HOW KINDERGARTEN CHILDREN CAN USE TOYS TO EXPLORE SCIENCE AND TECHNOLOGY CONCEPTS

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ABSTRACT

The aim of this paper is to present a science teaching strategy integrated in a wider project to develop, in Portugal, a kindergarten science curriculum with a Science-Technology-Society focus. Besides establishing the adequate science contents, process skills and scientific attitudes, it will develop a set of articulated practical activities (teaching, learning and assessment strategies) as well as the respective didactic resources (teacher's guide & materials).

At the present stage of the project ten different practical activities, regarding several science concepts, were designed. They were all validated in real-context by Kindergarten teachers who attended an in-service training program designed with the purpose of developing the necessary subject matter and pedagogical knowledge to support these educational practices.

Detailed presentation of one of these science teaching strategies (aims, guide, resources and assessment), will be made, as well as of its validation process and conclusions.

"Granny's toys and mine" is a context-based teaching strategy intended to engage kindergarten children (3-6 years old) in exploring concepts regarding the presence of science and technology in our daily lives, namely in toys. While placing a variety of toys in two different points of a given time line according to underlying criteria, children also construct upon prior knowledge to recognize the consequences of the evolution of science and technology.

Data from the validation process indicates that throughout the activity children demonstrated a functional understanding of some scientific inquiry processes as well as of related science concepts.

Keywords: *Science Education; Science in Kindergarten; Teaching and learning strategies; Competences development; Scientific and technologic literacy.*

INTRODUCTION

The research community today shares the understanding that scientific and technological literacy should have an early start, as soon as in kindergarten, in a child-centered approach and in a socio-constructivist environment. This approach allows children to progress from a descriptive level of the natural phenomena they observe in their daily lives to an explanation level, and 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; Keogh & Naylor, 1999; Charpak, 1996) arguing that it does undoubtedly contribute to scientific literacy. Moreover, science education can even be regarded as a right for everyone (Fumagalli, 1998), included in the right for education.

As far as scientific literacy is concerned, the STS (Science-Technology-Society) strands of the science curriculum have been regarded as the best way for school science to face the challenges of 21st century society (Acevedo-Diaz et al., 2003; Aikenhead, 2002; Membiela, 2001). Science and technology should be taught embedded in social contexts which are relevant to students, displacing its focus from concepts. School science should allow children to construct an authentic image about science and technology, about the way scientists work and about the role that science and technology play in the evolution of Humanity. Students should be prepared to critically interact with an increasingly demanding world, where social and ethical values should be considered when deciding and acting (both individually and collectively) on its problems and demands.

STS is therefore assumed as a strand that promotes students motivation both on science and on school science (Caamaño e Martins, 2005) developing positive attitudes towards science and science teaching.

At kindergarten level the emphasis should be placed on context based teaching, assuming it as a teaching setting where children can start simple interactions with scientific and technological issues, while engaged in sound, but nonetheless ludic teaching strategies.

Kindergarten children have shown to be very competent in science when quality education in this field is provided, as detailed by authors such as Saracho & Spodek (2008), Van Hook & Husiak-Clark (2008), Havu-Nuutinen (2005) and Hadzigeorgiou and others (2009). Learning activities should sustain and promote children's curiosity and enjoyment so that they develop a lasting interest in science.

Enquiring children who are led to explore the world in a scientific way are most likely to be science literate citizens who see science and technology in a positive way, understanding and making the most of its strengths and limitations. This will contribute to their understanding of the role played by science and technology in modern society, and how to use them critically to make society evolve in a sustainable way, based on human, cultural and social values.

Emphasizing the scientific and technological strain of modern society, the research community agrees on the need of science and technology literate citizens. The educational system must therefore give an adequate response to this global challenge, investing at the teacher, the curriculum and the resources levels (Eurydice, 2006).

Kindergarten curriculum must necessarily include a strong, consistent scientific dimension within a child-centered approach, such as Osborne & Dillon (2008) defend in their report to the Nuffield Foundation. It should promote the development of children's scientific ideas in a constructivist learning environment that fosters scientific and technological literacy, emphasizing science in the curriculum.

The current project was developed on a design-based research approach (Wang & Hannafin, 2005), as it identified authentic shortcomings of the educational system and associated them with subsequent actions to improve the status quo.

PROJECT RELEVANCE AND DESCRITPTION

Science curriculum in kindergarten is determined by the complementary influence of the three main axis of education in general: the *Kindergarten Teacher* (and his underlying education process), the *curriculum* and the *resources* available to implement such a curriculum. It is therefore understood that solid subject content and pedagogical knowledge are required of the kindergarten teacher (KT) to support the construction of the science curriculum he/she intends to develop with his/her class, fully supported by a range of teaching strategies.

National Portuguese Curricular Guidelines for KTs date back to a decade ago and since then an increased awareness of the role of early science teaching has taken place.

It is the overall purpose of the wider project to present a science curriculum based on the assumption that, in kindergarten, children must take an active part in learning situations that support both the investigative (skills and attitudes) and knowledge-based aspects (concepts) of science education.

To support such a curriculum, ten practical activities were developed, leading to the exploration of several concepts relating to *Materials and objects*, *Light, Force & motion* and *Living things*. They are all varied in their typology, in the didactic resources they require, their duration and intend to develop a wide range of specific and transversal competences while laying the foundations for a growing understanding of basic scientific concepts. Enquiry is regarded as a form of content and as a way to teach (Yager, 2009), focusing on children's understanding and requiring their scientific knowledge and enquiry processes.

KT is the mediator between the children and the resources, conditioning the learning and development outcomes. A specific teacher training program was developed with the purpose of empowering them with the ability to maximize the expected results.

Assessment to be made of the adequacy of the activity is to take into account data gathered from the developed teacher training program, in order to fully relate and understand all the implications. It is also to consider the input given by these KTs, which will contribute to better their potentiality as a means to innovate kindergarten science teaching.

The whole implementation process is to be repeated, in an interactive, iterative and flexible research process, with KTs who will not attend a specific teacher training program. This will allow for establishing their potential in sustaining the development of children's scientific competences, regardless of KTs specific training.

RESEARCH METHODOLOGY

In this paper a practical activity relating to the topic of materials, objects and technology, entitled "*Granny's toys and mine*" is detailed, along with the implementation process which led to its validation.

Activity description

"*Granny's toys and mine*" is a sorting activity, in which children are challenged to group different toys according to their views on the epoch they were built. Children are expected to build on prior scientific understanding, evolving to more precise ideas about the core concepts involved and the intertwined nature of both science and technology.

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

- *Content knowledge*: (i) The diversity of materials available of natural and non-natural origin, (ii) the presence of growingly complex equipment and (iii) science and technology together allow for a growing diversity of materials and more sophisticated technology in toys.
- *Skills*: like observing, comparing, identifying differences and similarities, describing events and observations, inferring, interpreting information, questioning, thinking critically, notice change, communicate, evaluate and select information, construct argumentation, make decisions and work autonomously.
- *Attitudes:* like curiosity, showing interest in understanding the world, questioning daily events, considering ideas and opinions from others, willingness to consider evidence and to change ideas, perseverance and working cooperatively.

Teachers guide
Each teaching strategy comprises a teacher's guide, which presents and describes their objectives, the related concepts and the teaching, learning and assessment strategies. All are flexible, as far as their framework is concerned, allowing the KT to adjust aspects of its methodology to its own group of children, and presenting the following components:

Concepts – Allowing the KT to know which are used to explain the phenomenon;
Key-words – Those related to what they will observe and explore (*materials, natural materials, old, new, recent, modern, evolution, technology, science, mechanism* …);
Learning outcomes - Those expected to be accomplished at the end of the activity.
Didactic resources - Presenting what is needed to implement the activity;
Context-strategy - Describing the resources and respective activity. This intends to, on one hand, ascertain about the children's ideas on the subject and discuss them, and, on the other hand, set off their curiosity, contributing to a more motivated participation;
Framework - Presented as a flexible frame to explore the concepts with the children;
Questions – Allowing the KT to understand how he/she can stimulate children's thought and help them progress in their ideas;
Systematization – A phase at the end of the activity, intended to clearly organize the learning outcomes, and establish relations with other daily events.
Assessment strategy - Describing the resources and respective activity, along with the evidence the KT should look for in order to ascertain about children's mobilization and development of scientific attitudes and science process skills, as well of their understanding of the related scientific concepts.
Further activities – Some are presented, allowing the KT to consider related teaching strategies, as extension activities.
Communication – Is considered important while leading children to communicate to others (colleagues, classes, parents…) what they did and what they have learned;
Research – Is also recommended as a means to gather more information on the subject.

Teaching resources
The teacher's guide is accompanied by a pack of **didactic resources** which includes all the resources the KT needs in order to develop the activity with the children.

As a **context-strategy** (**Figure 1**), the pack includes a short movie made from different clips easily accessed through the internet. These depict scenes from the daily lives in the early 20th century (cooking, washing, transport, communication, etc) edited from old movies and even present-day cartoons. These scenes are easily associated with the children's grandparents, who most probably led lives like the ones portrayed in the movie.

For the development of the **practical activity**, the resource pack includes a set of 27 different toys (**Figure 2**), such as dolls, cars, balls, puppets, yo-yos and others. These can be placed into two separate groups, considering the underlying criteria: *material nature* and *attached technology*. After freely exploring the set of toys, children will classify them accordingly, debating their choices and rectifying them when required.

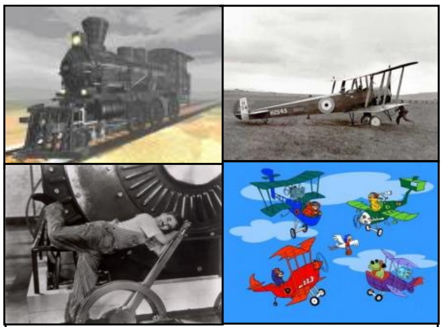

Figure 1 – Images from the context activity.

Figure 2 – The resource pack.

The toys that could have belonged to children’s grandparents (**Figure 3**) are mostly Portuguese traditional toys, made of natural materials such as wood, raffia, leather, clay, and fabrics (like cotton, wool and silk) and also of metals (like lead, tin and iron). The more recent ones (**Figure 4**) can include materials of non-natural origin, such as plastic, rubber, silicone and synthetic fibres (like nylon, polyester).

Figure 3 – The set of “old” toys.

Figure 4 – The set of “new” toys.

The toys can also be sorted out by epoch according to their attached technology: the older ones’ main purpose was to be set in motion by the child’s application of a mechanical force (pushes and pulls resulting in slides, rolls, bounces…) whereas the most recent ones may also resort to magnetism, batteries or solar energy to cause movements, sounds, lights, etc. Implicit in all this is the fact that the most recent toys allow for a more complex interactivity with the child.

As an **assessment strategy** at the end of the activity, children are asked to match a two-by-two pieces puzzle (**Figure 5**), corresponding to sets of images showing the same object or structure built in two different periods of time (telephones, televisions, bridges, pens, lamps…). To do so, they are led to establish relationships between what was discussed up until this point and the images in the puzzles, transferring whatever knowledge they were able to construct.

Figure 5 – Puzzle for learning assessment.

Teacher training program

The developed teacher training program was entitled *STS education in kindergarten – Importance of experimental work*, and its aims were to allow KTs 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 STS education; and (iv) Promote the development of adequate teaching strategies in kindergartens.

The practical activity detailed in this paper was validated by a KT who attended this 50 hour workload in-service training program, intended to promote the implementation of the 10 activities developed in this project. The 25 contact hours included theoretical (9 hours) and practical (12 hours) sessions, and a final four-hour group session intended to promote group interaction, leading to the discussion, analysis and reflection of the whole process and its outcomes.

Implementation session

"*Granny's toys and mine*" was implemented in a kindergarten located in the city centre of Mirandela, in the Bragança district (Northern Portugal). Although the KT chose to conduct the initial part of the activity with the whole group (25 children), the practical activity was later developed with a smaller group of 5 3-4 year-old children, taking approximately a total of two hours.

The KT preceded the suggested context strategy in the teacher's guide by another derived from her class previous experiences. A child's grandmother (granny Dulce) was asked to visit the class and talk about her childhood, bringing also some of her old toys and sharing memories of her childhood play. Those toys were later kept in the classroom, and children could explore them, with proper care. It was in granny Dulce's company that the class watched the video included in the activity resource pack (the **context-activity**), later discussing what they saw and comparing it to their present lifestyle. Once again, the grandmother was an important element to facilitate children's relation with a past time and lifestyle, as she impersonated it.

Throughout this talk, the KT promoted the discussion of children's ideas. She focused on the materials used to make the objects shown on the video and on the different kinds of toys represented, always trying to direct children toward the evidence of their answers.

In the practical activity (**Figure 6**) children were challenged to form two different groups of toys: those which could have belonged to their grandparents and those which could have not.

After allowing for a period of children's spontaneous manipulation of the toys, the KT engaged them in more focused observations, questioning them if a given toy could have belonged to granny Dulce. Children would observe it and think about what they saw on the video, about what granny Dulce told them about her childhood and about the facts referred to on the previous discussion of their ideas.

Throughout the activity children were asked to justify their choices, thus providing opportunities for the development of a variety of science process skills and attitudes.

Their answers, and the reasons presented to justify them, were discussed among the children, through heedful guidance on the KT's part that would contribute to conceptual scaffolding. She intended her questions to lead children to focus their attention on the toys' details which could help situate them in one of the epochs. This intended to allow them to gain and construct some meaning about the core concepts involved and to build knowledge from children-generated ideas.

After all the toys were placed on their respective sets, the KT promoted the discussion of children's ideas regarding what they did, leading to the **systematization** of the activity learning outcomes.

The KT then presented children with the puzzle pieces referring to the **assessment activity** (**Figure 7**), asking them to try and match the correct pairs. As they did this, they were asked to compare them, to try and explain the differences found between them and to explain why they thought those two pieces were related to each other. While promoting talk, as an active assessment activity (Weavers, 2008), this lead children to reveal their understanding about the concepts involved and their learning progress.

Figure 6 – Children manipulating a wooden bird and a magnetic drawing board.

Figure 7 – Children matching puzzle pieces showing two telephones.

Data analysis and results

The implementation sessions were audio-recorded and photographed, which, along with handwritten data, allowed for a posterior accurate transcription of the occurred events. Analysis of the didactic strategy was based on the evidence children gave, through their behaviour, performance and words, of mobilising the specific set of capacities, attitudes and values. Knowledge was ascertained considering their responses throughout the activity, and moreover during the assessment strategy, focusing on the matches they made and the justifications given for making them.

Throughout the activity, and relating to the existent resources, children gave evidence of mobilizing a set of skills, attitudes and values, while constructing new and more complex knowledge, as they later revealed on the assessment activity. Analysis of the whole process was focused on evidence children gave as to the mobilization of **science process skills**, **scientific attitudes** and **content knowledge**.

Regarding **science process skills**, when they were asked to *establish comparisons* among the different toys, children were required to *make focused observations*, trying to *identify differences and similarities* among them. They often did so not only by comparing the set of toys with their own, quickly determining which could be considered as the more recent one, but also recalling what granny Dulce showed them and talked about. Children also established relations with scenes depicted in the movie they watched, having recalled such examples to justify their choices upon placing a given toy in its respective set. They would often say "*Because I had such a tricycle when I was smaller*", "*Because my grandfather has a pen like that at home*", "*Because its like the one granny Dulce showed us*" or "*Because the car is like the one Charlot drove on the movie we saw, and its nothing like my father's car*".

Children mobilised their *communication* skills all through the activity, mainly by *describing what they saw and did*, but also by *sharing and discussing their ideas* on the subject. They have shown to be able to *construct argumentation*, albeit at an elementary level, when they recalled the aspects in the given toys which led them to choose the set they thought it belonged to. This was supported by the KT, who promoted children's talk, also as a means to develop their *reasoning skills*. This guidance and conceptualization main purpose was to allow children to evolve from mere description, and to engage them in higher stages of reasoning, while challenging unsuitable concepts and contributing towards the construction of more precise ones. Children also *used specific vocabulary* (key-words) to justify their choices (ex: "*That's too technological to be my grandparent's motorcycle*"; "*Scientists hadn't invented automatic escalators like those before*"), leading us to conclude that they were connecting it to their everyday lives and gradually building a range of functional vocabulary to stand for future situations. This is important to consider in a Vygotskyan perspective, which values the teacher's and children's communicative attitude throughout the activity as a means to enforce the child's conceptual understanding. While sharing and discussing their ideas and understandings children are engaged in a purposeful communication process, leading to the promotion of authentic language usage.

Children's actions and explanations throughout the practical and the assessment activities give evidence of being able to *interpret information* (focusing on either the toys details or on their 'reading' of the images of the puzzle pieces), *evaluate it* and *construct on it* to build more solid knowledge about the concepts involved.

The children's attention to the toys' details and the time they seemed to take in considering other's ideas, also suggests that while *making decisions*, they were also showing some sort of *critical thinking*. They often considered both the facts and their colleagues' ideas to make up their own mind as to where to place a given toy. Their effort to tackle their natural impulse to distribute the toys on their own was, nonetheless, visible.

Children also demonstrated to be able to *work autonomously*, both during the practical activity as well as the assessment one.

They have given evidence of *inferring*, mostly on the assessment strategy, having justified some of the relations among the objects illustrated in the puzzle pieces using knowledge accessed during the practical activity. When asked why he paired a wooden wheel (wagon) with a rubber one (car tyre), the child argued: "*We've already said that in the old days they could only use wood to build things*". Notwithstanding, throughout the whole practical activity children were observed to support their choices with knowledge drawn form granny Dulce's visit, the movie and information discussed throughout the activity.

Analysis of the implementation session of this activity was also focused on evidence regarding the mobilization and development of **scientific attitudes** on the children's part. These should be considered important not only in the context of school science at kindergarten level but also as a way to interpret and to interact with the world around them, as a science literate citizen.

KT's main focus should be to build on children's curiosity in order for them to construct new and more precise knowledge about the word. Throughout the activity, they revealed *curiosity* about aspects of the different objects at their disposal, and also about the situations depicted in the introductory movie. Their questions ("*Why does that train make so much smoke?*"), their remarks ("*That plane does not look like 'our' planes!*") and the attention they paid from beginning to end, allows us also to conclude about their *interest in understanding the world*, namely on the concepts involved in the practical activity.

Although rather young, some children showed to *consider others ideas and opinions*. This happened mostly due to the KT's care in promoting a debated discussion of both facts and ideas, insisting on asking children if they thought a certain idea was correct, and if so, why. They appeared to be able to analyze a given idea, and to give arguments for or against it, revealing *willingness to consider evidence and to change ideas*. This can be inferred when children were confronted with facts that didn't sustain their decisions ("*Yes, that truck operates on batteries, so it couldn't have belonged to my grandparents!*").

In both activities, (practical and assessment) children gave evidence of *perseverance*, as they showed continued effort and determination to accomplish the purpose of the activity, handling their doubts and insecurities. When faced with a toy which they did not know where to place, their reaction was to ask for someone's opinion (the KT or a colleague), in order to help them decide, not giving signs of resignation or frustration. This also leads us to conclude that these children were able to *work cooperatively*, as in no occasion we witnessed any altercations among them. They waited while others chose an object, considered where to place it and explained their choice. They listened to one another and respected the others' opinions when they differed from theirs, contesting them when they disagreed ("*Can't you see your grandmothers drawing board couldn't have been a magnetic one?*").

Other evidence to be considered in the analysis of the implementation session regarded the children's construction of **knowledge**, assessing the ideas they showed throughout the activity, and the choices they made.

Children demonstrated to have constructed some general idea about the *diversity of materials available to man, both of natural and non-natural origin*. Although they did not express themselves using these precise terms, we can assume they were able to construct some knowledge about these concepts, inferring from the choices they made throughout the activity and, mostly, the arguments they gave to justify them. Children would often give justifications like "*This is made of wood, so it could be granny's toy", or "This is plastic, so it could not*", leading us to believe that they established a simple criterion to separate them: the material they were made of. Children clearly focused their attention in this characteristic of the toys to choose the set they found to be the correct one: those that could have belonged to our grandparents (toys made of materials from natural origin and metals) and that could not (toys made of materials of non-natural origin).

Evidence regarding the children's understanding concerning the *presence of growingly complex equipment* in those toys was also observed, albeit they did not resort to this criterion to support their choices as often and as clearly as they did with the one presented in the previous paragraph. Nonetheless, they focused on mechanisms such as solar cells, magnets and batteries to exclude a given toy from the set of "granny's toys" ("*Do you really think your grandmother could have had a toy with buttons which make all those lights and sounds?*").

Again the KT had an important role in allowing children to be familiarised with some science vocabulary in order to describe and explain the concepts involved. Mainly because of the

KT's input did they use words like "science", "technology", "modern" and "scientist" when characterising some of the toys they considered to be recent ones. Although the underlying meaning that those words may have for the children remains to be fully determined, we can however assume that some meaning was constructed.

Therefore, considering the content that *science and technology together allow for a growing diversity of materials and more sophisticated technology in toys*, we can only infer that children were able to form some kind of understanding about the processes and nature of science. Realising that science and technology are embedded in our daily lives, in this case, in most of today's toys, children concurrently build on the understanding that science and technology serve a useful purpose in our livelihood. Furthermore, to have formed some elementary idea about the dynamics of science and technology evolution towards more complicated objects will have contributed for the development of children's positive attitudes toward science and technology.

CONCLUSION

As a starting point, we assume that, on one hand, good quality teachers, with up-to-date knowledge and skills are the foundation of any formal science education system and, on the other hand 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. The wider project in which the development of this activity is included aims at contributing towards the required changes in current science teaching at the kindergarten level, in the Portuguese context. Science curriculum is therefore considered as a continuum (Braund; 2008).

We were able to gather evidence that, on one hand, the developed teacher training program contributed for KTs to construct knowledge to support the developed activities, and, on the other hand, that these activities can be considered as a means to achieve innovative practices in science teaching.

The assessment of the practical activities was based on the analysis made by both researchers and KTs who implemented them in a design-based research perspective, generating knowledge that can be transferred to real-context and can inform practitioners and other designers.

As the one presented in detail in this paper, all activities were considered adequate teaching strategies and didactic resources for the development of the kindergarten science curriculum. The concepts where considered appropriate and relevant, leading children to mobilize a set of skills and attitudes that are, in a Vygotskian perspective, well within their zone of proximal development.

The aforementioned process provides empirical evidence that the implementation of a set of specifically developed science learning strategies, such as the one presented, shows that it is possible to promote a wide range of scientific competences (knowledge, skills, values and attitudes) that should occur in any kindergarten context. This concurs with recent research showing young children's ability to do science as being underestimated, and presenting kindergarten as an eligible context for science teaching.

Moreover, it shows that when engaged in teaching strategies which are embedded in contexts familiar to them, kindergarten children are able to construct ideas not only about the presence of science and technology in our daily objects, but also about the evolution of science and technology.

External relevant people, like granny Dulce, may prove to be an engaging approach to bring children to relate with society, as a mediator of their kindergarten experiences with the inherencies of the modern world.

This strategy showed positive results in providing children with some nexus to the adults' complex world, relative to the underlying articulate relations to be found between the socio-cultural and human aspects of life and science and technology.

Evidence gathered throughout the implementation sessions leads us to consider new teaching strategies that would allow children to deepen their understanding about the evolution of science and technology. They have shown to be able to place a given object in two distinct places of a time line (their grandparent's time and the present day). This suggests as a pertinent extension activity one where children would be asked to place several images of a given object (cell phone, television, vacuum-cleaner…) in distinct places of a time-line. The images would illustrate the object as it was built in different periods of time, representing the visual features that portray its evolution. Likewise, it would be important to elaborate on children's knowledge about this subject, developing a teaching strategy that would allow them to understand that there are objects today which simply did not exist, for example, in their grandparents' days.

Teacher training programs have limited impact when it comes to reaching the whole teacher community. It is therefore assumed as important, in the context of the present study, to assess the teaching strategies impact with KTs who will not attend such a program. We are basing on the assumption that these activities should be able to sustain the development of children's scientific competences, regardless of KTs access to specific in-service training programs.

Children should be engaged and empowered, as to develop into lifelong learners in science, hence the need to provide children with multiple opportunities for joyful explorations and discoveries in science.

REFERENCES

Acevedo-Díaz, J. A., Alonso, A. V., Manassero Mas, M. A. (2003). Papel de la educación CTS en una alfabetización científica y tecnológica para todas las personas. *Revista Electrónica de Enseñanza de las Ciencias.* Vol. 2 Nº 2.

Aikenhead, G. (2002). STS Education: A rose by any other name. R. Cross (Eds.), *Crusader for Science Education: Celebrating and critiquing the vision of Peter J. Fesham*. New York: Routledge.

Caamaño, A., Martins, I. P. (2005). Repensar los modelos de innovación curricular, investigación didáctica y formación del profesorado para mejorar la enseñanza de las ciencias en las aulas desde una perspectiva CTS.In P. Membiela e Y. Padilla (Eds), *Retos y perspectivas de la enseñanza de las ciencias y el enfoque Ciencia-Tecnología-Sciedad en los inicios del siglo XXI.*Spain:Educación Editora.

Braund, M. (2008). *Starting Science… Again?* London, SAGE Publications.

Charpak, G. (1996). *La Main a la Pâte. Les Sciences a L'École Primaire*. Paris: Flammarion.

Eshach, H. (2006). *Science literacy in primary schools and pre-schools*. Netherlands: Springer.

Eurydice (2006). *Science Teaching in Schools in Europe*. Brussels: Eurydice.

Fumagalli, L. (1998). O Ensino das Ciências Naturais ao nível fundamental da educação formal: argumentos a seu favor. Em H. Weissman (org.) *Didáctica das Ciências Naturais. Contribuições e reflexões*, pp. 13-29, Porto Alegre: ARTMED.

Hadzigeorgiou, Y.; Anastasiou, L.; Konsolas, M. & Prevezanou, B. (2009) A Study of The Effect of Preschool Children's Participation in Sensorimotor Activities on Their Understanding of the Mechanical Equilibrium of a Balance Beam. *Research on science education*, Vol. 39, pp-39-55.

Harlen, W. & Qualter, A. (2004). *The Teaching of Science in Primary Schools*. London: David Foulton.

Harlen, W. (2006). *Teaching, Learning & Assessing Science 5-12.* London: SAGE Publications Ltd.
Havu-Nuutinen (2005). Young Children's Conceptions of Temperature and Thermometer. *The International Journal of Learning*, Volume 14, Issue 9, pp.93-102.
Keogh, B., Naylor, S. (1998). Concept Cartoons. *Primary Science Rev*iew, 51, 14-16.
Membiela, P. (2001). Una revisión del movimiento CTS en la enseñanza de las ciencias. In P. Membiela (Ed.), *Ensenãnza de las ciencias desde la perspectiva ciência-tecnologia sociedad - Formación científica para la ciudadanía*. Madrid: Narcea Ediciones.
Osborne, J. & Dillon, J. (2008). *Science Education in Europe: Critical Reflections*. London: The Nuffield Foundation.
Saracho, O. & Spodek, B. (2008). Contemporary Perspectives on Science and Technology in *Early Childhood Education*. USA: Author's edition.
Van Hook, S. e Huziak-Clark, T. (2008). Lift, squeeze, Stretch, and Twist: Research-based Inquiry Physics Experiences (RIPE) of Energy for Kindergartners. *Journal of Elementary Science Education*, Vol. 20, nº3, pp. 1-16.
Weavers, G. (2008). *Made you look, made you th!nk, made you "talk".* Cheshire: Milgate House Publishers.
Wang, F., Hannafin, M. J. (2005). Design-based research and technology-enhanced learning environments. *Educational Technology research and Development, 53* (4), 5-23.
Yager, R. (2009). *Enquiry: The Key to Exemplary Science*. USA: NSTA Press.