

Sounds of learning: Soundscapes - teacher perceptions of acoustic environments in Finland's open plan classrooms

Elina Hytönen-Ng, Kaisa Pihlainen

University of Eastern Finland, Finland

Kwok Ng

University of Eastern Finland, Finland; University of Limerick, Ireland; University of Turku, Finland

Eija Kärnä

University of Eastern Finland, Finland

The construction of new schools has undergone much debate as children and teachers spend a significant proportion of their lives in physical learning environments in schools. The school soundscape is central but often underestimated. In this study, we investigated teachers' experiences of soundscapes in two modern Finnish comprehensive schools by interviewing teachers (N=10). In addition, we analysed the data by the constant comparative method. According to the results, the school architecture influenced the soundscape and organisation of teaching. The designs of the schools encouraged collaborative learning through open plan learning spaces and flexible classrooms. Yet, the open plan learning environment and its soundscape did not always support the instructional needs of all children. We conclude that soundscape design should consider both the learning needs of children, and the well-being of both children and teachers.

Introduction

Elements of the physical learning environment are known to impact the learning processes and thus children's cognitive development (Naude & Meier, 2019). The soundscape is one such element of the learning environment and is ever-changing with newly designed buildings (Woolner & Stadler-Altmann, 2021). The soundscape can include irrelevant environmental stimuli that limit learners' working memory resources from the cognitive processes (Mealings, 2022). Despite the school staff spending considerable time in these environments, this topic seems to be under-represented in international educational research (Shu & Ma, 2019). Hence, we aim to study the teacher's viewpoint on soundscapes in modern schools.

Following Schafer's (1977) definition of soundscape, we considered soundscape to include all sounds within a particular environment that reaches the human ear. It can vary from pleasurable sounds to disturbing noise (Uimonen, 2013). Soundscape, therefore, reflects the relationship between the individual and the environment, while 'soundscape ecology' is thus the study of the effects of the acoustic environment' (see Truax, 1999). The terms, 'soundscape' and 'acoustic environment', can be seen as synonyms. The terms, nonetheless, have different disciplines in the background. The acoustic environment has an emphasis on architecture and physical structure (see, for example, Cucharero et al. 2021) and come from fields such as acoustic engineering and environmental studies. The soundscape has, on the other hand, an emphasis on the listener's perspective. Sounds can be viewed in negative contexts, for example, noise from transportation can be disturbing. Simultaneously, silence or quietness does not always bring out high quality within the

soundscape (see Aletta, Kang & Axelsson, 2016; Aletta & Kang 2019). In this study, we use the term soundscape as it refers to the relationship the individual has with it.

School soundscapes

Soundscape research in the past decades has focused on noise; however in recent years the emphasis has moved more into looking at how soundscape influences human well-being (van Kamp, Klæboe, Brown & Lercher, 2016) and the effects that nature sounds have on well-being (Largo-Wight, O'Hara & Chen, 2016; van Hedger et al., 2019; Shu & Ma, 2019). There is also some research on special needs children and soundscapes (van den Bosch, 2016), including pleasant soundscapes. It is just as important to gain information on the sonic environment that works for all children as it is to understand insights on the staff, because much of their day is spent there.

As soundscapes are strongly influenced by physical structures, new environments like open plan schools present new experiences with the individual's relationship with sound. The first open plan learning environment in Finnish schools appeared in the 1990s. Open plan solutions are favoured because of 'lower building expenses, ... higher worker density, better adjustability, and better access of daylight' (Kaarlela-Tuomaala et al. 2009, p.1423). Taken from open plan offices concepts, these open physical spaces enhance visibility, collaboration, and commonality within the work environment (e.g., Dibben & Haake 2013; Kaarlela-Tuomaala et al., 2009; Keränen 2015). Kaarlela-Tuomaala and others (2009) pointed out in their research that, when moving from private office rooms into open plan offices, speech privacy was reduced significantly as well as distractions and concentration difficulties increased. They pointed out that the benefits that were expected from the open plan offices did not appear. Mainstream media in Finland has also criticised open plan offices (Kaakinen, 2019; Laatikainen, 2016). Research on the physical learning environment on Finnish schools became more visible in the 2010s (e.g., Kattilakoski, 2018; Kuuskorpi, 2012).

Despite the criticism in Finland, many new schools have been built with open architectural plans compared to the traditional school buildings from the 1970s or earlier. The old schools were often designed with a straight corridor surrounded by classrooms of equal sizes (Jetsonen, 2022). Sound acts differently in these environments, as masses of pupils pass through the narrow corridors and few doors. When we compare soundscapes within the open plan and traditional schools, we get a deeper understanding of how different structures work in relation to children's development and concentration. Different architectural solutions also imply different teaching methods and values (Kattilakoski, 2018). According to Niemi (2021), the new school layouts in Finland influence teachers' aims and their preferred practices. Although many teachers were dissatisfied with the new, open plan solution, they felt that their school had improved their collegiality, and good experiences of team teaching had increased.

Earlier research indicates that teachers are at risk of hearing related symptoms due to noise (e.g., children's voices) in their work environment (Eysel-Gosepath, Daut, Pinger, Lehmacher & Erren, 2012; Fredriksson et al., 2019, 2021; Meuer & Hiller, 2015; Sjödin,

Kjellberg, Knutsson, Landström & Lindberg, 2012). In addition, results of a study on the noise annoyance responses of middle school pupils and teachers (Enmarker & Boman, 2004) revealed that both pupils and teachers felt chatter as the most disturbing noise source in the classroom. Furthermore, the teachers experienced themselves as more sensitive to noise, had poorer hearing status, and reported more intense stress symptoms than the pupils. Teachers were also more annoyed and perceived noise to be more unpredictable compared to pupils.

Many of these previous studies have been carried out in traditional school building settings such as classrooms. However, less is known about teachers' experiences of soundscape in new open plan learning environments. Subban and Round (2022) developed an instrument to quantitatively study teachers' perceptions of open plan classroom settings. They pointed out that teachers' perceptions were more positive in larger schools toward open plan classrooms, and previous positive experiences in open plan classrooms affected them favourably. This study aims to widen the understanding of teachers' perceptions of schools' soundscapes introduced in the study by Stubban and Round (2022) by using qualitative research methods. We focus on the following research question: How do teachers perceive modern schools' soundscape? To answer this question, we explore what teachers experienced to produce, increase, and decrease sounds in modern schools.

Description of the two schools

In School 1 (420 pupils and 54 staff), the primary school (7-12 years-old pupils) classes are taught in open plan learning environments, with first and second grades combined in one open learning environment and third and fourth grade sharing another. Secondary school (13-15 years-old pupils) classes are taught more in separate, subject-specific classrooms. The school had been open for half a year at the time the interviews took place.

In School 2 (700 pupils and 80 staff) all classrooms are divided into separate rooms that could be combined into bigger rooms by opening the wall dividing the two classrooms. The classrooms are set around a lobby type of wider corridor that could also be used during lessons, for activities such as pair or group work that demand more space. School 2 had been open for one and a half years when the interviews took place.

As depicted in Figure 1, both schools had six doors, designated for pupils in different grades. The secondary school classrooms in School 1 were on the second floor of the building whereas, in School 2, the upper grades were in their wing.

Methods

In this case study, we focus on two comprehensive schools (grades 1-9) in Finland. Data were collected by interviewing teachers and other staff members (in School 1 teachers 1-5, School 2 teachers 6-10). In School 1 the interviews were conducted in May 2019 and in School 2 in March 2020. Participants represented lower-level ($n = 4$) and upper-level

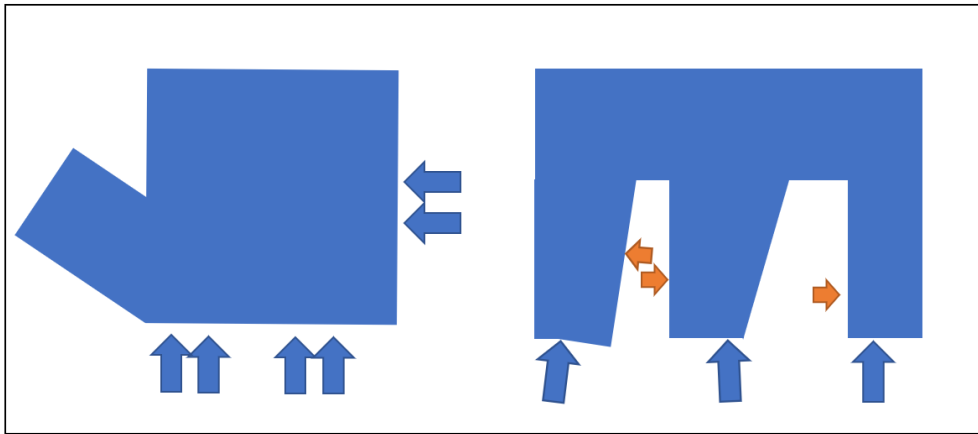


Figure 1: Broad schema of schools and main entrances
 (left): School 1 open plan: (right) School 2 'comb'. Key: blue arrows: entrance at first floor, orange arrows: entrance at first floor and to stairs for the second floor.

($n = 3$), as well as both lower- and upper-level teachers ($n = 2$) and other school staff ($n = 2$), such as a teaching assistant. Interviewed teachers were subject teachers (e.g., language and biology), special education teachers and classroom teachers. A variety of professionals involved were recruited specifically to describe the different resources and challenges that the teachers might face within the school soundscape. The frame used for the interviews can be found in Appendix 2.

The interviews were focused on the sounds within the entire school, including corridors, dining areas, yards, and playgrounds. These were considered as places where children moved through the most, generating sounds, as well as places used for their learning. The interviews were conducted within the schools, in the teachers' classrooms, and during or after the teacher's working hours. Interviews varied between 23 and 53 minutes. Interviews were recorded and transcribed afterwards before the relevant text was translated into English.

To protect the anonymity of the interviewees, they are referred to as teachers in the results section. The anonymisation process was discussed with the participants before and after the participation. The informants participated in the research of their own will and gave the researcher informed consent. Research permits for gathering the data and conducting interviews were granted by the principals in both schools.

Reflexivity has been taken into account through discussions with the interdisciplinary research team. Three authors from the research team have experience as teachers in schools in Finland and abroad. Another researcher is an expert in ethnographical fieldwork and soundscape. This allowed the researchers to view the schools as teachers, but also question some of the taken-for-granted views.

Data analysis

Interview data were analysed with a constant comparative method originally developed for the grounded theory approach by Glaser and Strauss (1967). In this study, the method was applied to systematize the analysis process. In the constant comparison method, the comparison is the dominant principle of the analysis (Boeije, 2002). Thus, the researcher categorises, codes, delineates categories, and connects them to discover conceptual similarities, refine categories, and discover patterns from the data (Tesch, 1990). The art of comparison has to do with creative processes and with the interplay between data and the researcher (Strauss & Corbin, 1998).

Data analysis in this study included three phases. In the first phase, three researchers independently read and coded the data from one school and created the preliminary analytic categories. Next, they read and coded the data from another school by utilising the categories from the first analysis. The categories were modified based on the data from the second school. Finally, the results of the individual analysis of three researchers were compared in two joint meetings in which the finalisation of the analytic categories and the analysis were completed (Appendix 1).

Results

The soundscape of modern schools consists of various elements and practices that produce or dampen sounds. Teachers' notions concerning school soundscape focused on four aspects: (1) school building; (2) technology; (3) people's behaviour; and (4) pedagogical cultures.

School building and interior design influence soundscape

Both schools in this study had many main entrances to divide pupils into smaller groups upon entering and leaving the building. This arrangement decreased sound levels from the pupils' talking and walking. Groups of pupils who used the same lobby area and doors had different schedules to avoid too many people in the same space at the same time. Teachers in School 2 referred to their school building as a "comb shape" because the structure of the school building had many aisles. With this design, the effect resulted in decreased transit and muted soundscapes in corridors.

The soundscape is supported by having the school in a comb shape so that pupils of different ages are in -- separate wings. It means that the stream of pupils flows in, about 80 pupils, from one door and the same door are flow out. We don't have hundreds of pupils from one specific door. (Teacher 8)

Teachers also mentioned the shape of classrooms and the availability of soundproof spaces that influenced the soundscape. Both schools had specific spaces that were soundproofed and located in places intended to be used for small group activities, meetings, individualised teaching, and recordings.

I feel that we have good soundproofing. That we have these small spaces where you can direct pupils or go by yourself to have a conversation with a pupil – where we have our own peace. (Teacher 6)

Even though teachers generally experienced the school's soundscape as positive, some aspects received criticism. Forms of limiting soundscape by soundproofing, such as mini booths to contain sound in a specific area, were not entirely liked, "We have a soundproof booth, [when inside] I feel quite anxious. Really. There isn't enough oxygen ... [and] it has totally black walls." (Teacher 4). In addition to soundproofed rooms, pupils could be dispersed into the corridors where they could learn together in groups without producing too much sound in the alcoves. Among the soundproofed rooms, alcoves in corridors enabled various and quieter soundscapes in larger environments to occur.

Appropriate use of interior design and furniture influenced the school soundscape. Specific chairs and the use of a grandstand produced sounds, and gaps between sliding walls allowed sound to emanate to adjacent spaces. Simultaneously, both schools had acoustic panels in walls and ceilings as well as soft benches and floors, carpets, curtains, and other soft materials to absorb sounds to make the soundscape quieter. The use of curtains decreased not only sounds, but also visual stimulation, and was especially important for young pupils and pupils with special needs.

I know that teachers in lower grades [preschool to second grade] wish to have thick felt curtains between their spaces [in open plan learning environment]. They wish them to block the sounds and also visual stimuli because young pupils take in everything that moves around there. When designing well, they [curtains] work pretty well. (Teacher 4)

One teacher noted the carpets and flooring in the following way: "We have wall-to-wall carpets here ... whereas in there [art class], there are harder floors, so sounds are clearly louder" (Teacher 1). Various materials used directly impacted the soundscape as they either seeped in sounds or reflected them, as in the dining halls.

Technology's influence on the soundscape

Technology, such as computers and ventilation, produced continuous humming sounds from the cooling units. When in use, sounds resonated from keyboard and mouse clicks. Technology within the school, such as recess bells, was not controlled by teachers which created a sense of irritation. The bell could ring in the middle of the class, as it was meant for other groups, thus making disruptions to the unintended class. Also, the volume of the bell could not be adjusted within the sports hall, and teachers considered it too loud.

Traditional technologies, such as musical instruments and vacuum cleaners, were also in use and supplemented a distinctive soundscape. Teachers minimised sounds by adjusting volume levels and using decibel indicators, earmuffs, or headphones to block sounds. "We have here special needs teaching anyway, pupils don't need any higher decibels to use headphones, they use them with pleasure [because] they block sounds, but some pupils may use headphones because of [the sounds from] ventilation" (Teacher 8). The

references to the ventilation and humming of the computers were evident also in another teacher's comment; "What we hear here in the classroom when it's a really quiet moment is that we hear these computers - - that system unit. So, it buzzes and ... ventilation, it hums" (Teacher 2).

Pupils were allowed to wear earmuffs and headphones when needed to block out sounds and distractions. The noise produced by technology tends to be sounds the individuals were able to tune out or ignore. With children with special needs, this might not always be the case and the unimportant sounds might distract them from the current activity.

People's behaviour influences the soundscape

Teachers emphasised the importance of improving the pupils' and staff's understanding of the soundscape. They mentioned examples of how they can influence the school soundscape and make the topic tangible for pupils. This was reflected in how the pupils were taught to behave at school by the school rules, for example, running in the corridors was prohibited and is also a safety measure. Both schools were called 'sock schools' where the pupils wore socks or indoor shoes. This actively reduced sounds from outdoor shoes inside the school as well as was a way to maintain the cleanliness of the school building, particularly during winter times. Schools had organised theme weeks to consider the soundscape of schools, such as walking quietly and not shouting. These practices were based on an understanding of the importance of protecting hearing and the negative health effects of noise on both pupils and school staff.

Loudness in the classroom, and soundscape in general, could be partly foreshadowed, such as controlling transitions in corridors or paying specific attention to pupils who are sensitive to sounds. Often limiting pupils' volume was based on following good manners, such as respectful and reciprocal interaction with others, talking one by one, and raising a hand to request to speak.

We have this discipline at school and guidelines ... that we talk politely, and this has been gone through with a homeroom teacher that we use normal volume in speaking and we talk politely. (Teacher 2)

When several pupils moved from one place to another the transitions usually produced loud sounds and, therefore, specific attention was needed to keep sounds to a minimum. Also, walking calmly on the right side of the corridor during transitions reduced noise. As one teacher noted; "We have a lot of common rules. That, for example, when moving in corridors, not running in the stairways, you walk the right side of the corridor." (Teacher 4) Teachers had also observed that pupils' use of technologies during recess has decreased the number of discussions and interactions, which also has reduced the sound levels.

Teachers also described that both pupils and teachers affect the soundscape. For example, teachers mentioned that younger pupils were at a developmental phase when they spoke things out loud and thus produced more sound. Teenagers, in turn, and especially some girls, screamed at times and talked in high-pitched voices as a 'trend'. For teachers, louder

speaking was also needed if a pupil had a hearing loss. Cultures within each family, for example how loudly the parents spoke, or health reasons for some individuals, could also affect the volume of speaking. One teacher described that aging decreases their tolerance to sounds.

We are different as people. Some tolerate sounds more. The others can be very sensitive to sounds ... others are fit for group work, and others want to work alone in silence. The other tolerates background music while working, the other doesn't want anything. You need to know the pupil and provide it. And somehow, I start with as neutral as possible so that it's not necessarily what I like or what's my way [or] the only way to do but we need to start with the class and preferably from silence, and through it, there are sounds from activities. (Teacher 1)

One teacher also described how many pupils, who were 'sensitive to sounds', could react to disturbing sounds by creating more sounds (Teacher 2). Some pupils may produce sounds by messing around because of a lack of motivation to study or sensitivity to sounds.

Pedagogical cultures influence the school soundscape

Participatory school culture and active pedagogy are based on pupils' participation and discussions in learning activities. The accepted normal part of current pedagogies that generate sound included learning by doing, group work, physical education, and outdoor activities during recess. Practicing social skills went beyond the formal lessons into recess and lunch breaks regulated by the school rules. Also, group work caused secondary sounds such as moving furniture, walking, and bringing materials from drawers. Teachers described the sounds belonging to the work with pupils were mostly tolerated or considered as a positive sign of learning activities. Younger pupils were encouraged to release their energy in a sports hall by running and shouting before concentrating on the lesson.

We work in very different spaces, in the classroom and outside the classroom ... somehow, I think that silence is not that you learn the best but there needs to be discussions, you need to be able to ponder, of course reasonable limits that it doesn't burden the others and their learning. (Teacher 3)

Simultaneously, teachers needed to decrease sounds through various pedagogical practices targeting individual pupils or the whole classroom. All teachers, especially language teachers, emphasised how important peace is for studying and listening to languages. Pupils were guided to provide interesting and motivating activities that helped them to concentrate on studying instead of other, louder activities. Also, teachers helped pupils' development of metacognitive skills by observing and discussing soundscapes.

Teachers emphasised the need for pupils' vitality and excitement to be controlled because the volume of talk and activities increased when pupils became excited. Limiting sounds provided by pupils happened by intervening and calming down pupils as well as through commanding. The teachers mentioned modelling the right level of loudness through their

behaviour. One teacher from the lower grades described how she collected pupils around herself and talked in a squat position on the floor close to pupils around her, so she was able to control her volume of talk. In another example, a teacher was compared to Buddha.

We had one [university] student in her teacher training who told that her teacher image changed so that a current teacher sits in front of a class like a Buddha statue and talks quietly, peacefully that your own modelling is very important. If you demand pupils to be quiet by shouting that sometimes happens, if you shout over the pupils so it doesn't [work] like why you are asking to be quiet and you are not by yourself. (Teacher 1)

Teachers used various group control techniques to influence the soundscape within the school. One pedagogical method that teachers described was to use echo clapping where a teacher started to clap, and all pupils joined the clapping until everyone joined. From the teaching viewpoint, one teacher referred to a more traditional school building where teachers used soft music to aid the pupils' concentration when carrying out an assignment. According to the teacher, this method was not possible in the open plan school because the music would distract other classes.

Teachers mentioned that using special education teachers and assistants mostly decreased sounds within the classrooms, as pupils received more individualised teaching and guidance. This gave the possibility for pupils to be split into smaller groups as more resources were available. Assistants were also needed as one teacher claimed, "we don't have enough assistants, so that a teacher could talk with two pupils in the corridor and assistant would look after here [in the classroom]. There is a vast need for assistants here" (Teacher 5). In the short term, teachers described that the assistant also produced sounds when verbalising the tasks to some pupils. However, they also decreased the sounds in the long term because pupils understood the task deeper and were able to concentrate on learning activities instead of improper behaviour.

In the open plan learning environments, teaching in cells required collaboration among the teachers where everyone had the responsibility to build constructive soundscapes in the shared learning space. Teachers planned daily schedules together and had common rules on how to order quieter and louder learning activities. In practice, some groups of pupils may learn outside the classroom while others had louder learning activities. Teachers used various spaces flexibly in teaching based on learning activities and the development needs of pupils.

Discussion

This paper focused on the staff members' experiences of the soundscape in two modern schools in Finland. Both schools opened between 2018 and 2019, approximately within two years prior to data collection. Four main themes were identified from the data; the physical structure of the school, pupils and teachers moving within the school, the technology used within it, as well as a pedagogical learning environment that affected the school soundscape. These aspects are discussed further.

Physical environment and people within it

In recent years, open plan and flexible learning environments have increased in Finland (Niemi, 2020). Challenges reported include that open plan learning spaces let sounds spread and distract other groups of pupils (Saarelainen, 2017). In this study, teachers' experiences of the open plan and flexible learning environments were mostly positive.

Most teachers in this study emphasised that sounds from pupils' discussions and moving from place to place are normal parts of school culture and pedagogy. From the learning theory viewpoint, teachers' notions refer to socio-constructivism where people are seen to learn best when working with others, collaboratively in social interactions (Amineh & Asl, 2015). Therefore, conversations and moving during the learning activities can be seen as 'sounds of learning', a natural reflection of pupils' active learning. These processes of social and active learning can be supported by the learning environment design (Brown & Long, 2006, p. 9) where multiple spaces for working in small groups are implemented and teachers can control the soundscape. In this study, teachers shared many experiences on how the structures of the new school building, such as soundproofed walls and number of doors, decreased distractive sounds. These were seen as positive ways to manage sound.

In this study, teachers' positive experiences of the new schools could also be because the school buildings had used new technological solutions. Staff had been included during the school building design process. As Niemi (2020) noted, the adaptation to the new school environments is strengthened when the teachers feel that their opinions about the design have been considered and acted upon. Niemi continued that more consideration of teachers' experiences should be part of designing new schools, particularly as open plan and flexible school designs influence the way the teachers organise their teaching (Niemi, 2020, p. 282). Our study reinforces Niemi's notion. Experienced teachers are encouraged to participate in co-designing new learning environments. Furthermore, there is a need to include school design practice in the curriculum of pre-service and in-service teacher training programmes.

Current learning theories emphasise that learning can happen everywhere including outside, in free time, and in various parts of the school building (Oblinger, 2006, p.8; Kumpulainen, 2011, p.46). In addition to the classrooms, teachers allowed the pupils to work in communal areas. The movement of pupils to learn beyond the classroom has been shown to improve the well-being of pupils, increased attention (Syväoja et al., 2013), and improve social skills (Haapala et al., 2017). In addition to these benefits, teachers can control sound levels by dispersing the pupils into small peer working groups. Flexible and modern learning environments seem to be porous, since physical walls do not exist, and the learning can be done outside the classroom.

Technology and pedagogical approaches

In recent years, more teacher training has included technology-based 21st century skills (Valtonen et al., 2011). Fixed technological equipment in classrooms brings back pupils from the communal areas to focus on what the teacher provides through technology.

Computers used also created background hum or noise to add to the layer of the soundscape. Furthermore, sensors placed around the school to control ventilation may control the humming during school hours (McNeill et al., 2022).

Teachers described sounds from digital and other technology that enabled more accurate and purposeful control of noise and other spatial configurations, such as heat, light, and air quality sensors. Even though these configurations have been described to influence the pupils' and teachers' performance (Schneider, 2002), teachers in this study focused on their positive aspects of them. For example, humming sounds of technology were background sounds and did not affect their daily activities. Only those sounds that were disruptive and uncontrollable, such as the school bell during the lesson, were less desirable. This kind of automatic technical system limited the teachers' autonomy and sometimes even their pedagogical choices. In addition, softer materials, and curtains along with soundproofing were seen as an easily controllable and important effect.

Previous studies (Choi et al. 2014; Minelli et al., 2022; Schneider, 2002; Ueno et al., 2019) have pointed out that soundscapes affect learners' cognitive performance, learning, and well-being. Many researchers have also emphasised the physical environments influencing pedagogy and learning (Barret, Zhan, Moffat & Kobbacy, 2013; Kattilakoski, 2018). The impact of the learning environment is not, however, straightforward, rather it depends on how well the environment, pedagogy, and curriculum are in line with each other (Cleveland, 2011). Staff in this study were very conscious of the various effects of soundscapes on teaching and children's learning. Adding sounds positively, such as quiet background music during some lessons can help academic skills, such as arithmetic (Črnčec, Wilson & Prior, 2006), although evidence of classical music on children's cognitive performance is lacking (Sala & Goblet, 2020).

The teachers were irritated by certain aspects of the physical learning environment that negatively influenced their pedagogical choices. For example, threatening teachers' autonomy was the need to consider when to use music as a pedagogical tool in an open plan learning environment. Consequently, teachers had to learn different ways to use pedagogy in their work in the new learning environments, as well as cooperate and plan more with other teachers. This is in line with the results of previous research, which indicated that teaching practices in an open plan learning environment require weekly and sometimes daily negotiations of space, resources, and authority (Alterator & Deed, 2013).

Soundscapes termed as noise has generally negative connotations. Noise can harm learning results, cognitive processes, concentration, memory, and reading and writing skills (Choi et al., 2014; Canning et al., 2015; Shield et al., 2010, in Kattilakoski, 2018). In this study, teachers mentioned various aspects of noise, such as talking, shouting and sounds from technical devices. It was evident that teachers used shared open plan spaces partly sequentially, to decrease the number of pupils in the same spaces and, therefore, decreased sounds. Also, Niemi (2020) noted that although many teachers were dissatisfied with the open plan and flexible learning environments, the openness increased good experiences of team teaching.

Research into teachers' well-being has increased in recent years (Hascher & Waber, 2021), yet lacking are studies that try to understand how the physical environment and soundscape influence the well-being of teachers. The acoustics and overall soundscape within the school may create an extra burden and have a long-term effect on the teachers' choice to stay within their profession. With such risks on teacher performance, staff shortages and social development, soundscape and its effects have an impact on the pedagogy and teacher's well-being. These should be examined further.

In summary, the teachers' experiences with the soundscape of their new schools were mostly positive, and their individual preferences varied only slightly. This may partly reflect the novelty effect in the new school that is commonly reported in human-computer interaction research, explained as the "first responses to a technology, not the patterns of usage that will persist over time as the product ceases to be new" (Sung, Christensen & Grinter, 2009, p. 45). The teachers may have emphasised more positive aspects over negative ones that reflect the first experiences in the new school building. Further studies are needed to study long-term implications and experiences concerning soundscapes in various modern learning environments. Moreover, the teachers have, to some extent, chosen to work at schools with open plans or flexible learning environments. This choice may have reflected the teachers' commitment to current pedagogies and versatile use of learning environments that may have reflected on teachers' positive notions concerning school architecture and soundscapes (see Niemi 2020). Commitment to a school's values, pedagogy and curriculum may support teachers' well-being at work and provide more positive teaching experiences.

Conclusion

Modern schools and their structure have a role in the way soundscapes influence the daily activities of teachers and pupils. The design of the school can facilitate louder or quieter spaces whereby pupils can carry out their study tasks as efficiently as possible. The teachers from two newly built schools in Finland reported how sounds play a role in the way teachers construct their pedagogy and plan for helpful or disturbing and harmful sounds.

One of the schools had an open learning environment design, where units were divided by a curtain, that separated the visual element, but not the sound. As a result, co-planning between teachers was common. Despite these professional efforts, pupils may have raised their sounds to noisy levels and teachers had to revert to commanding tools to reduce the sound levels of the pupils. This may have consequences on pupils in the inclusive learning environment, particularly for pupils who are sensitive to sounds. The design of the soundscape should be included in the aesthetics of the learning environment as the teachers' controllability and autonomy on the sounds are considered very important.

According to the results of this study, the new open learning environments require new pedagogical tools from the teacher. Furthermore, older teachers realised their old methods did not always work effectively within the new surroundings. The way that these architectural designs affect soundscape and the pupils' learning outcomes in the longer term, remains to be seen, but it would offer an interesting topic for a longitudinal study.

Acknowledgments

Funding details

The Finnish Cultural Foundation's local funds have supported the fieldwork and data collection of this project at the schools. We kindly thank all teachers who participated in this research.

Disclosure statement

The authors declare there are no conflicts of interest.

References

- Aletta, F. & Kang, J. (2019). Promoting healthy and supportive acoustic environments: Going beyond the quietness. *International Journal of Environmental Research and Public Health*, 16(24), article 4988. <https://doi.org/10.3390/ijerph16244988>
- Aletta, F., Kang, J. & Axelsson, Ö. (2016). Soundscape descriptors and a conceptual framework for developing predictive soundscape models. *Landscape and Urban Planning*, 149, 65-74. <https://doi.org/10.1016/j.landurbplan.2016.02.001>
- Alterator, S. & Deed, C. (2013). Teacher adaptation to open learning spaces. *Issues in Educational Research*, 23(3), 315-330. <http://www.iier.org.au/iier23/alterator.pdf>
- Amineh, R. J. & Asl, H. D. (2015). Review of constructivism and social constructivism. *Journal of Social Sciences, Literature and Languages*, 1(1), 9-16.
- Boeije, H. (2002). A purposeful approach to the constant comparative method in the analysis of qualitative interviews. *Quality and Quantity*, 36(4), 391-409. <https://doi.org/10.1023/A:1020909529486>
- Brown, M. & Long, P. (2006). Trends in learning space design. In D. G. Oblinger (Ed.), *Learning spaces*. Boulder: EDUCAUSE. <https://www.educause.edu/ir/library/pdf/PUB7102i.pdf>
- Canning, C., Cogger, N., Greenland, E., Harvie-Clark, J., James, A., Oeters, D., Orłowski, R., Parkin, A., Richardson, R. & Shield, B. (2015). *The acoustics of schools: A design guide*. Institute of Acoustics & Association of Noise Consultants. London. https://www.ioa.org.uk/sites/default/files/Acoustics%20of%20Schools%20-%20a%20design%20guide%20November%202015_1.pdf
- Choi, H. H., van Merriënboer, J. J. & Paas, F. (2014). Effects of the physical environment on cognitive load and learning: Towards a new model of cognitive load. *Educational Psychology Review*, 26(2), 225-244. <https://doi.org/10.1007/s10648-014-9262-6>

- Cleveland, B. W. (2011). *Engaging spaces: Innovative learning environments, pedagogies and student engagement in the middle years of school*. PhD thesis, The University of Melbourne, Australia. <http://hdl.handle.net/11343/36515>
- Črnčec, R. & Wilson, S. J., & Prior, M. (2006). The cognitive and academic benefits of music for children: Facts and fiction. *Educational Psychology*, 26(4), 579-594. <https://doi.org/10.1080/01443410500342542>
- Cucharero, J., Hänninen, T., Makkonen, M. & Lokki, T. (2021) Acoustic coating – A discreet way to control acoustic environment. *Frontiers in Built Environment*, 7, 665332. <https://doi.org/10.3389/fbuil.2021.665332>
- Dibben, N. & Haake, A. B. (2013). Music and the construction of space in office-based work settings. In G. Born (Ed.), *Music, sound and space: Transformations of public and private experience*, 151-168. <https://doi.org/10.1017/CBO9780511675850.008>
- Enmarker, I. & Boman, E. (2004). Noise annoyance responses of middle school pupils and teachers. *Journal of Environmental Psychology*, 24(4), 527-536. <https://doi.org/10.1016/j.jenvp.2004.09.005>
- Eysel-Gosepath, K., Daut, T., Pinger, A., Lehmacher, W. & Erren, T. (2012). Effects of noise in primary schools on health facets in German teachers. *Noise Health*, 14(58), 129-134. <https://pubmed.ncbi.nlm.nih.gov/22718111/>
- Fredriksson, S., Hussain-Alkhateeb, L., Torén, K., Sjöström, M., Selander, J., Gustavsson, P., Kähäri, K., Magnusson, L., Persson Waye, K. (2022). The impact of occupational noise exposure on hyperacusis: A longitudinal population study of female workers in Sweden. *Ear and Hearing*, 43(4), 1366-1377. <https://doi.org/10.1097/AUD.0000000000001194>
- Fredriksson, S., Kim, J. L., Torén, K., Magnusson, L., Kähäri, K., Söderberg, M. & Persson Waye, K. (2019). Working in preschool increases the risk of hearing-related symptoms: A cohort study among Swedish women. *International Archives of Occupational and Environmental Health*, 92(8), 1179-1190. <https://doi.org/10.1007/s00420-019-01453-0>
- Glaser, B. G. & Strauss, A. L. (1967). *The discovery of grounded theory: Strategies for qualitative research*. Chicago: Aldine. <https://www.routledge.com/Discovery-of-Grounded-Theory-Strategies-for-Qualitative-Research/Glaser-Strauss/p/book/9780202302607>
- Haapala, H. L., Hirvensalo, M. H., Laine, K., Laakso, L., Hakonen, H., Lintunen, T. & Tammelin, T. H. (2017). Differences in physical activity at recess and school-related social factors in four Finnish lower secondary schools. *Health Education Research*. 32(6), 499-512. <https://doi.org/10.1093/her/cyx069>
- Hascher, T. & Waber, J. (2021). Teacher well-being: A systematic review of the research literature from the year 2000-2019. *Educational Research Review*, 34, article 100411. <https://doi.org/10.1016/j.edurev.2021.100411>
- Jetsonen, S. (2022). *Kyläkoulusta lähiökouluhin 1945-1960 [From village to suburban schools 1945-1960]*. Museovirasto. <http://www.koulurakennus.fi/1950-luvun-koulu/arkkitehtuuri>

- Kaakinen, E. (2019). Suomalaiset sullotaan monitilatoimistoihin, vaikka kaikille se ei sovi – "Titteli ei kerro minkälaisen työtilan ihminen tarvitsee". [Finns are squeezed into multi-office jobs, even if it doesn't suit everyone - "The title doesn't tell you what kind of workspace you need"]. *YLE*, 20 January. <https://yle.fi/uutiset/3-10600769>
- Kaarlela-Tuomaala, A., Helenius, H., Keskinen, E. & Hongisto V. (2009). Effects of acoustic environment on work in private office rooms and open-plan offices – longitudinal study during relocation. *Ergonomics*, 52(11), 1423-1444. <https://doi.org/10.1080/00140130903154579>
- Kattilakoski, R. (2018). *Koulun toimintakulttuuri avautuvissa oppimistiloissa: etnografinen tutkimus uuteen koulurakennukseen muuttamisesta* [School culture in an opening learning space: An ethnographic study of moving to a new school building]. Jyväskylä: Jyväskylä studies in education, psychology and social research (616). <https://jyx.jyu.fi/handle/123456789/58031>
- Keränen, J. (2015). *Measurement and prediction of the spatial decay of speech in open-plan offices*. Doctoral thesis, Aalto University, Finland. <http://urn.fi/URN:ISBN:978-952-60-6089-7>
- Kuuskorpi, M. (2012). *Tulevaisuuden fyysinen oppimisympäristö. Käyttäjälähtöinen, muunneltava ja joustava opetustila*. Turku: Painosalama Oy. <https://www.utupub.fi/handle/10024/76724>
- Laatikainen, O. (2016). Avokonttori tuhoaa tuottavuuden - työnantajat eivät tunnista ongelmaa. [The open office is destroying productivity - employers fail to recognise the problem]. *Etelä-Suomen Sanomat*, 20 June. <https://www.ess.fi/uutiset/talous/art2280346>
- Largo-Wight, E., O'Hara, B. K. & Chen, W. W. (2016). The efficacy of a brief nature sound intervention on muscle tension, pulse rate, and self-reported stress: Nature contact micro-break in an office or waiting room. *Health Environments Research & Design Journal*, 10(1), 45-51. <https://doi.org/10.1177/1937586715619741>
- McNeill, V. F., Corsi, R., Huffman, J. A., King, C., Klein, R., Lamore, M., Maeng, D. Y., Miller, S. L., Ng, N. L., Olszewski, P., Godri Pollitt, K. J., Segalman, R., Sessions, A., Squires, T. & Westgate, S. (2022). Room-level ventilation in schools and universities. *Atmospheric Environment: X*, 13, article 100152. <https://doi.org/10.1016/j.aeoa.2022.100152>
- Mealings, K. (2022) Classroom acoustics and cognition: A review of the effects of noise and reverberation on primary school children's attention and memory. *Building Acoustics*, 29(3) 401-431. <https://doi.org/10.1177/1351010x221104892>
- Meuer, S. P. & Hiller, W. (2015). The impact of hyperacusis and hearing loss on tinnitus perception in German teachers. *Noise & Health*, 17(77), 182-190. <https://doi.org/10.4103/1463-1741.160682>
- Minelli, G., Puglisi, G. E. & Astolfi, A. (2022). Acoustical parameters for learning in classroom: A review. *Building and Environment*, 208, article 108582. <https://doi.org/10.1016/j.buildenv.2021.108582>

- Naude, M. & Meier, C. (2019). Elements of the physical learning environment that impact on the teaching and learning in South African Grade 1 classrooms. *South African Journal of Education*, 39(1), article 1342. <https://doi.org/10.15700/saje.v39n1a1342>
- Niemi, K. (2020). 'The best guess for the future?' Teachers' adaptation to open and flexible learning environments in Finland. *Educational Inquiry*, 12(3), 282-300. <https://doi.org/10.1080/20004508.2020.1816371>
- Oblinger, D. G. (Ed.) (2006) *Learning spaces*. Boulder: EDUCAUSE. <https://www.educause.edu/research-and-publications/books/learning-spaces>
- Saarelainen, J. (2017). *Avointen oppimisympäristöjen ääniolosuhteet [Acoustics of open-plan schools]*. Unpublished MSc thesis, Tampere University of Technology, Finland. <https://trepo.tuni.fi/bitstream/handle/123456789/24519/saarelainen.pdf>
- Sala, G. & Goblet, F. (2020) Cognitive and academic benefits of music training with children: A multilevel meta-analysis. *Memory and Cognition*, 48, 1429-1441. <https://doi.org/10.3758/s13421-020-01060-2>
- Schafer, R. M. (1977). *The tuning of the world*. New York: Knopf. Republished in 1994 as *The soundscape: Our sonic environment and the tuning of the world*. Vermont, USA: Destiny Books. <https://www.simonandschuster.com/books/The-Soundscape/R-Murray-Schafer/9780892814558>
- Schneider, M. (2002). *Do school facilities affect academic outcomes?* Washington DC: National Clearinghouse for Educational Facilities. <https://eric.ed.gov/?id=ED470979>
- Shield, B., Greenland, E. & Dockrell, J. (2010). Noise in open plan classrooms in primary schools: A review. *Noise & Health*, 12(49), 225-234. <https://doi.org/10.4103/1463-1741.70501>
- Shu, S. & Ma, H. (2019). Restorative effects of classroom soundscapes on children's cognitive performance. *International Journal of Environmental Research and Public Health*, 16(2), 293. <https://doi.org/10.3390/ijerph16020293>
- Sjödén, F., Kjellberg, A., Knutsson, A., Landström, U. & Lindberg, L. (2012). Noise exposure and auditory effects on preschool personnel. *Noise & Health*, 14(57), 72-82. <https://www.noiseandhealth.org/article.asp?issn=1463-1741;year=2012;volume=14;issue=57;spage=72;epage=82;aulast=Sj>
- Strauss, A. & Corbin, J. (1998). *Basics of qualitative research: Techniques and procedures for developing grounded theory*. London: SAGE. [4th ed.] <https://us.sagepub.com/en-us/nam/basics-of-qualitative-research/book235578>
- Subban, P. & Round, P. (2022). Investigating teachers' perceptions of open plan classroom settings: A case of an innovative convention? *Issues in Educational Research*, 32(2), 721-745. <http://www.iier.org.au/iier32/subban.pdf>
- Sung, J., Christensen, H. I. & Grinter, R. E. (2009). Robots in the wild: Understanding long-term use. In *Proceedings of the 4th ACM/IEEE international conference on Human robot interaction (HRI '09)*. Association for Computing Machinery, New York, USA, pp. 45-52. <https://doi.org/10.1145/1514095.1514106>
- Syväoja, H. J., Kantomaa, M. T., Ahonen, T., Hakonen, H., Kankaanpää, A. & Tammelin, T. H. (2013). Physical activity, sedentary behavior, and academic performance in Finnish children. *Medicine & Science in Sports & Exercise*, 45(11), 2098-2104. <https://doi.org/10.1249/MSS.0b013e318296d7b8>

- Tesch, R. (1990). *Qualitative research: Analysis types and software*. London: Routledge.
<https://doi.org/10.4324/9781315067339>
- Truax, B. (1999) *Handbook for acoustic ecology*. Simon Fraser University, Canada.
<http://www.sfu.ca/sonic-studio-webdav/handbook/>
- Ueno, K., Noguchi, S. & Takahashi, H. (2019). A field study on the acoustic environment of special-needs education classrooms. *Building Acoustics*, 26(4), 263-274.
<https://doi.org/10.1177/1351010X19877545>
- Uimonen, H. (2013). Äänimaiseman ja kulttuurisen äänen tutkimus [Soundscapes and cultural environmental sound research]. In P. Moisal & E. Seye (Eds.), *Musiikki kulttuurina*. Suomen Etnomusikologinen Seura.
- Valtonen, T., Pontinen, S., Kukkonen, J., Dillon, P., Väisänen, P. & Hacklin, S. (2011). Confronting the technological pedagogical knowledge of Finnish Net Generation student teachers. *Technology, Pedagogy and Education*, 20(1), 3-18.
<https://doi.org/10.1080/1475939X.2010.534867>
- Van den Bosch, K. A.-M. (2016). Safe and sound: Soundscape research in special needs care. In *INTER-NOISE and NOISE-CON Congress and Conference Proceedings, InterNoise16*, Hamburg, Germany, pp. 7623-7629. [see also PhD thesis, University of Groningen, The Netherlands. <https://research.rug.nl/en/publications/safe-and-sound-soundscape-research-in-special-needs-care>]
- Van den Bosch, K. A., Andringa, T. C., Post, W. J., Ruijsenaars, W. A. & Vlaskamp, C. (2018). The relationship between soundscapes and challenging behavior: A small-scale intervention study in a healthcare organization for individuals with severe or profound intellectual disabilities. *Building Acoustics*, 5(2), 123-135.
<https://doi.org/10.1177/1351010X18775022>
- Van Hedger, S. C., Nusbaum, H. C., Clohisy, L., Jaeggi, S. M., Buschkuhl, M. & Berman, M. G. (2019). Of cricket chirps and car horns: The effect of nature sounds on cognitive performance. *Psychonomic Bulletin & Review*, 26, 522-530 (2019).
<https://doi.org/10.3758/s13423-018-1539-1>
- Van Kamp, I., Klæboe, R., Brown, A. L. & Lercher, P. (2016). Soundscapes, human restoration, and quality of life. In J. Kang & B. Schulte-Fortkaamp (Eds.), *Soundscape and the built environment*. Boca Raton, USA: CRC Press and Taylor & Francis Group. (pp. 43-69). <https://www.taylorfrancis.com/chapters/edit/10.1201/b19145-6/soundscapes-human-restoration-quality-life-irene-van-kamp-ronny-kl%C3%A6boe-lex-brown-peter-lercher>
- Woolner, P. & Stadler-Altmann, U. (2021). Openness – flexibility – transition. Nordic prospects for changes in the school learning environment. *Education Inquiry*, 12(3), 301-310. <https://doi.org/10.1080/20004508.2021.1957331>

Appendix 1: Sounds in modern schools

Table 1: Ways sounds are produced, increased and decreased in modern schools

	Produce and increase sound	Decrease sound
School building and technology	Architecture Structure of school	Architecture Comb-shape structure of school Structure of classroom Soundproof spaces
	Interior design and furniture Hard floor Curtains instead of walls Components of chairs Gaps between sliding walls	Interior design and furniture Acoustic panels Soft floors, ceilings Folding screen with textile topping Soft carpets Curtains between learning spaces Chairs
	Technology Computers, screens Mobile phones, social media Loudspeakers School bell Piano	Technology New technology Earmuffs Headphones Decibel indicator Tuning volume
People and pedagogical culture	Pedagogy Activities for pupils to do Participatory culture Learning by doing Group work Practicing social skills Physical education Recess, outdoor activities Listening in language learning Age-appropriate activities Controlling actions that teachers lead Transition of furniture Physical education (warm up) Co-teach/Collaboration with others Participatory culture Group work Recess (collaboration with schedule) Physical Education (games)	Pedagogy Activities for pupils to do Theme weeks Interesting and motivating activities for the pupils Controlling actions that teachers lead Teachers' own behaviour, modelling Close physical proximity Group controlling techniques Tasks to make pupils concentrate Controlling excitement Hand raising Polite, reciprocal communication Controlled transitions No shoes inside Co-teach/Collaboration with others Special education teachers Assistants
Individual characteristics	Thinking aloud in younger age Challenges in hearing, e.g. hearing loss Sensitivity to sounds, e.g. messing around Prejudices to school subjects Children with special needs / lack of assistive personnel	Personal reasons, e.g. Sensitivity, surgeries Family cultures

Appendix 2: Framework used in the interviews

<p>General things about sounds and soundscape and learning environment</p>	<ul style="list-style-type: none"> • What are the first things that you think about when considering the soundscape of this school? • What kind of sounds do you hear in the spaces in here? • In what spaces do you hear sounds in particular? (in this classroom or other spaces) • What sounds do you hear during classes and recession or lunch? • What is special about the soundscape of this school compared to other schools that you've worked in? • How do open learning environments work in terms of sound? • What kind of sounds are missing from this space and why? • What works in the soundscape of this school? What challenges have there been? • In what kinds of situations do you see there being problems, for example too much noise, and why does it happen in those situations? • Who are (allowed) to make sounds in school premises? Whose voice can be heard? • Who are the people who guide / determine / plan what and when things can be heard? (whose rules?)
<p>Acoustic solutions and the use of them in teaching</p>	<ul style="list-style-type: none"> • What kinds of acoustic solutions have been used in the space? • How does the teacher use the acoustic solutions in their teaching and how do they function? • What kinds of acoustic solutions would you want in your school and why would these solutions be good or necessary?
<p>Technology</p>	<ul style="list-style-type: none"> • How does technology affect the soundscape? • What kinds of sounds does technology bring into the space and what kinds of sounds does it leave out? • What technology produced sounds can you effect? Do you tend to have an effect on them? (ventilation, cleaning, kitchen, etc.) • What kinds of teaching related technology sounds do you hear? (handicraft, etc.) • What are the technology related sounds that the pupils are producing? (mobile phone apps)
<p>Pupils individuality and taking that into account</p>	<ul style="list-style-type: none"> • How do this school premises suit different kinds of learners? • Can you give concrete examples of how the soundscape can support children with special needs and how could they be taken into account? • What should be taken into account when designing learning environments for all learners? • How do the open leaning environment works for children with special needs?
<p>General things for finishing off</p>	<ul style="list-style-type: none"> • Was there something that we did not talk about but you think is important for the topic? • Do you want to ask me anything?

Dr Elina Hytönen-Ng (corresponding author) holds the title of docent in ethnomusicology at the University of Turku. She is a cultural researcher who has specialised in the study of musical and sonic experiences. She has been an academic visitor at the Faculty of Music, University of Oxford, and a visiting research fellow at King's College London. Currently, she is the primary investigator in a three-year project, funded by Kone foundation, focusing on lamenting rituals in contemporary Finnish society.

ORCID: <https://orcid.org/0000-0003-4082-2490>

Email: elina.hytonen-ng@uef.fi

Dr Kaisa Pihlainen works as a post-doctoral researcher (tenure track) at the Philosophical Faculty, University of Eastern Finland. She has participated in many national and international development and research projects. Currently, her research topics focus on learning environments, participation, well-being, and the use of digital technology across the lifespan.

ORCID: <https://orcid.org/0000-0001-9437-4481>

Email: kaisa.pihlainen@uef.fi

Dr Kwok Ng holds the title of docent of 'Health Promotion and Adapted Physical Activity'. He currently holds active joint posts at the School of Educational Sciences and Psychology, University of Eastern Finland, Finland; Faculty of Education, University of Turku, Finland; and Department of Physical Education and Sport Sciences, University of Limerick, Ireland; and Faculty of Education, University of Turku, Finland.

ORCID: <https://orcid.org/0000-0002-5461-7706>. Social media: twitter @kwokwng

Email: kwok.ng@uef.fi

Professor Eija Kärnä works as a professor of Special Education at the University of Eastern Finland. Professor Kärnä has been a principal investigator in many national and international multidisciplinary development and research projects. Her research interests are inclusive learning environments, technology for individuals with special needs, and digital literacy of various age groups.

ORCID: <https://orcid.org/0000-0001-8107-3604>

Email: eija.karna@uef.fi

Please cite as: Hytönen-Ng, E., Pihlainen, K., Ng, K. & Kärnä, E. (2022). Sounds of learning: Soundscapes - teacher perceptions of acoustic environments in Finland's open plan classrooms. *Issues in Educational Research*, 32(4), 1421-1440.

<http://www.iier.org.au/iier32/hytonen-ng.pdf>