teacher, they can have important implications on the one hand for the development of activities for their professional upgrading in science, and on the other for curriculum and system changes that would provide appropriate conditions for achieving the objectives of early years education in the above field.

The study

Participants and contextual information

Eleven Greek early years teachers participated in this study. They were all female (the majority of early years teachers in Greece are female) and had an average of 15 years of teaching experience. The recruitment of the teachers was done from a randomly selected number of schools, and the teachers forming our sample were those who agreed to participate in this study.

In Greece, early years teachers are required to implement a curriculum that introduces children of 4–6 years of age to basic science concepts and natural phenomena. This curriculum was based on those of other countries with a greater tradition in this level of education, including Belgium, France, Canada and Cyprus.

The National Curriculum for Greek pre-primary education (1990) distinguishes two kinds of activities: 'free' activities for the children, being activities chosen and carried out by the children themselves without direct teacher involvement, and 'teacher-organized' activities, being activities planned and organized by the teachers in accordance with objectives that have to be met.

The topics for science activities come from units of material that the curriculum calls 'cycles of knowledge and experiences'. These are:

- (a) acquaintance with the physical properties and characteristics of objects (colour, weight, temperature, material properties such as the property to float or sink, to melt, to dissolve in water, etc.)
- (b) acquaintance with the natural environment which includes: living things (plants and animals), natural phenomena (the phenomenon of gravity, atmospheric phenomena such as water evaporation, rain, snowfall, rainbow, etc.) scientific concepts (sound, light, motion, magnetism, etc.) and the Earth and Outer Space (with topics on earth, sun, moon and the phenomenon of day and night).

Teachers are required to select topics for science activities from the above units, decide their content and the didactic approach they are going to use and choose the appropriate materials. The usual duration of these 'teacher-organized' science activities is 30 to 40 minutes, and teachers are required to organize such activities once a week.

The curriculum states that children should be actively involved in the activities,

both mentally and physically. They should experiment with materials and carry out investigations. Instruction materials should be displayed in the 'science corner' of the classroom ahead of time, so that the children can explore and become familiar with them. Children should use the science process skills of observation, prediction, classification and drawing of conclusions. The curriculum stresses the importance of teachers setting up problem-solving situations by asking appropriate questions. Finally, the curriculum states that children should work in an atmosphere that cultivates inquiry, autonomy and initiative.

It is clear from the above that the science curriculum for Greek pre-primary education makes considerable demands of the early years teacher who is called upon to implement it. It should be noted that in Greece, as in many other countries, these teachers' post-secondary education has centred mostly on educational sciences and humanities, with some elementary mathematics, but very little or nothing of natural sciences (Vicentini-Missoni, 1980).

Design and procedure

The research reported in this paper is qualitative. It was designed as a small-scale exploratory study, with data obtained from three sources: one take-home written task and two group interview sessions. In the written task teachers were asked (a) to report and elaborate on the problems they encounter when developing and introducing science activities to the young children, and (b) to describe their needs and the support they think they should have in order to overcome their problems and improve science instruction in early years education.

Teachers were given one week to prepare their reports. Each teacher produced a written protocol of an average of 600 words. To supplement and clarify the information derived from the written assignment, two group interview sessions were held, each of about 90 minutes' duration. Group interview was chosen because it presents opportunities for interaction between participants, development of discussions of points that may come up spontaneously, production of a broad spectrum of answers and stimulation of unanticipated but useful trains of thought in the participants (Cohen & Manion, 1997). Prior to the interviews, the author—who acted as researcher as well as interviewer—conducted preliminary analyses of the teachers' written protocols in order to identify the predominant themes. This assisted the researcher in deciding the focus of the interviews and in forming probing and clarifying questions during their course. The interviews were recorded and transcribed.

Data analysis and results

A three-level analysis system was used to interpret the data protocols (written assignments and group interviews). Initially, the data were repeatedly read and the most striking and ultimately most important aspects were isolated. These data were then unitized; i.e. units of information (phrases, sentences or paragraphs), which later served as the basis for defining categories, were identified. In the second level

of analysis, a constant comparison technique was used to sort units of information into internally homogeneous categories. At the third level, the categories were organized into themes (Merriam, 1988; Strauss & Corbin, 1990). The interpretation of the data was informed by the definitions of ‘late concerns’ and ‘problems’ given by Fuller (1969) and Veenman (1984) respectively (see introduction). In the present study the word ‘worries’ is used to describe teachers’ emotional responses to problems they encounter.

In order to validate interpretations, member checks—‘taking data and interpretations back to the people from whom they were derived and asking them if the results are plausible’—were used continuously throughout the study (Guba & Lincoln, 1981; Merriam, 1988) and peer examination—‘asking colleagues to comment on the findings as they emerge’—was employed in the devising of categories and themes (Merriam, 1988).

The main themes and their categories that emerged from the data analysis are the following:

- (1) Problem
 - (a) Level 1: Knowledge-related
 - Other
 - (b) Level 2
- (2) Worries
- (3) Consequences
 - (a) Teacher
 - (b) Pupils
- (4) Perceived Needs
 - (a) Educational
 - (b) Other

An itemized presentation of each of the above themes and their categories is given in Tables 1–4. Findings are reported only if they were expressed by at least seven of the participating teachers, and are not ranked, since only the most important of them are mentioned. Results are presented analytically and representative examples are given below. It emerges that the teachers correlate the first three of the above themes in the manner presented in Figure 1.

Problems

Teachers’ problems were organized in two categories. ‘Level 1’ and ‘Level 2’. ‘Level 1’ includes those problems reported by the teachers that, in their view, lead to ‘Level 2’ problems (see Figure 1 and Table 1). ‘Level 1’ problems were classified in two subcategories according to their nature: ‘knowledge-related’ and ‘other’. The first subcategory includes problems concerning teachers’ knowledge of the subject matter and teachers’ knowledge of appropriate didactic approaches (methodology). Insufficient knowledge of the subject matter was reported by all of them as constituting

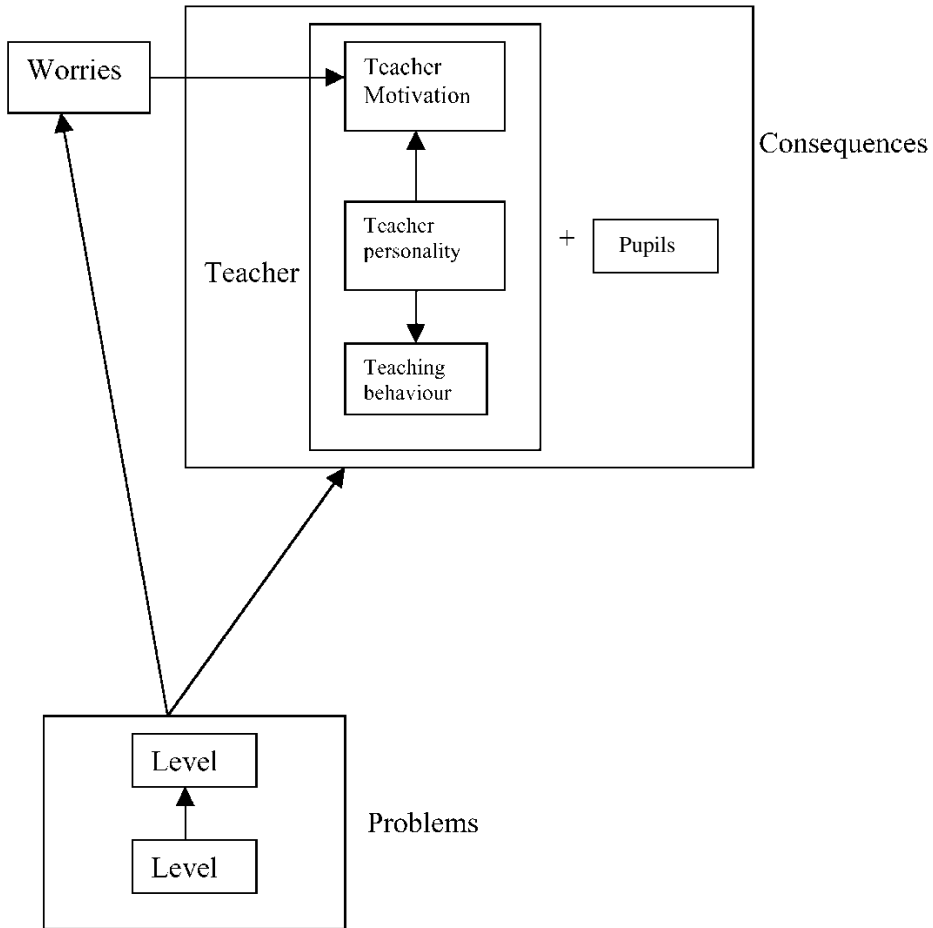


Figure 1. Correlation model of teachers' problems, worries and their consequences

one of their most serious problems: *'My greatest problem, which puzzles me and makes me feel tense in teaching science, is my ignorance of basic science issues'*.

The second subcategory of problems, labelled 'other', includes problems concerning school infrastructure and guidance, support and evaluation of teachers' work in science. It is interesting to note that most of the teachers of the present study attributed the inadequate guidance and support and superficial evaluation of their work in science on the part of the educational advisors to the fact that these advisors are not specialists in science but advise on all subjects on the pre-primary curriculum.

The difficulties (see Table 1) teachers reported facing when developing and conducting science activities for young children (Veenman, 1984) were characterized as 'Level 2' problems. As noted earlier, teachers consider that these difficulties stem both from their limited knowledge of the subject and of appropriate methodology and from factors categorized as 'other', i.e. from 'Level 1' problems. The majority of these difficulties, however, were felt by teachers to stem from their own

Table 1. Detailed presentation of problems reported by early years teachers

Problems	
Level 1: Knowledge-related:	<ul style="list-style-type: none"> – Insufficient knowledge of the subject matter – Insufficient knowledge of appropriate teaching methodology
<i>Other:</i>	<ul style="list-style-type: none"> – Inadequate teaching materials – Inadequate classroom space for science activities – Large class size – Absence of a teaching assistant in class – Inadequate guidance and support for their work in science by the educational advisors – Superficial evaluation of their work by the educational advisors
Level 2:	<ul style="list-style-type: none"> – Difficulty in interpreting and adapting content to make it comprehensible to young pupils – Difficulty in choosing appropriate concepts and topics for science activities – Difficulty in forming science activity plans – Difficulty in choosing appropriate instruction materials for science activities – Difficulty in answering children’s science-related questions – Difficulty in organising classroom work – Difficulty in classroom management

insufficient knowledge of the subject matter. Characteristic examples include the difficulty in selecting appropriate instruction materials for science activities: ‘Good knowledge is for me the prerequisite. When I know the subject well it is not that difficult for me to choose instruction materials. I know what I need to teach it’; the difficulty in answering children’s science questions which, as most of the teachers reported and elaborated in their interview, is quite ‘disturbing’ for them: ‘I have great difficulties in answering children’s questions that need scientific explanations that I am not knowledgeable about’, ‘I have knowledge gaps in themes concerning outer space and most times I cannot deal with children’s questions related to their observations’; and the difficulty in adapting content to the young pupils’ level: ‘In order to adapt complex things so that they become comprehensible for young children without distortion, one needs to have very good knowledge of the subject’.

Teachers reported experiencing the most difficulties in topics relating to physics, atmospheric phenomena and outer space, and less in topics relating to biology (plants and animals) (see also Holroyd & Harlen, 1996): ‘I have great difficulties in explaining weather phenomena because I don’t have sufficient knowledge of these concepts and some of them are incomprehensible to me’.

Some of the teachers’ difficulties, such as the difficulty in managing the classroom during science activities, are felt by them to be induced by factors classified as ‘other’: ‘Twenty-five kids are too many for a class and I cannot manage it during science activities. I don’t have any assistance. They all want to see and touch and this is when I don’t know what to do’.

Finally, difficulty in organizing classwork and difficulty in choosing appropriate concepts and topics for science activities are examples of difficulties that teachers

Table 2. Early years teachers' worries

Worries
<ul style="list-style-type: none"> • – About the correctness of their science activities. • – About the extent to which their science activities are interesting and motivating for children. • – About their level of success in acquainting children with basic science issues and concepts. • – About the danger of creating misconceptions in children. • – About the safety of children during science activities.

consider to be induced by a combination of knowledge-related problems and of factors classified as 'other':

They [the curriculum] give us everything [a wide range of topics] and we have the choice. From one point of view it is good that in preschool they leave the freedom of choice to the teacher, but from another it is a double-edged knife. Our knowledge in science is limited and also I do not know which are the appropriate ones [concepts and topics] for the children's conceptual level. How do I know that I have chosen the right ones? We have no guidance. We need suggestions not solutions.

One of the complaints formulated by the early years teachers and worth reporting here is that, although early years education is crucial for children's cognitive and emotional development, the state has placed more emphasis and given greater priority to the higher levels of education. They also noted that, when special events or extra activities arise during the week, it is all too often the scheduled science activities that are cancelled in order to accommodate them (see also Appleton & Kindt, 1999).

Worries

The most serious of the teachers' worries that are induced by 'Level 1' and 'Level 2' problems are listed in the fairly self-explanatory Table 2. As can be gathered from this Table, most of these worries focus on the accuracy and quality of teachers' work in science and its outcomes for children. Some representative examples of teachers' statements reflecting their worries are:

I am worried that I may not manage to make kids comprehend some simple yet basic science concepts. My knowledge is poor and I may not be able to respond.

The level of my knowledge in science is low and so is my knowledge of different instruction techniques. What worries me is that my science activities may not attract the children's interest. The topics I choose and the way I organize the activities may be boring for the kids.

The other day we [the class] were making soap bubbles using straws and detergent solutions. I couldn't watch all of them, there are too many of them for one class without assistance, and I was very worried that they might swallow the detergent.

Consequences

Teachers referred to the consequences that they think their problems have. The

Table 3. Consequences of early years teachers' problems and worries

Consequences	
Teaching behaviour:	<ul style="list-style-type: none"> – Turn to more teacher-centred teaching approaches – Become more authoritarian
Teacher motivation to teach the subject:	<ul style="list-style-type: none"> – Avoid teaching science or do not carry activities through
Teacher personality:	<ul style="list-style-type: none"> – Lower self-confidence – Lower self-esteem – Bad self-image as teacher – Inadequacy – Insecurity – Guilt
Pupils:	<ul style="list-style-type: none"> – Eventual loss of interest

most important of them are listed in Table 3. Teachers believe that their problems have an impact on their teaching behaviour, their personality, their motivation to teach science and on the pupils' interest in the subject (see Figure 1).

For example, teachers consider that their insufficient knowledge of the subject matter often leads science activities to a dead end and consequently to their abandonment. Insufficient knowledge of the subject is also felt by teachers to be one of the factors that make them avoid teaching the subject or lead them to adopt more teacher-centred teaching approaches and a more authoritarian manner:

It has many times happened to me that I start working with a topic and in the course of the activity I decide to drop it because it doesn't lead anywhere. And of course from a certain point on the children aren't interested any more, and then I become sharper and more authoritarian.

My lack of knowledge of the subject and of methodology and my difficulty in adapting topics influence my teaching behaviour. My teaching becomes more teacher-centred. I try to control everything in the activity and I allow only questions that I can respond to.

Teachers consider that their problems, especially those related to their knowledge, also have an impact on their personality. Lower self-confidence, lower self-esteem, bad self-image as a teacher, inadequacy, insecurity, and even guilt were all reported by the teachers:

The problems we face in our work influence our self-confidence and therefore our personality ... My insufficient knowledge makes me insecure and stressed and this of course is reflected in my teaching.

Teachers also consider that some of their worries influence their motivation to teach the subject:

When I am worried about conveying incorrect knowledge to the children due to my lack of knowledge, this often makes me decide not to carry out science activities. I pull my shutters down and I don't touch it [the subject].

On the other hand, they consider that the changes they undergo in their personality affect their teaching behaviour as well as their motivation to teach the subject (see Figure 1):

This insecurity I feel and my low confidence because of my lack of knowledge put me under terrible strain, which in turn is reflected in my behaviour... For example I become more authoritarian.

You see, when you have no confidence to teach a subject or if you are possessed by a feeling of inadequacy you try to avoid teaching it. This is what happens with us and science activities.

Finally, teachers reported experiences showing certain consequences of their problems and associated difficulties for the pupils. The most serious of them is pupils' loss of interest in science activities.

One rainy day that was also thundering the children were very excited and curious. I tried to explain to them but it was hard. I tried to simulate the phenomenon. I used rubber balloons but nothing came out. I couldn't handle it. I felt so ridiculous. Then I tried to organize it the next day but the children weren't interested any more. Their enthusiasm had already evaporated.

Needs

An overview of teachers' needs as these are perceived by the teachers themselves is given in Table 4. As shown by this Table, teachers' needs can be classified in two categories: 'educational' and 'other'. Educational needs refer to the improvement of different aspects of teachers' knowledge: knowledge of content, knowledge of methodology and knowledge of ways to adapt content for young pupils. According to the teachers, improvement of their content knowledge—especially in physics—is their first priority. Teachers don't want just general education in science but improvement of their working knowledge of the subject at a level which would make them understand how some things work and would be useful to them to use with children. Teachers also indicated the need for a broader knowledge of didactic methodology in science for young pupils and for more information and suggestions on how to represent and formulate topics to make them comprehensible to young pupils.

'Other' needs related to guidance of their work in science, school infrastructure and state support. Teachers stated that in order for their work in science to be more correct and more effective, guidance by specialists in science and pedagogy is needed. They expressed the view that instruction of science in the early years is a multidisciplinary matter. They also stated that they need more systematic support of their work in the difficult and 'new' (as they characterized it) subject of science by the educational advisors. Teachers commented that they called it a 'new' subject since it was not included in their college curriculum, nor were they further trained for the implementation of the science aspects of the pre-primary curriculum.

Concerning school infrastructure, teachers believe that reduction of class sizes, the development of appropriate and adequate space by improving school buildings and

Table 4. Early years teachers' needs in science as perceived by them

Perceived needs	
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Educational:	<ul style="list-style-type: none"> – Working knowledge in science (especially in physics) – Broader knowledge of didactic methodology in science appropriate for young pupils – Knowledge of ways of representing and formulating science topics for young pupils
Other:	<ul style="list-style-type: none"> – Advice and guidance for their work in science by specialists in both science and pedagogy – Better support for their work in science by the educational advisors – Better school infrastructure (appropriate space for science activities, adequate instruction materials, classroom assistant) – Smaller classes – A teacher's guide – More attention paid by the state to pre-primary education

the provision of adequate instruction materials and of a guide that contains suggestions and explicit directions on how to develop science activities would contribute to the improvement of their work in science. Generally they believe that the state ought to pay more attention to the needs of pre-primary education, to teachers' professional upgrading and to the upgrading of school infrastructure.

Discussion

The present study provides some insights into experienced early years teachers' science-related problems and needs, as these are perceived by the teachers themselves. Findings indicate that, in the performance of their task in science, experienced early years teachers encounter a variety of problems that are related to their knowledge of the subject, to their teaching and to factors linked to school infrastructure and guidance, support and evaluation of their work in this subject. Results indicate that these teachers consider that their problems on the one hand have an impact on their teaching behaviour, personality and motivation to teach science and, on the other, are the cause of several of their worries about the quality and efficiency of their work and the quality of their teaching performance in science. Results also indicate that experienced early years teachers expressed two types of needs in science: educational needs, with the emphasis on improvement of their working knowledge of the subject, and needs related to school infrastructure and state support. We shall discuss the most striking of the findings, starting with the problems related to teachers' knowledge and teaching.

As indicated by the results, early years teachers consider their insufficient knowledge in science as one of their most serious problems and link it directly to a large number of the difficulties they encounter in the performance of their task in this field. Two of these difficulties, which raise interesting points for discussion, are difficulty in interpreting, formulating and representing content to make it compre-

hensible to young pupils and difficulty in answering pupils' science-related questions.

The ways of representing and formulating content to make it comprehensible to others constitute aspects of teachers' pedagogical content knowledge as these have been elaborated by Shulman (1986, 1987) and Tamir (1988). Teachers' difficulty in representing and formulating content to make it comprehensible to the young pupils reveals that experienced early years teachers also encounter the problem of inadequately developed aspects of their pedagogical content knowledge in science, which they consider as the result of their limited knowledge of this subject. The influence of teachers' subject matter content knowledge on different aspects of teachers' pedagogical content knowledge has been documented by previous studies (e.g. Leinhardt & Smith, 1985; Hashweh, 1987; Grossman, 1991), which examined the link between these two kinds of teachers' knowledge.

Regarding difficulty in answering children's questions, experienced early years teachers seem to have the common notion that the teacher has to be able to answer all the children's science-related questions. These questions often involve scientific issues that are quite important for the development of children's science concepts, but some of them are fairly complex. Answering all children's science questions would be impossible, and is also inadvisable (Harlen, 1999) because the answers to these questions 'even if the teachers know them might not be accessible to children of such a young age' (Kallery, 2000). Early years teachers do not seem to be aware of young children's question-handling techniques, and probably are not aware of the value of young children's science questions. Children's questions can constitute an invaluable tool in teachers' hands since, with guidance, they can lead children to investigations that stimulate their thinking, introduce them to lots of scientific information and bring them closer to understanding the issues involved (Harlen, 1996; Kallery, 2000). Turning young children's complex scientific questions into 'investigable' ones is an important skill, which, however, requires basic knowledge and good understanding of the issues involved on the part of the teacher (Kallery & Psillos, 2001). Ability to handle young children's science-related questions is therefore a matter as much of methodological competence as of subject content knowledge.

Comparison of the results of the present study with the results of other studies of the problems of experienced and beginning teachers (see literature review) yields the following interesting finding. While mastery of content is not one of the higher-ranking problems cited by the experienced teachers in these studies, it is one of the prime concerns of both experienced early years teachers and beginning teachers in the early stages of their professional development (e.g. Fuller & Bown, 1975; Zeidler, 1984). The comparison yields three more findings. First, both experienced early years teachers and those in the early stages of their professional development express concern with such teaching situation difficulties as class control, methods and materials, answering of questions and formulation of content. Second, the worries expressed by experienced early years teachers relating to the quality and efficiency of their work and the quality of their teaching performance in science are shared by teachers in the early stages of the above process. Third, the personality changes

reported by experienced early years teachers, such as becoming less confident and more insecure, and behavioural changes such as becoming more authoritarian, coincide with the teacher personality and behaviour changes occasioned by the 'reality shock' undergone by beginning teachers as they assimilate the complex reality of their first period of actual teaching (Veenman, 1984). It seems, therefore, that the problems that experienced early years teachers encounter in the teaching of science cause them to fall back into an earlier stage of their professional development in this field.

Plausible reasons for this could include the fact that, while teachers may be expected during their student period to acquire their basic content knowledge of the subjects that they are called to teach (De Jong *et al.*, 1999), early years teachers do not seem to acquire such knowledge in science since in Greece as in other countries their education centres on subjects other than science (see contextual information). Further, the development of these teachers' pedagogical content knowledge in science, which is mainly expected to develop once they start teaching, may in the case of early years teachers be hampered by their insufficient knowledge of the subject, since, as was noted earlier, subject matter content knowledge has been found to affect teachers' pedagogical content knowledge. Finally, the 'reality shock' that early-years teachers may still experience, despite many years of teaching, can be explained by the fact that science constitutes a 'new' subject for them and they can therefore be considered 'beginners' in it. It may, consequently, be concluded that one of the main causes of experienced early years teachers' fall back to an earlier stage of their professional development in science is their insufficient knowledge of the subject matter.

It is also worth noting here that, while early years teachers worry about their success in acquainting children with basic scientific knowledge, they made no reference to children's development of science process skills, although this is required by the curriculum (see contextual information). This could be interpreted in two ways: either they are not aware that development of skills is a vital aspect of science education for young children (e.g. Zeitler, 1984; Harlen, 1996) or they identify teaching science content as the major purpose of pre-primary science education. Since it is the teacher who frequently determines the content of the science programme actually taught in the early years classroom, 'the challenge to stress the importance of teaching processes seems to rest with those responsible for the science preparation of teachers' (Zeitler, 1984).

Therefore, although, as some (e.g. Veenman, 1984) argue, many authors do not resist the temptation to blame teacher education for teachers' problems, the findings of the present study suggest that several of the most serious knowledge-related problems reported by experienced early years teachers are, in fact, the result of their inadequate preparation in science as well as in science teaching skills.

As for the problems listed as 'other', most of them concern weak school infrastructure and inadequate support for teachers' work in science. The teachers ascribed this to the low priority the system places on pre-primary education. Compounding the problem, however, is the low priority placed on science within the pre-primary education framework. This view is supported by several facts: teachers are called

upon to implement the science aspects of the curriculum without any special training, the time allocated to science activities is short (one organized activity per week) compared to other subjects, and science—as teachers reported—is often the subject dropped when extracurricular activities crowd the timetable (see also Appleton & Kindt, 1999). Therefore science instruction in the early years appears to be affected by a combination of inadequate teacher preparation in the specific subject and by factors linked to the school environment and the education system. Overall, this investigation supports the view that teachers' professional upgrading in science, support for teachers' work and changes in the system are imperative for successful improvement of teaching practices in the early years science classroom.

With regard to needs in science expressed by experienced early years teachers, results indicate that these teachers consider improvement of their knowledge of the subject as their first priority. There is a strong opinion (see Harlen, 1996) that these teachers may know more than they think about what is really relevant to teaching science at the pre-primary level, and that their worry about not knowing enough may be the result of their misunderstanding of what teaching science at this level involves. However, results indicate that experienced early years teachers clearly distinguish between 'general' knowledge in science and basic understanding of scientific issues involved in the development of science activities for the young pupils, i.e. adequately developed working knowledge in science, and that without it they have difficulties in choosing and planning the appropriate topics and the right materials and activities (see also Hashweh, 1987), as required by the curriculum. Previous independent studies (see Kallery & Psillos, 2001, 2002), in which experienced early years teachers were also observed in their classrooms during science activities, have documented their low levels of working knowledge in science and their problems in teaching this subject. Therefore these teachers seem to be aware of their limited content knowledge and its inadequacy for working effectively with young pupils and also, as was discussed earlier, of their limited pedagogical content knowledge in science. These shortcomings, as early years teachers reported, tend to make them insecure and less confident to teach science to the young pupils (Wenner, 1993; Holroyd & Harlen, 1996).

Early years teachers' awareness of their problems and needs is a factor that can contribute positively to making teachers more receptive and responsive to an in-service teacher education programme in science. Some teachers have the attitude that science instruction has little effect upon their survival as teachers or their success in the profession (Cunningham & Blankenship, 1979). Teachers coming to science courses with a negative attitude have a low probability of knowledge improvement (Zeitler, 1984). The fact that early years teachers expressed the need for adequate working knowledge of the subject matter to be taught and for better knowledge of methodology appropriate for young pupils reveals a positive attitude towards science courses.

Although the above factors are very important for the upgrading of teachers' knowledge, improvement of science instruction depends on other factors as well. Planning for such improvement can draw useful information from the needs the teachers expressed and from how teachers correlate their problems (both educa-

tional and those related to school infrastructure, guidance, support and assessment of their work in science), their worries, their motivation to teach science and the changes in their behaviour and personality (see correlation model of Figure 1). It emerges that teacher support needs to be provided at several levels.

Educational support for early years teachers could usefully address issues such as

- Improving teachers' understanding of the objectives of pre-primary science education, for example the importance of the development of pupils' science process skills. Teachers should understand that 'science process skills are the vehicle for generating content and a means by which concepts are formed' (Funk *et al.*, 1985) and become acquainted with ways of teaching science through the process approach.
- Improving teachers' knowledge and understanding of the science topics they are called to introduce to young pupils. As noted earlier, without this understanding teachers 'are not in a good position to guide children to materials and activities which develop their understanding' (Harlen, 1996).
- Improving aspects of teachers' pedagogical content knowledge. This includes teachers' understanding of what makes the learning of specific topics easy or difficult for pupils of different ages (Shulman, 1986). This, together with improvement of teachers' content knowledge in science, would assist them in formulating content to make it comprehensible to young pupils.
- Developing teachers' techniques for handling children's questions. There do exist strategies that can be useful to teachers for handling different types of children's science questions (see, for example, Harlen (1996) and Jelly (1986)).
- Improving teachers' understanding of the curriculum material and guidelines necessary to respond effectively to its requirements.

The support described above pays attention to experienced early years teachers' problems related to their knowledge and teaching skills and takes into consideration the educational needs expressed by these teachers. However 'development of an extensive support system requires equal commitment on the part of all involved in bringing about the desired changes' (Dass, 2001). The state also must demonstrate commitment to changes fostering collaboration with building administrators and supplying specialized educational advisors that can provide early years teachers with assistance in both the scientific and the pedagogical aspects of their work as well as emotional support in the performance of their task in the demanding and—to them—'new' subject of science and, finally, to system changes in assessment practices of teachers' work as well as changes in curricular structures. All these are components of a change in the context of teachers' work in science (Dass, 2001). State commitment addressing changes and support can help alleviate many of the problems and their consequences and the related teachers' worries, ultimately leading to improved science instruction in the early years.

Exposition of the problems of early years teachers, especially those with many years of experience, is, as noted earlier, somewhat rare in science education literature. The significance of the present study lies in the fact that it brings these teachers' voice to the forefront. The research methodology employed in this study

was fruitful. The written take-home assignments allowed teachers to elaborate on their views without time pressure. These assignments provided the main frame of information. In the group interviews the fact that teachers were encouraged to talk freely about their problems and the fact that they were able to interact both with each other and with the interviewer supplemented the initial information with a large number of useful and illuminating details. It appears that the combination of these two tools—written take-home assignments and group interviews—make it possible to collect interesting data and could be used in the exploration of teachers' problems in other discipline areas as well.

The study has revealed a number of trends that are consistent with other studies, but has also identified a number of features particular to experienced early years teachers. While findings should be interpreted within the limitations of, on the one hand, a small-scale exploration study and, on the other, a study of teachers coming from a single country, they may be used to guide research and interpretation of early years teachers' experiences in other countries as well. Research into the problems of early years teachers who implement pre-primary science curricula in other countries would produce a pool of interesting and useful information that could contribute to the improvement of science instruction in pre-primary education everywhere.

Notes on contributor

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