JOURNAL OF BALTIC SCIENCE EDUCATION

ISSN 1648-3898

"YOUNG NOISE RESEARCHERS": AN INTERVENTION TO PROMOTE NOISE AWARENESS IN PRESCHOOL CHILDREN

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Abstract. *While little is known about how young children understand noise and its environmental aspects, this topic is suggested to be included in science curricula from early years on. To investigate if and to what extent preschool children's level of noise awareness could be improved the 'Young Noise Researchers' educational scenario was designed, implemented and evaluated. Research design involved a pretest-posttest procedure. Participants were 52 Greek preschool children, who attended public kindergarten classes. The scenario involved 9 activities following the principles of context-based, socio-cognitive and multimodal teaching and learning, which were implemented by the teachers of the classes in a 4-week period. Prior to and after the intervention participants engaged in individual, semi-structured interviews. The results indicated improvement in children's noise awareness in regard to acknowledging everyday noises, understanding annoyance and subjectivity of noise, adopting negative attitudes towards noise and acknowledging its health effects. Nevertheless, their noise awareness did not significantly improve in other crucial respects. Implications for teaching involve a more systematic focus on the distinction between sound and noise, noise subjectivity, the annoyance caused by noise in daily life and the possibility of more active and preventive protection measures.*

Key words: *early childhood education, pupils' noise awareness, science education.*

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Introduction

Noise pollution is an important environmental issue in contemporary societies. Noise is defined as any "unwanted or disturbing sound" (Environmental Protection Agency [EPA], n.d.) that can cause different degrees of annoyance, ranging from obstructing everyday activities such as conversation, to significantly diminishing one's quality of life. Exposure to noisy environments has various and severe health effects including hearing loss, development of psychological and neurological disorders (such as stress-related illnesses, sleep disruption), and damages in the digestive, endocrine, and circulatory systems. Furthermore, reduced productivity, as well as antisocial and violent behavior are considered to possibly result from exposure to noise (Prasher, 2000; World Health Organization [WHO], 2003, n.d.).

Noise annoyance is a multifactorial problem, with noise level (i.e. loudness) being only one of its components; other, non-acoustic factors, for instance attitudes towards a noise source, the informational content of noise, an individual's subjective sensitivity to noise, personal beliefs, and lifestyle also play an important role (Babisch, Schulz, Seiwert, & Conrad, 2012; WHO, n.d.).

Children are more vulnerable to noise than adults, since their ability to choose and control their acoustic environment is restricted (Babisch et al., 2012); they have difficulty in predicting, understanding, and facing the problem (Waye, van Kamp, & Dellve, 2013) and tend to underestimate the effects of noise on their personal health (West, 2012). Moreover, children's exposure to noisy environments can induce bodily symptoms, affect cognitive development and functions related to memory and learning, and cause an inability to concentrate, comprehend and communicate (Prasher, 2000; Shield & Dockrell, 2003). Therefore, children are considered to be a special risk group in regard to noise compared to the general population (Babisch et al., 2012; WHO, n.d.).

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While research on science education has extensively studied pupils' ideas on a wide variety of subjects, including forces, energy, and electricity, only a small number of relevant studies have focused on sound (Eshach, 2014; Huang, 2009; Lautrey & Mazens, 2004), although pupils acquire a multitude of sound experiences earlier on (Huang, 2009; Çalik, Okur, & Taylor, 2011). Similarly, though environmental education research has widely investigated issues, such as air pollution, climate change, or waste management, noise pollution has attracted only limited attention from researchers (Houle & Barnett, 2008).

In particular, empirical studies exploring young children's conceptions of sound have mainly addressed the topics of sound production and propagation (Driver, Squires, Rushworth, & Wood-Robinson, 1994; Eshach, 2014; Huang, 2009; Piaget, 1971; Sözen & Bolat, 2011), and the physical characteristics of sound (Butts, Hofman, & Anderson, 1994). A substantial body of research has concentrated on students' alternative idea of sound as a material entity (Driver et al., 1994; Eshach, 2014; Eshach & Schwartz, 2006 Hernandez, Couso, & Pintó, 2012; Houle & Barnett, 2008; Lautrey & Mazens, 2004; Sözen & Bolat, 2011), which apparently constitutes a critical obstacle to understanding relevant phenomena. Crucial difficulties in understanding sound and its properties seem to persist, as such beliefs appear even among university students (Huang, 2009; Pejuan, Bohigas, Jaén & Periago, 2012; West & Wallin, 2013). However, since the focus of this research is on the concept of noise as a techno-scientific issue that affects everyday life, and not the concept of sound, an extensive review goes beyond the scope of the present study, thus reference to the relevant literature is only indicative.

Research focusing on the exposure of children to noise (Babisch et al., 2012; Bulunuz, 2008; Waye et al., 2013) indicates that even from preschool age children can perceive noises and describe the annoyance these cause them referring to the feeling of anger, along with physical symptoms regarding their head, heart, or stomach (Waye et al., 2013). Children report greater annoyance from noise produced by family members or in the neighbourhood than from traffic noises (Babisch et al., 2012). Furthermore, even young children are capable of suggesting both active and passive ways of coping with noise by means of noise reduction or noise avoidance behaviours respectively (Waye et al., 2013).

Other studies, however, have recorded significant limitations in pupils' understanding of noise pollution. More particularly, pupils have been found to underestimate the effects of noise on hearing, claiming that loud sounds are not harmful once they come from the music they like, they are temporary or they don't cause earache (Bulunuz, 2008; West, 2008). Pupils' capability of developing appropriate strategies for coping with noise is also regarded as an important research question (Waye et al., 2013), although largely disregarded (Harrison, 2005).

Similarly to the underrepresentation of the topic in educational research, noise has not attracted the deserved attention in science teaching, nor has it been widely included in science curricula internationally (Bistrup, 2003; Eshach, 2014; Treagust & Kam), especially those intended for early childhood. Lacking an adequate conceptual understanding of noise and its consequences could lead to attitudes of defencelessness towards noise (Bulunuz, 2008), which in turn could inhibit children's development of coping behaviours, thus, negatively affecting later life quality and threatening their health (Waye et al., 2013).

On the other hand, a central aim of teaching science is to appropriately prepare pupils to be capable of critically engaging in science as adults (Aikenhead, 2006; Osborne & Dillon, 2008). Within this line of thinking important issues like noise pollution should be included in science curricula (Harrison, 2005; West, 2012) and contribute to the promotion of scientific literacy (Bistrup, 2003; Hernandez et al., 2012). Thus, appropriately designed teaching and learning sequences can have a positive effect on pupils' understanding of noise as a techno-scientific issue related to everyday-life and health (Houle & Barnett, 2008; Treagust & Kam, 1985). After such intervention students tend to adopt more healthy choices, avoiding loud noises (West, 2012). These findings indicate that noise awareness and preparedness to cope with noise should be included in science curricula as central teaching objectives (West, 2012), from an early age (Bulunuz, 2014).

Interventions aiming at the promotion of scientific literacy suggest pupils' critical engagement in real-life techno-scientific issues (Aikenhead, 2006; Hernandez et al., 2012; Osborne & Dillon, 2008). In this perspective, context-based, or STS (Science-Technology-Society) teaching, a trend encompassing a wide age spectrum, including primary school students (Bennet, Lubben, & Hogarth, 2007; Castano, 2008; Maloney, 2007), has lately been regaining interest (Fensham, 2009). By introducing science and technology-related issues with social implications, the requirement of "science for all" can be met, promoting activity-based science teaching and learning which take students' everyday experiences as a starting point (Aikenhead, 1994; Fensham, 2009; Lijnse, Kortland, Eijkelhof, van Genderen, & Hooymayers, 1990; Sadler, 2011; Zeidler, Applebaum, & Sadler, 2011; Zeidler, Herman, Ruzek, Linder, & Lin, 2013).

This overarching principle can be served by providing children with context-based learning experiences, including investigation of simple research questions; collecting, analysing and organizing observations and measurements in different forms of representations; using reflective classroom discussions with teachers posing scaffolding questions to prompt pupils' ideas. Teachers can also encourage students to meaningfully interpret the outcomes of the activities, formulate conclusions and communicate them to the school community (Ainsworth, 2008; Butts et al., 1994; Gilbert, 2006; Houle & Barnett, 2008; Pruneau, Richard, Langis, Albert, & Cormier, 2005). In this sense, context-based teaching interventions often adopt a socio-cognitive approach for learning emphasizing the identification and juxtaposition of different –often contrasting- conceptions and their experimental investigation which could trigger socio-cognitive conflict (Gilbert, 2006; Pruneau et al., 2005; Ravanis & Bagakis, 1998).

Within this perspective, participation in community activities and practices (Gauvain, 1998), interaction with more experienced and knowledgeable individuals (e.g. teachers), mediation of cultural tools such as language, symbolic systems and visual representations (Stetsenko, 1999), and interaction with varied teaching materials (e.g. books, educational software) supports children's knowledge development (Ravanis, Christidou, & Hatzinikita 2013) who obtain access to a new cognitive device for thinking about natural phenomena (Shepardson, 1999). Such teaching materials are largely multimodal, i.e. they integrate different semiotic modes to produce meaning (Kalantzis & Cope, 2012; Kress & van Leeuwen, 1996). Preschool children, who are not fully literate in the conventional sense, tend to develop alternative strategies -among which visual reading strategies- to deduce meaning from a text, based on other modes rather than solely on language (Papadopoulou & Christidou, 2004). Moreover, science-related texts are mostly multimodal regardless of the specialization of the public they are addressed to (Kress, Jewitt, Ogborn, & Tsatsarelis, 2001; Unsworth, 2001). Visual representations such as diagrams and graphs are an integral part of multimodal texts and a suitable means for bridging the gap between everyday experiences and scientific knowledge and can therefore be used as tools for knowledge construction (Yore & Treagust, 2006). Besides, being able to read and produce multimodal science texts constitutes a crucial component of scientific literacy (Gonitsioti, Christidou, & Hatzinikita, 2013).

The preceding analysis indicates that little is known about how young children understand noise and its environmental aspects (Houle & Barnett, 2008). In view of the necessity of meaningful teaching and learning about noise addressing young children, the aim of this study was to investigate if and to what extent their level of noise awareness could be improved when they participate in an intervention involving relevant teaching and learning activities. More specifically, the aspects of noise awareness investigated were reflected in the research questions of the present study, which involved:

1. Does preschool children's understanding of the concept of noise change as a result of the intervention?
2. Does children's ability to acknowledge noise annoyance improve after the intervention?
3. What are the effects of the intervention on children's awareness of the health effects of noise?
4. Are children more capable of proposing noise protection measures after participating in the teaching and learning activities?

Methodology of Research

In order to respond to the research questions described in the previous section data collection instruments were constructed and a teaching intervention was designed and implemented in kindergarten classes. The design adopted involved pre- and post-tests administered to young children before and after participating in the teaching and learning intervention, a specifically designed educational scenario for raising awareness of noise and noise-induced annoyance and health effects. Comparison between pre- and post-test results enabled the evaluation of the teaching intervention. The study took place between December and April during the 2013-14 school year.

Participants

A total of 54 pupils, coming from three preschool classes (aged 4.5-5.5 years, M = 58.1 months, SD = 2.6 months) participated in the study. A low drop-out rate was observed, since two of the pupils (3.7%) were absent during the post-test and were entirely excluded from the data analysis. Thus, the sample consisted of 52 children, namely 28 boys (53.8%) and 24 girls (46.2%).

The participants attended classes in 3 different public kindergarten schools in high noise-level urban and

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semi-urban districts in Alexandroupolis and Volos cities in Greece. None of the children had previously participated in any teaching and learning intervention related to noise. Recruitment of participants was based on their teachers' voluntary involvement in the study.

The participants attended typical Greek schools, with firmly pre-constructed and pre-determined infrastructures and uses, following a curriculum common in all Greek schools, centrally prescribed by the Ministry of Education. Therefore, the schools chosen to participate could be considered as representative of Greek kindergartens.

Prior to the study a consent form was distributed to the parents of the prospective participants briefly explaining the purpose and process of the study (pre- and post- test interviews and teaching – learning sequence) and asking their permission for their children to participate in the study. All parents provided their agreement by returning the consent forms signed to the teachers.

The "Young Noise Researchers" Educational Scenario

An educational scenario entitled 'Young Noise Researchers' was designed, implemented and evaluated. The principles of the context-based, socio-cognitive and multimodal teaching and learning approaches outlined in the previous section were taken into account when developing the scenario.

Additionally, the scenario design took into account children's difficulties and alternative conceptions (Driver et al., 1994; Osborne, Bell, & Gilbert, 1983) as reported by previous studies (Babisch et al., 2012; Bulunuz, 2008; West, 2008) and recorded during pre-test interviews in the present study. These conceptions could be summarized as follows:

- Noises are produced only by people and their activities;
- Noises are produced only in the urban environment, not in the countryside;
- Noises are simply annoying and are not harmful to people's health;
- Noises are very loud sounds;
- Noises are perceived the same by all people or people are equally annoyed by the same sounds every time.

The overall aim of the "Young Noise Researchers" scenario was to raise young children's awareness of their acoustic environment and the direct and long-term effects of noise. The scenario was designed for young children (aged 5-8) and its implementation developed in 9 activities, which extended to a period of 4 weeks.

The educational scenario aimed at supporting children in:

- understanding the concept of noise and that it is not produced only by human activity or only in urban environments;
- distinguishing sound from noise;
- understanding the subjective character of noise;
- becoming sensitized to the effects of exposure to noisy environments;
- developing positive attitudes towards minimizing exposure to noise;
- acquiring ways to reduce noise with practical interventions.

The main activities of the scenario are briefly described in the following paragraphs (for a more detailed presentation, see Noiseaware, 2014).

Activity 1: Orientation. A sound document was presented combining different sounds (e.g. people's voices, a dog barking, traffic noises, a drill, loud music in a bar, etc.). After a discussion, children were encouraged to name the sounds heard, guess their origin, and express their feelings about being in such a place. They were prompted to express their views about what is annoying in this situation and search for a word describing what they had heard.

Activity 2: Sounds and noises – what things cause noise? The children carefully listened to sounds from inside and outside the classroom. While they reported the observed sounds, the teacher recorded them on a spidergram. A discussion followed, focusing on whether all sounds recorded were noises or not. Children were invited to fill in an individual Listening Record Sheet to record noises heard at home during one day.
On the next day the noises individually recorded at home were transcribed into the spidergram; in addition, a summary classroom Listening Record Sheet was created, integrating the children's records, that is, the overall frequency of each distinct noise. Further discussion led to the definition of noise as *"every unwanted sound that we*

don't like and that irritates us".
The children were encouraged to find a way of estimating and representing which of the noises were more frequent and which were uncommon. Thus, a bar chart illustrating the incidence of noises coming from different sources was constructed (Figure 1).

Figure 1: Bar chart representation of the incidence of domestic sounds.

Activity 3: Recording sounds in the city. A procedure similar to that of Activity 2 was followed to observe city noises and record their sources (for instance traffic, a street market, a playground, a bakery shop etc.) on relevant Listening Record Sheets. The new recordings were added to the summary Listening Record Sheet.

Activity 4: Recognition and classification of different noises. This activity involved children familiarization with the categories of noise sources through play with digital files. Children were left to navigate the files, observe noises and match them with images of their sources aiming at finally identifying the four principal noise source categories: natural; urban, human-made environment; urban and interurban traffic; work environment. Different noises were classified according to source category. The observation that noises not only exist where people live and work, but also in nature, was rather counter-intuitive and provided an opportunity for cognitive conflict and fruitful dialogue in the classroom.

Activity 5: Why is noise irritating? This activity focused on whether and under what circumstances each noise would be annoying, what noises prevent us from doing and how we feel when we hear noises. Possible health problems stemming from people's exposure to noises were referred to (earache, anger, headache, dizziness, nausea, stomachaches, sleep disorder). This discussion was initiated by comics created with relevant freeware (Figure 2) comprising short, self-contained stories with people suffering from the above consequences.

Figure 2: Example of comic strip story about noise consequences on hearing.

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Activity 6: Use of the Sound Meter and construction of a sound thermometer. A simple digital sound meter installed on a smartphone was introduced. From a variety of free relevant applications, those based on color signification of different sound levels (e.g. 'colored sound thermometer' – see Figure 3, or bar chart – see Figure 4) were selected as more readily 'decoded' and used by young children.

After exploring the sound meter aiming at familiarizing children with its function and indications, they produced and 'measured' what we would call 'absolute silence' in the classroom and discovered that such a thing does not exist, but corresponds to sound levels of at least 25-30 dB. Subsequently, they measured common sounds and noises (e.g. the tearing of paper, a whisper, a normal conversation, rain falling, a quiet street with no traffic, a busy street, a hoover, a plane flying above, etc.). Before measuring each sound, children were asked to predict its level. Subsequent measurement either confirmed or contradicted their predictions inducing, thus, cognitive conflict.

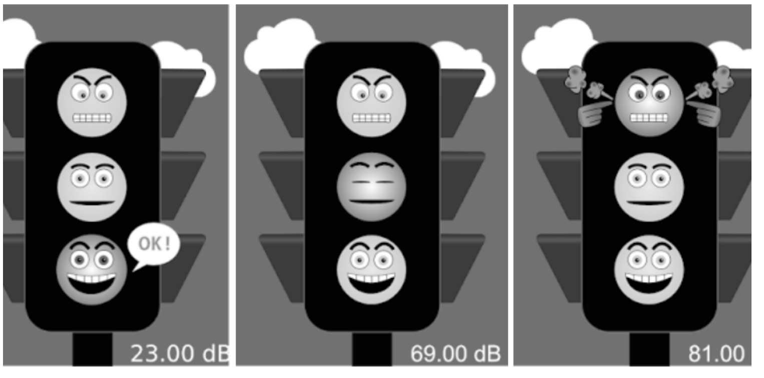

Figure 3: Screenshots of the Noise Moderator application.

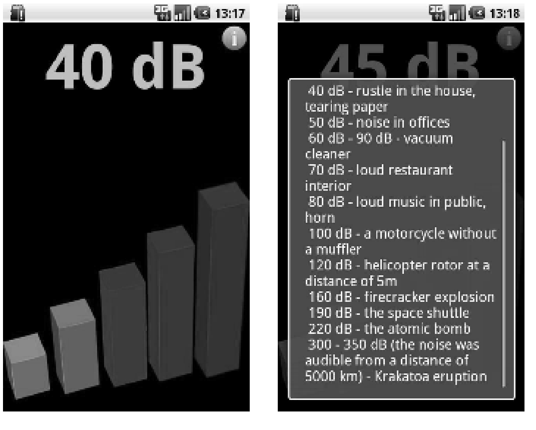

Figure 4: Screenshots of the Sound Meter application.

Children recorded their measurements on a 'sound thermometer' integrating color and symbols to signify sound levels. Images of sound sources were pasted on each side of the scale (Figure 5).

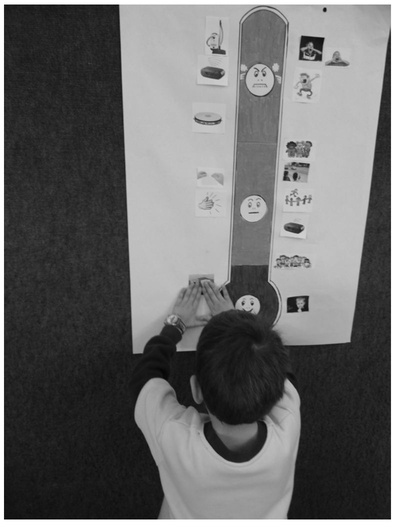

Figure 5: Sound thermometer representing measurements carried out with the digital sound meter.

Activity 7: The same sound can sometimes be a noise and sometimes not. The teacher played a sound clip altering its volume. This introduced a connection between the concept of noise and the volume of sound in the discussion (e.g. we may like the same music at a normal volume level, but it might annoy us at a higher volume). A further point for discussion concerned whether the same sounds at the same volume were always perceived as noises or not. For example, the voice of a familiar person could sometimes be welcome (when we converse with them) and sometimes annoying (it disturbs us when we try to do something else).

Activity 8: How can we protect ourselves from noise? Children were invited to propose ways of protection from noise. Suggestions could involve measures taken to reduce levels and instances of noise occurrence at home, in the classroom, or in the city. Children tried to communicate protection measures by filling in relevant comic strips with text or drawings (Figure 6).

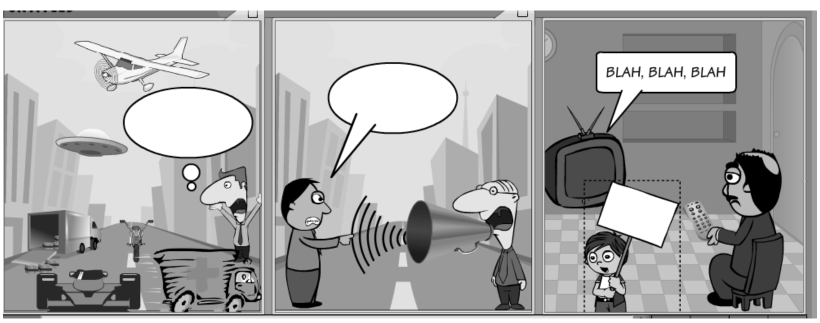

Figure 6: Comic strip for completing with noise reduction suggestions.

Activity 9: Passing our messages for noise awareness to others. Questions such as: *"Do noises ever stop?"*, *"Is there what we call absolute silence?"* were introduced to deduce that noises can be heard anywhere and anytime. The discussion then shifted to recalling noises from previous activities and seeking solutions for their reduction. Children worked in groups to produce information material –e.g. a poster, a PowerPoint presentation– on different topics (for instance *"Our ears never rest"*, or *"How can we reduce noises in our everyday life?"*). Each group presented their work to the classroom. Publicity events were organized to inform the school community and local authorities about the program's outcomes and promote noise awareness to the wider public.

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Data Collection

Pre- and post-tests were implemented by means of individual, semi-structured interviews with the participants. A quiet, isolated room was available in each school for the purposes of the data collection.

The interview consisted of 14 indicative questions (see Appendix), which aimed at eliciting pupils' views about: the concept of noise, distinction between noise and sound, noise annoyance, noise effects on health, coping with and protection from noise. The interview procedure was identically followed during pre- and post-test, using the same probes and encouraging children to express their views as thoroughly as possible. Oftentimes, children's responses to one question also extended to and covered other questions, as well. For instance, when asked to locate where they usually hear noises (Question 3), most children also indicated the kinds of noises they hear (Question 4, see Appendix). Also, many children spontaneously referred to their dislike of hearing noises from loud music, or TV (Questions 8 and 9) while responding to other questions, earlier on during the interview. In these cases, questions already answered by a child were not subsequently posed to him/her. Each interview lasted 10-15 minutes on average. Prior to the main study, a preliminary pilot study at one of the participating schools was conducted with a sub-sample of 6 pupils who did not participate in the main study. The interview questions proved to be appropriately formulated and were well understood by the pupils in the pilot study, therefore no significant modifications were required for the main study.

The pre-test was conducted during the week that preceded the beginning of the scenario implementation, while the post-test took place three weeks after its completion.

Data Analysis

All pre- and post-test interviews with children were audio recorded and transcribed verbatim. An analysis framework was constructed consisting of 4 principal axes, namely, *understanding of noise*, *noise annoyance*, *health effects of noise*, and *measures of protection from noise*, to record participants' views on the main themes explored during the interviews. Each axis of analysis comprised further dimensions, illustrated in Figure 7 and described below.

Understanding of noise. Analysis examined if children's definitions of noise were based on annoyance caused by noise, on noise volume (i.e. loudness), or on particular examples of noise. Furthermore, the specific instances of noises and/or noise sources elicited were recorded and further classified according to the principal source categories: human-made environment, natural environment, traffic, or work environment. The number of noise instances spontaneously mentioned by each child also provided a measure of their awareness of noises occurring in their environment. Furthermore, by examining noise definitions and examples, as well as comments made throughout each interview, analysis focused on whether the participants explicitly distinguished it from the general concept of sound.
This axis of analysis also investigated whether the children acknowledged noise subjectivity, that is the fact that the same sound can be pleasant or unpleasant (i.e. noise) under different circumstances or for different people.

Noise annoyance. This axis focused on whether children expressed negative –namely annoyance, dissatisfaction, or frustration- or positive attitudes towards noise, or alternatively if they made contradictory comments throughout the interview. Absence of explicit attitudes was also recorded. Moreover, the number of particular instances of annoying noises mentioned by pupils were considered as an additional indicator of children's noise awareness. Instances of noise annoyance were further classified as acoustic or non-acoustic.

Health effects of noise. Analysis according to this axis primarily explored whether the children acknowledged the fact that noise exposure can have short- or long- term consequences on health. In case their responses were positive, specific instances of noise effects were considered as another measure of the pupils' level of noise awareness and classified as acoustic (namely earache, or hearing loss), bodily (e.g. nausea, headache, or stomach ache), or psychological (e.g. anxiety, sleep disorders).

Protection measures. The last axis of analysis primarily explored if the children were capable of proposing protection and coping strategies regarding noise. Pupils' suggestions were categorized as prevention or coping measures.

The former concerned actions aiming at preventing noises from occurring. Coping measures could be active (i.e. interventions to reduce existing noise) or passive (that is intervention to protect oneself from existing noise that is not considered as reducible at the source, for instance, by covering the ears, wearing earplugs, closing doors and windows, etc.). Responses involving both prevention and coping measures were coded as 'combination'.

Data analysis was independently performed by two of the authors. Independent codings were compared to search for agreement, yielding an inter-rater reliability of 92%. Sporadic discrepancies that occurred were resolved by means of discussion between raters, with the participation of a third researcher. Further issues of validity and reliability of the study were addressed in the following ways: i) the members of the research team did not relate to the participating school communities (i.e. pupils and staff) in any way, which ensured avoidance of bias in data collection and interpretation; ii) all three participating classes followed exactly the same procedure, i.e. the teachers identically implemented the educational scenario, after being accordingly trained by the research team; iii) the researchers compared and controlled the topics investigated by the interviews to ensure that elicited data responded to the research questions initially posed and that different researchers would end up with identical records for the same interview.

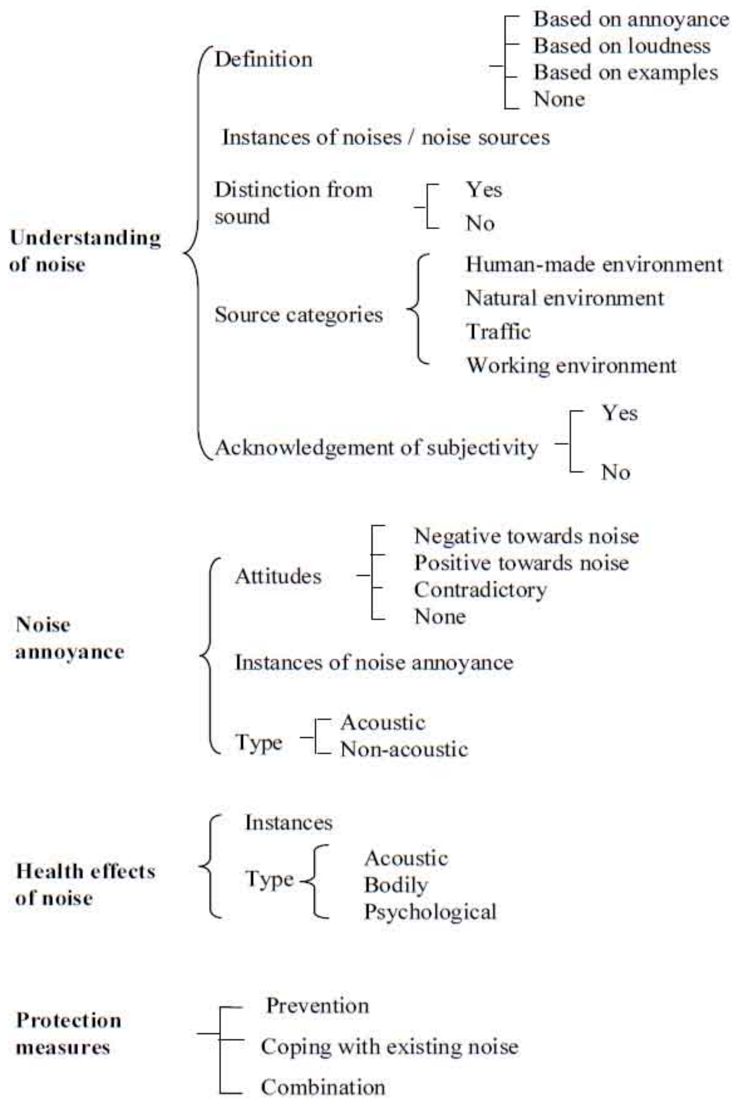

Figure 7: The framework of analysis.

ISSN 1648–3898

To estimate potential differences between children's responses to pre- and post-tests the χ^2 criterion and the dependent samples t-test were used. The former was employed to indicate whether pupils' responses significantly varied in respect to different categories of responses between pre- and post-test interviews. The latter was performed to compare mean numbers of instances of noise, noise annoyance, and noise health effects spontaneously provided by the participants during the two phases of data collection. A significant increase in the mean number of instances reported would signify improvement of their level of noise awareness.

Results of Research

The results are summarized in Table 1 and are presented in the following paragraphs according to each axis of analysis and respective dimensions.

Understanding of Noise

Prior to the teaching and learning sequence most children (29 instances) described noise by means of examples, or were unable to attribute meaning to the term (11 instances). Instances of noise definitions based on annoyance (6 instances) or volume (8 instances) were occasionally recorded. These tendencies were reversed after the intervention, with definitions based on annoyance (18 instances) or volume (14 instances) being recorded more frequently than expected [$\chi^2(3) = 13.48$, $p<.005$]. This evolution in children's conceptualization of noise could be characterized as positive, since annoyance-based definitions are consistent with scientific knowledge. Even definitions based on volume, although inadequate, could be characterized as higher level responses compared to inability to define the term or resort to noise examples, since volume is a component of noise.

Table 1. Absolute frequencies of pupils' responses according to dimensions of analysis.

			Pre-test	Post-test
Understanding of noise	Definition	Based on annoyance	6	18
		Based on loudness	8	14
		Based on examples	29	16
		None	11	6
	Instances of noise		360	430
	Source category	Urban environment	51	48
		Nature	30	33
		Traffic	26	38
		Working environment	3	6
	Distinction from sound		7	22
	Subjectivity		27	32
Noise annoyance	Attitudes	Negative towards noise	24	44
		Positive towards noise	1	0
		Contradictory	19	4
		None	10	6
	Instances of annoying noises		122	125
	Type	Acoustic	25	22
		Non-acoustic	34	44

			Pre-test	Post-test
Health effects	Acknowledged		40	44
	Instances of effects		80	164
	Type	Acoustic	35	48
		Bodily	29	91
		Psychological	16	25
Protection measures	Prevention		2	3
	Coping		35	36
	Combination		11	11

Furthermore, the children provided significantly more instances of noises experienced in their environment during post-test (430 instances, M = 8.27, SD = 4.12) than during pre-test (360 instances, M = 6.65, SD = 3.60): $t(51) = 2.99$, $p < .005$. This finding indicates an overall improvement in pupils' awareness of existing noises in their environment.

Instances of noise mentioned by pupils corresponded to different source categories. Noises stemming from the urban environment –such as, people yelling, a tap dripping, electric appliances like a hoover, or a television-predominated both prior to (51 instances) and after the intervention (48 instances). Noises from nature (mostly noises made by animals, the wind, or rain) were also brought up (30 and 33 instances during pre- and post-test respectively), as well as traffic noises, such as cars, car horns and alarms, motorcycles (26 instances during pre-test and 38 during post-test). Noises from work environments (such as, pneumatic drills and excavators in public works) were only sporadically mentioned.

Additionally, the children who were able to distinguish noise from sound were not many (namely 7 prior to and 22 after the intervention, see Example 1). However, their number significantly increased in the post-test [$\chi^2(1) = 10.76$, $p<.001$].

Example 1: (P.47, Girl, 5 years, post-test):
Interviewer: Do you know what sound is?
P. 47: It's when we hear something, whatever we hear.
I.: Do you know what noise is?
P. 47: It's when something [we hear] annoys us.

Another critical attribute of noise, namely subjectivity, was acknowledged by 27 pupils during pre-test and 32 during post-test, implying that a sound might be desirable by one individual, but annoying –hence noise- for another, or in another circumstance as the following interview excerpts illustrate.

Example 2 (P.47, Girl, 5 years, pre-test):
Interviewer: Do you like watching TV on a loud volume?
P. 47: No, because if I have the volume loud while my mom is sleeping, she will wake up. […] My grandpa leaves the TV at a high volume while we eat and it annoys us and my grandma switches it off, because it annoys her ears. It annoys me, too.

Example 3 (P.46, Girl, 4.5 years, post-test)
Interviewer: Do you know what noise is?
P. 46: It's when someone makes a fuss […] It's something that someone does when someone [else] wants to sleep and the other has the music so loud it's noise.

Noise Annoyance

When pupils were asked whether they were annoyed by noise, the majority responded positively expressing negative attitudes towards noise (24 instances during pre-test and 44 during post-test, correspondingly), as

Example 4 indicates. Positive attitudes towards noise were only expressed by one girl during pre-test, while 19 children during pre-test and 4 during post-test provided contradictory comments. Others did not clearly express their attitudes towards noise. Negative attitudes towards noise were recorded during post-test more frequently than expected, while the reverse tendency was revealed for contradictory attitudes, which were more frequent during pre-test interviews [$\chi^2(3) = 17.72$, $p<.001$].

Example 4 (P.23, Boy, 4.5 years, post-test):
Interviewer: How do you feel when you hear a noise?
P 49: It annoys me very much because I am afraid that my ears will become deaf and I will not hear anything.

In regard to recalling specific instances of noises that annoyed them, the children made 2.35 (122 instances) and 2.40 (125 instances in total) references on average during pre- and post-test respectively. Annoyance experienced from these noises was either acoustic (25 and 22 instances, see Example 5), or non-acoustic (34 and 44 instances during pre- and post-test, as in Example 6). Apparently children more readily acknowledged non-acoustic annoyances during post-test compared to their initial comments, which indicates preschoolers’ readiness to identify different kinds of noise annoyance.

Example 5. (P.7, Girl, 5 years, post-test)
Interviewer: How do you feel when you hear a noise?
P.7: I feel sad, because I can’t hear the TV […], the computer, because the hoover makes a lot of noise.

Example 6. (P.25, Boy, 5.5 years, pre-test)
Interviewer: Can you remember some time that a noise annoyed you very much?
P.25: Last year, while I was sleeping someone came and yelled in my ear and I woke up.

Health Effects of Noise

In regard to the health consequences of noise, analysis revealed that 40 children during pre-test and 44 during post-test recognized that noise is harmful. When asked to specifically name what the health effects of noise could be, they mentioned 80 instances during pre-test ($M = 1.5$, $SD = 1.11$) a number that significantly increased to 164 instances ($M = 3.17$, $SD = 2.13$) during post-test, $t(51) = 5.69$, $p < .001$.

Health effects mentioned during pre-test were primarily acoustic, (35 instances) but also bodily (29 instances, as in Example 7), and psychological (16 instances).

Example 7. (P.4, Girl, 5 years, pre-test)
Interviewer: How do you feel when you hear noises that annoy you?
P.4: My head aches. I feel dizzy.

On the other hand, during post-test bodily effects predominated (91 instances), followed by acoustic (48 instances) and psychological (25 instances). Acoustic and psychological effects were favored prior to the intervention, while bodily effects were recorded more frequently than expected during post-test and these differences were statistically significant [$\chi^2(2) = 8.09$, $p<.05$]. Acknowledging bodily noise effects could also be considered to be a positive evolution of children’s views, since it was not self-evident for most pupils prior to the intervention, who denied that noise can affect human health apart from hearing. In the following excerpt a boy mentions a variety of noise effects:

Example 8. (P.11, Boy, 5.5 years, post-test)
Interviewer: What can happen to us if we often hear lots of noises?
P.11: We can become deaf […] our head aches, we can’t concentrate, our tummy aches, we can’t sleep.

Protection Measures

Overall, 48 of the children prior to and 50 after the scenario implementation suggested a variety of measures for protection from noise. These primarily concerned coping with existing noises (36 and 31 relevant responses, see Example 9). Prevention measures, that is actions to restrict noise occurrence, were only recommended by 2 and 3 pupils during pre- and post-test respectively. On the other hand, 12 children prior to and 16 after the intervention combined prevention and coping measures in their responses, as illustrated in Example 10.

Example 9. (P.43, Boy, 5 years, pre-test)
Interviewer: What can others do so that we don't have too much noise?
P. 43: They can say "Stop! It's dangerous! Our eardrums will break!", "Stop! This is not permitted! We must not make so many [noises], we will wake up other people! We can be heard even outside the planet!".

Example 10. (P.12, Boy, 5.5 years, pre-test):
Interviewer: What can you do to protect yourself from noises?
P. 12: I can wear earphones with the music off so that I don't hear the noises.
I.: What can others do so that we don't have too much noise?
P. 12: They should not take their large vehicles outside, the bulldozers, the excavators. They should not take the cars and motorcycles out. They should go on foot. I come to school on foot.

Discussion

The results presented in the previous section revealed a binary image. The participants' level of noise awareness improved regarding some of its aspects, while it did not significantly change regarding others.

More particularly, the participants could name significantly more instances of noise after the scenario implementation. This increase could be regarded as particularly critical, since acknowledging health effects of noise is a prerequisite for protecting oneself from being exposed to noisy environments and developing relevant risk behaviors in later life. These results are in accordance with earlier findings (Waye et al., 2013) and suggest that the educational scenario contributed considerably to raising children's noise awareness and enhanced their acoustic observation competency. Instances of noise provided by children were closely related to their everyday life, as previous research has indicated (Babisch et al., 2012). They could recognize noises from different source categories, including the natural environment, though work environments –probably not a part of direct experiences of young children- were not designated by many as a source of noise.

The scenario implementation also appeared to have a positive effect on at least some of the participants' ability to provide operational definitions of noise. Hence, several children gave more appropriate definitions based on annoyance, while others based their definitions on loudness. At the same time, some children improved their ability to draw a distinction between sound and noise.

Subjectivity, an inherent attribute of noise, was acknowledged by nearly half of the participants even during pre-test, while they performed better after the intervention. Although improvement in regard to noise subjectivity was not significant, the majority of participants acknowledged it. This finding is noteworthy, since it could also be interpreted as an indicator of cognitive decentration, that is, the ability to consider multiple aspects of a situation and possibly differentiate between one's own and another person's understanding of a situation. This indication supports the argument of preschoolers' perspective taking abilities, which has empirically emerged as a point of differentiation from Piaget's egocentrism (Kesselring, & Müller, 2011; Light, 1983; Piaget, 1995).

The abovementioned findings concerning children's readiness to comprehend noise based on the annoyance it causes and appreciate its subjective character could be considered to be an essential contribution of the present study. Besides, adequate conceptualization of noise is a prerequisite for implementing effective interventions on noise awareness.

Furthermore, participants adopted more negative attitudes towards noise during post-test, stating their frustration when exposed to noises in accordance with previous studies (Babisch et al., 2012; Waye et al., 2013). Frustration and annoyance caused by noise were the strongest tendency among pupils even prior to the intervention, yet a considerable number of children revealed contradictory dispositions during pre-test. These inconsistencies were largely eliminated, as negative attitudes towards noise increased significantly during post-test.

ISSN 1648–3898

Unlike earlier research reporting young people's tendency to underestimate health effects of noise (Bulunuz, 2008; West, 2008), the majority of participants in the present study exhibited an adequate understanding of this topic even before the intervention. Moreover, pupils' participation in the 'Young Noise Researchers' scenario apparently contributed to raising their awareness of the consequences of noise on health, since the average number of health effects mentioned in the interviews increased significantly from pre- to post-test. The development of children's awareness of health effects of noise was not only reflected in the quantity, but also in the type of the recorded effects; prior to the intervention acoustic disorders prevailed in their comments (namely eardrum rupture, hearing loss), while a significant shift towards references to bodily effects (such as, headache, trembling, or nausea) was recorded in post-test interviews (Waye et al., 2013). Psychological consequences were also recorded in both tests and involved sleeping disorders, stress, etc.

Nevertheless, the teaching and learning sequence was not so effective in other respects. In other words, the number of participants who apparently comprehended annoyance as a crucial aspect of noise and were able to distinguish noise from sound, though significantly increased after the intervention, remained a minority. Furthermore, the children tended to focus on volume (or 'loudness') as the most –or the only- crucial characteristic of noise, which indicates partial understanding of the concept (Bulunuz, 2008; Waye et al., 2013; West, 2008).

Moreover, while children's awareness of noise instances in their environment seemed to improve, this was not the case for the awareness of annoyance caused by these noises, since their references to relevant instances did not significantly increase. Similarly, the pupils' suggestions of protection measures did not significantly change. This outcome may be seen in the light of the fact that the vast majority of children were capable of proposing measures of protection from noise even before the intervention, as previous research has indicated (Waye et al., 2013). However, their preference to coping instead of prevention strategies signifies a rather passive –even defeatist- stance implying that one cannot impede noises from occurring, hence the most appropriate protection measure is to avoid existing noises by covering the ears, leaving a noisy environment, or asking others to control the noises they produce.

Conclusions

The results presented and discussed in the previous sections underline the necessity of including the relevant topic of noise pollution in educational programs and curricula, even from early childhood. Noise belongs to children's experiential realm; hence it is an opposite topic for negotiation in the classroom. Besides, the children constitute a sensitive and particularly vulnerable population group, thus the timely development of their noise awareness is a crucial factor for supporting them in selecting appropriate lifestyles in later life and protecting their health.

Teaching interventions that adopt a context-based, socio-cognitive perspective of science teaching and learning, using multiple modes of representation and communication of complex phenomena could be regarded as conductive to the construction of new knowledge and to supporting young children's development of noise awareness in particular and scientific literacy in general.

Nevertheless, understanding noise and its characteristics appears to be a complex and demanding task for young children. Developing noise awareness in these respects could entail extensive conceptual change, requiring longer and more focused interventions to allow for children's premature cognitive structures to be modified, so as to adequately integrate new, scientifically appropriate information. The question whether overcoming these difficulties is subject to young children's developmental limitations, or could be achieved by preschool children with more systematic, directed, and long-term engagement in learning activities deserves further investigation.

Implications of the present study for future teaching and learning about noise could involve a) rendering the distinction between sound and noise more explicit; b) determining noise subjectivity; c) supporting children's awareness of the annoyance caused by noise incidents in their daily life; and d) highlighting the possibility of more active and preventive protection measures.

References

Aikenhead, G. (1994). What is STS teaching? In J. Solomon & G. Aikenhead (Eds.), *STS education: International perspectives on reform* (pp. 47-59). New York: Teachers College Press.

Aikenhead, G. (2006). *Science education for everyday life*. New York, NY: Teachers College Press.

Ainsworth, S. (2008). The educational value of multiple-representations when learning complex scientific concepts. In J. K. Gilbert, M. Reiner, and M. Nakhleh, (Eds.), *Visualization: Theory and practice in science education* (pp. 191-208). Netherlands: Springer.

Babisch, W., Schulz, C., Seiwert, M., & Conrad, A. (2012). Noise annoyance as reported by 8-to 14-year-old children. *Environment and Behavior*, *44* (1), 68-86. doi: 10.1177/0013916510387400

Bennett, J., Lubben, F., & Hogarth, S. (2007). Bringing science to life: A synthesis of the research evidence on the effects of context-based and STS approaches to science teaching. *Science Education*, *91* (3), 347-370.

Bistrup, M. L. (2003). Prevention of adverse effects of noise on children. *Noise Health*, *5* (19), 59-64.

Bulunuz, N. (2008). Noise pollution in Turkish elementary schools: evaluation of noise pollution awareness and sensitivity training. *International Journal of Environmental & Science Education*, *9* (2), 215-234.

Butts, D. P., Hofman, H. M., & Anderson, M. (1994). Is direct experience enough? A study of young children's views of sounds. *Journal of Elementary Science Education*, *6* (1), 1-16.

Çalik, M., Okur, M., & Taylor, N. (2011). A comparison of different conceptual change pedagogies employed within the topic of "sound propagation". *Journal of Science Education and Technology*, *20* (6), 729-742.

Castano, C. (2008). Socio-scientific discussions as a way to improve the comprehension of science and the understanding of the interrelation between species and the environment. *Research in Science Education*, *38* (5), 565-587.

Driver, R., Squires, A., Rushworth, P., & Wood-Robinson, V. (1994). *Making sense of secondary science: Research into children's ideas*. London: Routledge.

Environmental Protection Agency (n.d.) Noise pollution. Retrieved September 20, 2014 from http://www.epa.gov/air/noise.html

Eshach, H., & Schwartz, J. L. (2006). Sound stuff? Naïve materialism in middle-school students' conceptions of sound. *International Journal of Science Education*, *28* (7), 733-764.

Eshach, H. (2014). Development of a student-centered instrument to assess middle school students' conceptual understanding of sound. *Physical Review Special Topics-Physics Education Research*, *10* (1), 1-14. Retrieved from http://journals.aps.org/prstper/abstract/10.1103/PhysRevSTPER.10.010102

Fensham, P. J. (2009). Real world contexts in PISA science: implications for context-based science education. *Journal of Research in Science Teaching*, *46* (8), 884-896.

Gauvain, M. (1998). Thinking in niches: Sociocultural influences on cognitive development. In D. Faulkiner, K. Littelton, & M. Woodhead (Eds.), *Learning relationships in the classroom* (pp. 67–89). London: Routledge.

Gilbert, J. K. (2006). On the nature of "context" in chemical education. *International Journal of Science Education*, *28* (9), 957-976.

Gonitsioti, H., Christidou, V., & Hatzinikita, V. (2013). Enhancing scientific visual literacy in kindergarten: Young children 'read' and produce representations of classification. *International Journal of Science, Mathematics, and Technology Learning*, *20* (1), 1-15.

Harrison, J. (2005). Science education and health education: Locating the connections. *Studies in Science Education*, *41* (1), 51–90.

Hernandez, M. I., Couso, D., & Pintó, R. (2012). The analysis of students' conceptions as a support for designing a teaching/learning sequence on the acoustic properties of materials. *Journal of Science Education and Technology*, *21* (6), 702-712.

Houle, M. E., & Barnett, G. M. (2008). Students' conceptions of sound waves resulting from the enactment of a new technology-enhanced inquiry-based curriculum on urban bird communication. *Journal of Science Education and Technology*, *17* (3), 242-251.

Huang, T.H. (2009). *Student learning of measurement and sound: examining the impact of teacher professional development* (Doctoral dissertation, University of Pittsburgh). Available from ProQuest Dissertations and Thesis database (UMI No. 3400489).

Kalantzis, M., & Cope, B. (2012). *Literacies*. Cambridge: Cambridge University Press.

Kesselring, T., & Müller, U. (2011). The concept of egocentrism in the context of Piaget's theory. *New Ideas in Psychology*, *29* (3), 327-345.

Kress, G., Jewitt, C., Ogborn, J., & Tsatsarelis, C. (2001). *Multimodal Teaching and Learning: The Rhetorics of the Science Classroom*. London: Continuum.

Kress, G., & van Leeuwen, T. (1996). *Reading Images. The Grammar of Visual Design*. London and New York: Routledge.

Lautrey, J., & Mazens, K. (2004). Is children's naive knowledge consistent? A comparison of the concepts of sound and heat. *Learning and Instruction*, *14* (4), 399-423.

Light, P. (1983). Piaget and egocentrism: a perspective on recent developmental research. *Early Child Development and Care*, *12*, 7–18.

Lijnse, P. L., Kortland, J., Eijkelhof, H. M. C., van Genderen D., & Hooymayers, H. P. (1990). A thematic physics curriculum: a balance between contradictory curriculum forces. *Science Education, 74* (1), 95-103.

Maloney, J. (2007). Children's roles and use of evidence in science: an analysis of decision-making in small groups. *British Educational Research Journal*, *33* (3), 371-401.

ISSN 1648–3898

Noiseaware. (2014). *Educational scenario.* Retrieved March 5, 2015 from Awareness Program for the Consequences of Noise Exposure Web site: http://www.noiseawareness.gr/en/node/51

Osborne, R. J., Bell, B. F., & Gilbert, J. K. (1983). Science teaching and children's views of the world. *European Journal of Science Education*, *5* (1), 1-14.

Osborne, J., & Dillon, J. (2008). *Science education in Europe: Critical reflections*. London: Nuffield Foundation. Retrieved September 17, 2014 from http://efepereth.wdfiles.com/local--files/science-education/Sci_Ed_in_Europe_Report_Final.pdf

Papadopoulou, M., & Christidou, V. (2004). Multimodal text comprehension and production by preschool children: An interdisciplinary approach of water conservation. *International Journal of Learning*, *11*, 917-927.

Pejuan, A., Bohigas, X., Jaén, X., & Periago, C. (2012). Misconceptions about sound among engineering students. *Journal of Science Education and Technology*, *21* (6), 669-685.

Piaget, J., & Garcia, R. (1971). *Les explications causales* [Causal explanations]. Paris: Presses Universitaires de France.

Piaget, J. (1995). *Egocentric and sociocentric thought*. In J. Piaget (Ed.), Sociological studies (pp. 276–285). London: Routledge, (Original work published in 1951).

Prasher, D. (2000). A European concerted action on noise pollution health effects reduction - NOPHER. *Noise Health*, *2* (7), 1-3. Retrieved October 3, 2014 from http://www.noiseandhealth.org/text.asp?2000/2/7/1/31747

Pruneau, D., Richard, J. F., Langis, J., Albert, G., & Cormier, M. (2005). The evolution of children's ideas on pollution in the framework of experiential and socioconstructivist activities. *International Journal of Environment and Sustainable Development*, *4* (1), 17-34.

Ravanis, K., & Bagakis, G. (1998). Science education in kindergarten: sociocognitive perspective. *International Journal of Early Years Education*, *6* (3), 315–327.

Ravanis, K., Christidou, V., & Hatzinikita, V. (2013). Enhancing conceptual change in preschool children's representations of light: A sociocognitive approach. *Research in Science Education*, *43* (6), 2257-2276.

Sadler, T. D. (2011). Situating socio-scientific issues in classrooms as a means of achieving goals of science education. In T. D. Sadler (Ed.), *Socio-scientific Issues in the Classroom* (pp. 1-9). Springer Netherlands.

Shepardson, D. P. (1999). Learning science in a first grade science activity: A Vygotskian perspective. *Science Education*, *83* (5), 621-638.

Shield, B., & Dockrell, J. (2003). The effects of noise on children at school: A review. *Journal of Building Acoustics, 10* (2), 97-106.

Sözen, M., & Bolat, M. (2011). Determining the misconceptions of primary school students related to sound transmission through drawing. *Procedia-Social and Behavioral Sciences*, *15*, 1060-1066.

Stetsenko, A. P. (1999). Social interaction, cultural tools and the zone of proximal development: In search of synthesis. In S. Chaiklin, M. Hedegaard, & U. J. Jensen (Eds.), *Activity theory and social practice: Cultural-historical approaches* (pp. 235-252). Aarhus, Denmark: Aarhus University Press.

Treagust, D. F., & Kam, G. A. (1985). Noise pollution - an overlooked issue in the science curriculum. *Journal of Science and Mathematics Education in Southeast Asia*, *8* (1), 34-39.

Unsworth, L. (2001). *Teaching Multiliteracies Across the Curriculum: Changing Contexts of Text and Image in Classroom Practice*. Buckingham: Open University Press.

Waye, K. P., van Kamp, I., & Dellve, L. (2013). Validation of a questionnaire measuring preschool children's reactions to and coping with noise in a repeated measurement design. *British Medical Journal BMJ Open, 3* (5).

West, E., & Wallin, A. (2013). Students' learning of a generalized theory of sound transmission from a teaching–learning sequence about sound, hearing and health. *International Journal of Science Education*, *35* (6), 980-1011.

West, E. (2008). *Teaching about sound, hearing and health-knowledge base, suggestions for teaching and copying material*. Department of Education, University of Gothenburg. Gothenburg. Retrieved October 14, 2014 from https://gupea.ub.gu.se/handle/2077/18685

West, E. (2012). Learning for everyday life: students' standpoints on loud sounds and use of hearing protectors before and after a teaching–learning intervention. *International Journal of Science Education*, *34* (16), 2583-2606.

World Health Organization (2003). *WHO Technical Meeting on Exposure-Response Relationships of Noise on Health.* Bonn: World Health Organization - Regional Office for Europe.

World Health Organization (n.d.). *Children and noise: Children's health and the environment. WHO training package for the health sector*. Retrieved from http://www.who.int/ceh/capacity/noise.pdf

Yore, L., & Treagust, D. (2006). Current realities and future possibilities: Language and science literacy-empowering research and informing instruction. *International Journal of Science Education*, *28* (2-3), 291-314.

Zeidler, D. L., Applebaum, S. M., & Sadler, T. D. (2011). Enacting a socioscientific issues classroom: Transformative transformations. In T. D. Sadler (Ed.), *Socio-Scientific Issues in Science Classrooms: Teaching, Learning and Research* (pp. 277–306). The Netherlands: Springer.

Zeidler, D. L., Herman, B. C., Ruzek, M., Linder, A., & Lin, S. S. (2013). Cross-cultural epistemological orientations to socioscientific issues. *Journal of Research in Science Teaching*, *50* (3), 251-283.

Appendix: The interview questions

5. Do you know what sound is?
6. Do you know what noise is?
7. Where do you usually hear noises?
8. What kinds of noises do you hear?
9. How do you feel when you hear a noise?
10. Which noises annoy you the most?
11. Can you remember some time that a noise annoyed you very much?
12. Do you like to listen to loud music?
13. Do you like watching TV with the voice on a loud volume?
14. What do you feel when you hear noises that annoy you?
15. What can happen to us if we often hear lots of noises?
16. What do you do when a noise annoys you?
17. What can you do to protect yourself from noises?
18. What can others do so that we don't have too much noise?

Received: *May 16, 2015*　　Accepted: *September 10, 2015*

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