

Pre-school science education in Portugal: teacher education and innovative practices.

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This is a presentation regarding a work resulting in the synergies between two separate and complementary projects regarding science education in kindergarten: a teacher training program. It intends to present some of the achieved results to the present date and to share ideas and opinions with a wider research community.

Theoretical framework

We are based on the shared assumption that our actual society is a scientific and technological one, which requires from its citizens scientific and technological literacy. That will enable them to understand the role science and technology play in modern society in order to use it critically to make it evolve in a sustainable way, based on human, cultural and social values.

The research community today shares the understanding that scientific and technologic literacy should have an early start, as soon as in kindergarten, in a child-centred approach and in a socio-constructivist environment. Allowing children to progress from a *descriptive* level of the natural phenomena they observe in their daily lives to an *explanation* level and progressing from personal and 'small' ideas to shared and 'big' ideas (Harlen & Qualter, 2004).

The reasons for early science education have been presented by a vast number of researchers (Harlen, 2006, Heshach, 2006, Van Hook & Husiak-Clark, 2008, Hadzigeorgiou et al., 2009, Keogh & Naylor, 1999, Charpack, 1996) arguing that it does undoubtedly contribute to scientific literacy. Moreover, science education can even be regarded as a right for everyone (Fumagalli, 1998), along with the right for education.

Education and science education: the Portuguese context

Recent studies regarding scientific literacy (PISA, 2006; EUROSTT, 2003) show that Portuguese students rang poorly comparing to most European countries, with results close to Italy, Israel and Greece. These are results below OECD average, showing an impact of socio-economic and cultural background above OECD average (Pinto-Ferreira, Serrão e Padinha, 2007).

Pre-school education in Portugal

In Portugal, kindergarten, or pre-school, is non-compulsory, aimed at children in the 3-6 years old range. It is provided both in private and public schools, consisting the later in a rather recent network (since 1974).

In 1997, the ministry of education published the *Curricular Guidelines for Pre-School Education*, which are presented as guidelines for kindergarten teachers (KTs), unlike a curriculum. Its goals are to raise the social value of pre-school education, improve and uniformize teaching practices nationwide and to promote articulation with elementary school.

These guidelines present three main content areas, which are regarded as fields of knowledge, which include different scopes of learning, considered attitudes and know-how as well as knowledge itself.

This document presents three content areas: (1) *Personal and Social Development*, (2) *Expression and Communication* (including the following domains: motor, drama, plastic and musical

expression; oral expression and writing approach and mathematic expression) and (3) *Knowledge of the World*. This last content area is regarded as a first approach to science and to scientific thinking.

Changes in science education

Facing the current situation, and considering science education at the kindergarten level and, in particular, science education in the Portuguese context, government authorities have shown to be interested in investing in science education in the early years.

In the more recent years some steps have been taken to contribute to the improvement of the Portuguese panorama.

The *Program of primary school teacher's education in experimental science teaching* has been developed for the fourth year in Portugal, showing an increasing number of elementary teachers enrolled each year, throughout the country (from 986 in 2006/2007, to 2940 in 2008/2009).

It is sanctioned and financed by the Ministry of Education with a workload of 126 hours/Year, consisting of sessions of diverse typology, at the responsibility of teachers with qualifications at the masters degree. Teachers interested in attending a second year have a whole set of new contents available, presented in the form of thematic booklets also available on the internet (http://www.dgidec.min-edu.pt/experimentais/Paginas/Recursos_Didacticos.aspx).

In January 2010 the ministry of Education published a booklet "Despertar para a Ciência – Actividades dos 3 aos 6" ("*Wake up to science – activities for 3-6 year-olds*") which provides kindergarten teachers with a theoretical framework supporting science education in kindergarten, as well as 20 practical activities and references to support innovative practices in science.

This booklet is available on-line (http://sitio.dgidec.min-edu.pt/recursos/Lists/Repositrio%20Recursos2/Attachments/805/pre_ciencias_1.pdf) and was delivered to every school's administrative services in the country. At the same time, a nationwide training program was implemented, intending to allow KT's to learn, reflect and discuss the actual guidelines regarding science teaching in kindergarten, as well as experiment and access the practical activities presented in the booklet.

In 2007, the same Ministry issued *Regulation n°17/DSDC/DEPEB/2007* presenting KT's with guidelines to support the construction of their classes' curriculum, clearly emphasizing science education as an important part of it.

The axis of change in education

Nonetheless, changes in the education system, to be effective, should comprehend the complementary influence of the three main axis of education in general, and of science education in kindergarten in particular: the *KT* (and his underlying education process), the *curriculum* and the *resources* available to implement such a curriculum. It is therefore understood that this is an approach that should be considered in a pluri-dimensional way, leading the authors to choose to work cooperatively, benefiting with the expertise drawn from each other's investigations.

The TTP as presented, was developed by two teams of researchers, each researching different aspects related to science education in kindergarten, namely, teacher training and science curriculum.

Project presentations

Project A is entitled *Kindergarten Teacher Continuous Education – Contributions for the performance of experimental activities with kindergartners* and its aim is to design a Teacher Training Program (TTP) that promotes the (re)construction of subject content and pedagogical knowledge leading to innovative practices regarding science education in Kindergarten.

The developed program should be based on the characterization of the KT's profile, shortcomings and practices, in order to establish its objectives, contents, strategies and assessment.

To accomplish that purpose, a questionnaire was handed to all the KT's in public and private kindergartens in the Bragança district (northern Portugal), in May 2008. Accomplishing a 91,5%

response ratio, we were able to ascertain about 194/213 answers. From the questionnaires' analysis we can conclude that comparing to private schools' KT's, those on public schools have, on average an older age (45 years), longer practices after their academic degrees (+15 years) and a lower investment in continuous science education (81 KT have attended no TTP and 21 attended 1 TTP). The difficulties referred by KT's in conducting scientific related activities can be presented on the following table.

Scale	Response ratio (%)					
	1	2	3	4	5	N/A
Scientific knowledge	2	7	66	17	2	7
Planning	1	9	56	25	4	6
Activity development with children	3	11	51	23	6	7
Content selection	1	11	51	25	5	7
Content adaptation to children's age	4	14	42	28	5	7
Resource acquisition	8	21	46	16	3	6
Connections with other content areas	2	13	41	28	6	9
Group management	2	18	37	26	10	8

1 – very high; 2 – high; 3 – medium; 4 – low; 5 – inexistent ; N/A – no answer

Table 1 - difficulties felt by KT's in conducting scientific related activities.

Considering the responses given in the 192 questionnaires, the KT's suggested measures to improve their own didactical practices are presented in table 2.

Professional & personal level	More subject content and didactic	92
	Acquire scientific knowledge	21
	Practical education in context	6
	More active continuous education	3
Resource availability	Didactic resources	11
	Social & human resources	11
	Logistical/financing	3
Space management	Adequate area in classroom	24
	Non-formal education	7

Table 2 - Suggested measures by Kts to improve their didactical practices

Project B is entitled *Scientific Literacy in Kindergarten – a curriculum proposal* and its aim is to develop a kindergarten science curriculum with a Science-Technology-Society (S-T-S) focus. In order to do so, it is necessary to establish the adequate science contents, process skills and scientific attitudes, developing, at the same time, a number of practical activities (concepts and teaching, learning and assessment strategies) as well as the respective didactic resources (teacher's guide & materials).

This work will lead to the definition of a science curriculum for kindergarten, presenting *what* to teach (concepts), *why* teach science (science process skills and scientific attitudes) and *how* to teach science to preschoolers (strategies).

From an initial analysis of the *Curricular Guidelines for Pre-School Education* some limitations to the document emerged. As a 13 year old document, it shows itself as very generalist, where the S-T-S and E-S-D perspective is omissive, with inexplicit content presentation and a lack of relevant concepts. It is inexplicit in its competence development presentation (regarding knowledge, skills, values and attitudes) failing to present clear teaching and learning strategies (regarding types of activities, the framework, the resources...).

Articulation with the elementary school curriculum is also absent, leaving kindergarten teachers unsupported in planning their own.

All this in a context where over the last decade we've been able to witness the increased awareness of the role of early science teaching, as a consequence of science and technology's progressive preponderance in modern-day society.

Resulting from this analysis, and supported by international investigations in this domain, ten practical activities were designed.

These teaching strategies are based on a teacher's guide, presenting its objectives (concepts and teaching, learning and assessment strategies) as well as the necessary didactic resources.

These activities were validated in real-context by KT's who attended the in-service TTP developed by both projects, and as described ahead.

The same activities are to be developed again in real-context by KT's who have not attended the specific in-service TTP.

Further ahead, the assessment of KT's practices (in both cases) and of the activities implementation process will serve to validate the proposed curriculum.

Cooperation between projects

Project A is, in general terms, based on the assumption that KT's must have the necessary subject content and pedagogical knowledge to support innovative science teaching, and project B assumes that kindergarten curriculum must necessarily include a strong, consistent scientific dimension within a child-centered approach. These are crucial conditions to promote the development of children's scientific ideas in a constructivist learning environment that fosters scientific and technologic literacy.

To accomplish such a task it is necessary to teach teachers, developing the necessary and adequate TTP, and, on the other hand, there is the need to have teaching strategies available to KT's, providing them with a curriculum and adequate teaching strategies.

Teacher Training Program presentation

The developed TTP was entitled *S-T-S education in kindergarten – Importance of experimental work*, and its aims were to allow KT's to (i) understand the relevance and need of science education in the early years; (ii) (Re)construct subject content and pedagogical knowledge; (iii) Know international guidelines for science education – namely S-T-S education; and (iv) Promote the development of adequate teaching strategies in kindergartens

The TTP was recognized by the Portuguese teacher's continuous education council. It was developed in Mirandela, in the Bragança district, on a 3 hour/week sessions basis, during the months of October and November 2009. It had a workload of 50 hours, of which 25 were presential

and other 25 were of autonomous work. 14 KT's participated in this TTP, having 6 of them participated further in the continuance of the current projects (project A and B). The TTP's **chronogram** was as described in the following table.

Contents	Durati	Session typology
- Chronogram construction - Program aims presentation	3 h	Group sessions (TP) - 12h Promote group interaction, dialogue, discussion, analysis, reflection ...
- VOSTS questionnaire; - S-T-S science education - Kindergarten science education and the development of children's competences. - Scientific competences.	3h	
- Kindergarten science education – recent studies - Different science education perspectives - Teaching and learning strategies – experimental work - Experimental work planning	3h	
Objects and materials	3h	Small group sessions (TP) – 12h Practical activities development and discussion.
Light	3h	
Forces and movement	3h	
Living things	3h	
- Activities development in kindergartens	25h	Individual sessions/work – 25h Activities implementation in kindergartens.
- Results communication and discussion - Assessment	4h	Group session

Table 3 – TTP chronogram

The TTP's **practical activities** were organized in 4 thematic blocks, leading to the exploration of some relative concepts:

- *Materials and objects* - thermal conductivity, materials & objects, technology in toys and material diversity.
- *Light* – shadows, color mixing, mirrors and light propagation.
- *Force & motion* – results of forces in toys, kinetic energy, friction and viscosity.
- *Living things* – bees, living & non-living, germination and silkworms.

These activities were all varied in their typology (exploratory, sorting, illustrative, fair test ...), in the didactic resources they require (daily lives, laboratory ...), their duration (from 1 hour up to 2 months) and in the scientific competences they could develop in children.

As an **example of an activity** developed for this TTP, we can present *Just let me sleep!*

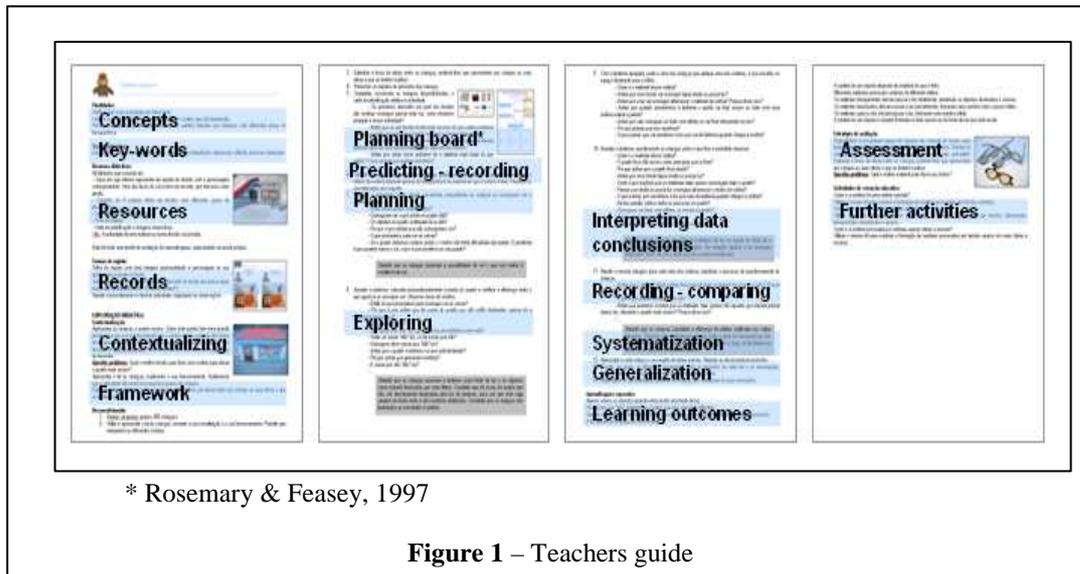
This activity aims at the development of a wide range of scientific competences, as described through the examples presented.

- *Content knowledge*: there are luminous and illuminated objects, we can only see when there's light, light can pass through an object/material or cause a shadow, different opacity of materials cause different shadows.

- *Skills*: like comparing, identifying differences and similarities, inferring, interpreting information and questioning.

- *Attitudes*: like showing interest in understanding the world, consider others ideas and opinions, willingness to consider evidence and to change ideas, and perseverance.

Its **framework** is presented as followed, with its main aspects highlighted. KT's were presented to the teachers guide, where all the aspects regarding its framework are present, in the form of a consistent plan, which they could adapt to different kindergarten contexts. The different phases of the activity, as well as all the aspects regarding their development were explained in detail.



This activity, as all the others developed for the TTP, point also to a communication phase, in which children can communicate to others (colleagues, classes, parents,...) what they did and what they learned, and also a research phase in which they can search for more information regarding the subject.

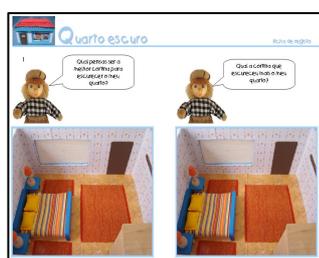
All the teacher's guides present a set of questions for the children, aimed at helping the kindergarten teacher to stimulate children's thought and helping them to progress in their ideas.

All the proposed activities are flexible as their framework is regarded, allowing the KT to adjust some aspects of its methodology to its own group of children. At the implementation sessions both researchers witnessed, it was evident that KT's adapt some of the phases to their own and specific context.

This activity also includes, besides its framework, a pack of **didactic resources** which includes all the resources the KT needs to develop it with its children.

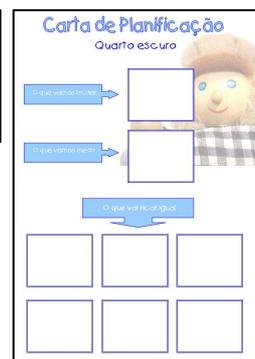
The **resource pack** consists of a box, made up to portray a bedroom, including its wooden furniture and a big open window. This window stands for the starting point of the activity, leading children to suggest solutions for the little man's problem: What to do to allow him to sleep during the day as his room is too bright and he works nights?

The resource pack includes also a flashlight, and a set of 4 curtains made of fabrics of different opacity.



The **record sheet** included in the pack represents two images of the bedroom, and children are asked to glue, over the window, a sample of the fabric which they think its best to darken the room - children's ideas. At the second image of the bedroom (on the right) they are asked to glue a sample of the one they saw was best for that purpose - children's observations.

Included in the resource pack is also a **planning board**, with a set of cards which have the different variables involved in this experiment illustrated through images. With the help of the KT, children will try to ‘read’ the images and after understanding their meaning will proceed in filling out the planning board on the correct places.



The **assessment strategy** consists of a set of four glasses whose lenses were substituted with the same fabrics used in the curtains of the bedroom. Children are asked to explain which one they think allows a better vision, applying what they observed and learned in the practical activity.

Results of the TTP

We can assess that the KTs considered the TTP as important and adequate for their needs, showing positive results in their practice reconstruction, by presenting new and innovative ways of teaching science. It was considered an important practical education program in context, making them realize the need to continue attending science education programs, as they understood that they are at the start of a long process.

Regarding the developed activities, they’ve shown to be adequate in science education at kindergarten level, after minor changes in some. The concepts were considered appropriate and relevant, and the skills and attitudes they demand of children adequate. At the end, they were considered adequate teaching strategies and didactic resources for the kindergarten science curriculum.

All this leads us to conclude about the relevancy of continuous professional education in improving and extending ways in which science is taught and, simultaneously, that children demonstrated a functional understanding of some scientific inquiry processes as well as related science concepts.

Teacher Training Program - Conclusions

To conclude, we can consider as an input to the whole process the *Teacher Training Program*, on one hand, and the developed *practical activities*, on the other. Both were based on the *shortcomings* present in the science education in kindergarten context, respectively, KTs’ *lack of formation* and *lack of resources*.

The work developed led to the development of a *Teacher Training Program* and the *set of activities*. As an output of the process, and as far the TTP is concerned, we were able to gather evidence regarding the KTs’ *gained knowledge to support the developed activities*, thus leading us to conclude about the *relevancy of knowledge* in science education. On the other hand, and regarding the developed *practical activities*, we were able to gather evidence to consider them as a *means to achieve good practices*, allowing us to conclude about the *relevancy of the resources* in science teaching.

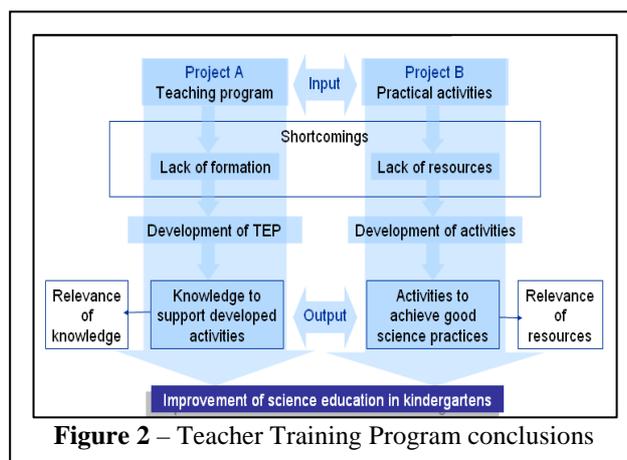


Figure 2 – Teacher Training Program conclusions

Furthermore, we are able to conclude, at the end of the analysis of the whole process, that as a result of the development of the TTP, activities included, it demonstrates itself to be a relevant means of improvement of science education in kindergarten.

Overall conclusions

Emphasizing the scientific and technological strain of modern day's society, the research community agrees on the need of science and technology literate citizens. The educational system must give an adequate response to this global challenge, investing at the teacher, curriculum and resources level.

There is a need for adequate teacher training programs, as well as for adequate teaching strategies, fully supported by a curriculum.

In this context, and as conclusions from results regarding the work developed so far, a TTP can show positive results when developed through cooperative work among researchers of co-related areas, contributing to the improvement of science education at kindergarten level.

We can consider the work developed – the Teacher Training Program – as giving a clear example of two of the recommendations given by Osborne & Dillon in their report to the Nuffield Foundation (2008). Basing ourselves, on one hand, that good quality teachers, with up-to-date knowledge and skills, are the foundation of any formal science education system and, also that innovative curricula and ways of organizing the teaching of science are required to improve the science and technology literacy levels of the next generations.

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