

# **An Assessment of Open Plan and Enclosed Classroom Listening Environments for Young Children: Part 2 – Teacher’s Questionnaires**

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**Purpose:** Recently open plan classrooms have been growing in popularity in primary schools. This paper is part of a two-part study that investigated how classroom noise affects teaching and learning in different types of open plan and enclosed classrooms. Part 1 of this research investigated Kindergarten children’s perceptions. This study explored the teachers’ perspectives.

**Method:** Sixteen Kindergarten and Year 1 teachers (four from enclosed classrooms, three from double classrooms, six from triple classrooms, and three from a Kindergarten-to-Year 6 classroom) completed a questionnaire about their teaching background and style, the demographics of the children in their class, how they perceive the classroom listening environment, what internal and external noise sources are present, how they cope with noise, and their perceptions of open plan versus enclosed classrooms.

**Results:** Teachers of larger, noisier classrooms (especially those that were not acoustically treated) were more distracted by noise and found speech communication significantly more difficult than the teachers of smaller, quieter classrooms. They also needed to elevate their voice and experienced vocal strain and voice problems more often.

**Conclusions:** These results suggest that noise is a problem particularly in large, untreated open plan classrooms, and it negatively impacts teachers. This suggests that smaller enclosed classrooms are more appropriate learning spaces for teachers of young children. Differences between the teacher’s and children’s perceptions of the classroom environments from Part 1 of this study are also discussed.

## **Introduction**

Recent changes in teaching methods has seen open plan classrooms growing in popularity, particularly in primary schools (Shield, Greenland, & Dockrell, 2010). This paper is the second part of two qualitative questionnaire studies that aimed to provide insight into the acoustic suitability of open plan learning spaces for listening activities with young children. The first study investigated the Kindergarten (i.e. 5- to 6-year-old) children’s perceptions of noise and its effect on learning in different types of classrooms. The current paper investigated how the teachers of these different types of classrooms perceive their teaching environment and compares this to the children’s perceptions.

## **Changing Teaching Methods**

Up until the 1960’s, the main teaching style was didactic with children seated in rows of desks while they listened to their teacher who taught from the front (Shield et al., 2010). During the progressive educational reform in the 1960’s, however, there was a major shift in teaching style to a more ‘child-centred’ approach which focused on experiential learning and group work (Brogden, 1983; Shield et al., 2010). This change in teaching style also saw the emergence of open plan classrooms to better facilitate these teaching methods (Shield et al., 2010). In the 1980’s, however, there was shift back to more traditional values and teaching methods, hence many open plan classrooms were converted back to enclosed classrooms (Shield et al., 2010).

Nonetheless, the 21st century has seen a return to progressive educational styles such as constructivism, which is predominant in Western countries including Australia (Rowe, 2006). Constructivism is currently a major feature of teacher training courses with didactic teaching methods seen as being boring and old-fashioned (Rowe, 2006; Westwood, 1999). Constructivist

methods focus on the teacher being the facilitator who provides opportunities for the children to acquire their own knowledge and meaning, rather than the teacher being the instructor (Rowe, 2006). This change in teaching method has been demonstrated in a recent study by Greenland (2009) which assessed 84 teachers' perceptions of semi-open plan classroom environments from 12 schools in the United Kingdom. In this study, 58% of teachers surveyed used a child-centred style compared to only 15% of teachers who used a didactic whole class teaching style (Greenland, 2009). The remaining 27% of teachers used a mix of both teaching methods (Greenland, 2009). This change has also been found in New Zealand in a study by Wilson (2002) which involved 122 teachers from seven schools in Auckland. This study reported that traditional didactic style only made up 12% of teaching time, compared to group work which made up 38% of teaching time. Furthermore, the majority of teachers (i.e. 71%) tended to walk around the class when teaching rather than teaching from the front.

This change in teaching methods has again seen the reemergence of open plan classrooms, often renamed as '21st century learning spaces' (Shield et al., 2010). These spaces are thought to better suit the range of activities and group work focus of this more child-centred teaching philosophy (Hickey & Forbes, 2011). They are also thought to aid children's social development and make them take more responsibility for their work (Brogden, 1983; Hickey & Forbes, 2011). Additionally, open plan classrooms are seen to benefit teachers as they promote the sharing of skills, ideas, and experiences (Brogden, 1983). They also allow for team-teaching, joint planning and organisation, provide access to a wide range of resources and equipment, allow teachers to share children, thereby reducing child-teacher personality clashes, and facilitate a more cooperative and supportive teaching and learning atmosphere (Brogden, 1983; Hickey & Forbes, 2011). The teachers of the semi-open plan classrooms in the study by Greenland (2009) generally agreed that open plan classrooms enabled a wider range of activities for the children than enclosed classrooms, and that children were more independent and responsible, and benefited socially from the more open plan space. However, the teachers also agreed that children in open plan classrooms were more easily distracted visually and by noise compared to children in enclosed classrooms.

### **Classroom Acoustics**

The current recommendations for classrooms in Australia are that the unoccupied noise level should be < 35-45 dBA, and the unoccupied reverberation time should be < 0.4-0.5 seconds (Australia/New Zealand Standard, 2000). Like many countries, however, these standards are only for unoccupied classrooms. For occupied classrooms, the literature suggests that noise levels should be < 50 dBA (Berg, Blair, & Benson, 1996). Additionally, the signal-to-noise ratio (SNR; which compares the teacher's speech level with the noise level), should be > +15 dB (i.e. the teacher's voice should be 15 dB above the noise level) throughout the classroom (American Speech-Language-Hearing Association, 2005; Crandell & Smaldino, 2000). These acoustic conditions, however, are rarely achieved in the classroom (see American Speech-Language-Hearing Association, 2005, for a review).

One of the problems with open plan classrooms is that they can have high noise levels due to different class bases engaging in different activities. A recent study by Mealings, Buchholz, Demuth, & Dillon (2015) investigated the acoustics of four different types of classrooms: an enclosed classroom (with 25 children), a double classroom (with 44 children), an untreated, fully open plan triple classroom (with 91 children), and a Kindergarten-to-Year 6 (K-6) purpose-built semi-open plan '21st century learning space' (with 205 children). Mealings, Buchholz, et al. (2015) found much higher intrusive noise levels coming from the other classes sharing the space in the triple classroom and the K-6 classroom compared to the double and enclosed classroom. This resulted in SNRs to be well below those recommended. When all classes including the participating class were engaged in group work activities, however, the noise levels were excessive in all classroom types.

### **Effects of Noise on Teachers' Vocal Health**

Many research studies have shown the adverse impact of classroom and environmental noise on teachers' (and students') health; noise raises blood pressure, increases stress levels, causes headaches, and results in fatigue (see Anderson, 2001, and Shield et al., 2010, for a review of these studies). The high noise levels that are especially present in open plan classrooms can make the environment seem chaotic (Hickey & Forbes, 2011). This can result in teachers feeling distracted, anxious, and stressed (Hickey & Forbes, 2011). Additionally, teachers in any classroom are already prone to experiencing vocal strain from their constant vocal use; research shows that while only 5% of the general population experiences vocal fatigue, it is experienced by 80% of teachers (Gotaas & Starr, 1993). This puts them at high risk of vocal abuse and developing pathological vocal problems from the need to continually raise their voice above what is comfortable so they are heard (Gotaas & Starr, 1993; Smith, Gray, Dove, Kirchner, & Heras, 1997). In noisy conditions, teachers report decreased vocal comfort and vocal control, and increased vocal fatigue compared to quiet conditions (Hunter et al., 2015). Teachers in classrooms with poor acoustics are more likely to believe their job contributes to voice and throat problems and take sick days from work (MacKenzie & Airey, 1999; Smith et al., 1997). Interestingly, however, teachers' vocal use depends on the type of noise present in the classroom. A recent study by Rantala, Hakala, Holmqvist, and Sala (2015) found that in the presence of ambient noise (i.e. noise from equipment, air-conditioning system, and outside noise such as traffic), teachers tend to raise the level of their voice. Furthermore, teachers who work in noisy classrooms tend to speak louder outside of work compared to teachers in quieter classrooms. During child-generated activity noise, however, teachers tend to change their voice quality, rather than their vocal level. This was demonstrated by more uneven vocal fold vibration for teachers working in higher activity noise levels than those working in lower noise levels. These vocal changes may lead to weakened muscle tone and long term vocal effects (Rantala et al., 2015). We would therefore expect vocal health problems to be a major issue for teachers in poorly designed open plan classrooms. There are,

however, strategies that teachers can use to help minimize the need to raise their voice. These include clapping their hands or using a whistle to get the children’s attention, using visual cues to get the children’s attention, gathering the class close to them, changing the seating arrangement, changing the teaching activity, and arranging a compatible activity schedule with other teachers if in an open plan classroom (Greenland, 2009; Rantala et al., 2015).

### Perceptions of Noise by Teachers

Recently there has been growing evidence that the physical work environment influences both the workers’ performance and their job satisfaction (see Vischer, 2007, for a review). According to Vischer (2007), ergonomic factors such as lighting, noise, and space affect people’s ability to work. When these factors are not suitably considered in the workspace design, they can elevate stress amongst workers (McCoy & Evans, 2005). This stress can result in decreased performance, motivation, comfort, and social interaction (see McCoy & Evans, 2005, and Vischer, 2007, for reviews).

While noise from their own class was the most common reported noise source (reported by 83% of teachers in semi-open plan classrooms) in the study by Greenland (2009), noise from other classes was reported by 62% of teachers as a dominant noise source and noise from other teachers was reported by 37% of teachers. Twenty-five percent of teachers reported that the noise from other classes was highly distracting. Teachers in classrooms with more than four class bases were significantly more distracted by noise and reported higher perceived noise levels than teachers in classrooms with less than four class bases. Ten percent of teachers reported that they frequently or more often experienced voice/throat problems. Grouping the class closely around them was the most frequently reported coping strategy which was used by nearly half the teachers.

In the New Zealand study by Wilson (2002), most of the teachers were from enclosed classrooms, but the acoustic quality of these classrooms varied widely. As a result, noise was still a major problem in these classrooms with 71% of teachers reporting inside noise problematic and 59% of teachers attributed this to the children. Forty-seven percent of teachers said that noise from other classes was problematic. Significantly more teachers from classes with poor acoustic ratings reported they needed to raise their voice often or always (55%) and experienced vocal strain (41%). Group work required the highest vocal level with 49% of teachers needing to raise their voice during this teaching style which is concerning as this was the most frequent teaching style.

The results of these studies indicate that noise can be problematic for teachers in both semi-open plan classrooms and enclosed classrooms. However, because different surveys were used for these studies and a broad range of classrooms were clustered together for each study, it is difficult to make direct comparisons across the classroom types to determine which classrooms provide better teaching environments. Additionally, these studies only report qualitative data from the teachers’ perspectives. It has long been known that young children are more affected by poor room acoustics than adults (Nelson &

Soli, 2000; Picard & Bradley, 2001; Prodi, Visentin, & Feletti, 2013). Many studies have shown that children find it more difficult discriminating and understanding speech than adults especially in noisy and/or reverberant environments (Crandell & Smaldino, 2000; Finitzo-Hieber & Tillman, 1978; Johnson, 2000; Leibold & Buss, 2013; Nelson & Soli, 2000; Nishi, Lewis, Hoover, Choi, & Stelmachowicz, 2010; Whitlock & Dodd, 2008). This is because children’s auditory systems are still developing neurologically, so they may not be as efficient as adults at using top-down processes, or may still be developing the skills adults use to aid speech perception (Boothroyd, 1997; Nelson & Soli, 2000; Wilson, 2002). This raises the importance of considering the children’s perceptions of noise in the classroom as well as the teachers’ perceptions. However, there have been no studies to our knowledge that directly compare teachers’ and children’s perceptions of classroom environments. Therefore, comparing the teachers’ and children’s perceptions in the present study would provide valuable insight as to whether particular classrooms are suitable for both the teachers and children to successfully work in.

### Present Study

The purpose of the present study, therefore, was to directly compare how the teachers in the four different types of open plan and enclosed classrooms used in the classroom acoustics study by Mealings, Buchholz, et al. (2015) perceive their teaching environment using the same questionnaire and methodology across participants. Investigating the perceptions of the teachers is of vital importance as they are often not consulted in the decision-making process when classrooms are converted to open plan designs (Hickey & Forbes, 2011). Additionally, this paper compares the teachers’ perceptions to the children’s perceptions reported in Part 1 of this two-part study (Mealings, Dillon, Buchholz, & Demuth, 2015). This is an important comparison as children struggle listening in noisy environments more than adults (see Nelson & Soli, 2000), so this needs to be taken into consideration when adults are designing classrooms. Therefore, the aim of the current paper was to answer the following research questions:

- 1) Do teachers of open plan classrooms spend more time in group work activities and less time out the front in didactic teaching than teachers in enclosed classrooms, as open plan classrooms are thought to better facilitate group work (Brogden, 1983; Shield et al., 2010)?
- 2) Do the teachers of noisier open plan classrooms rate their classroom listening environment poorer than teachers in quieter enclosed classrooms?
- 3) What noise sources can the teachers hear inside and outside their classrooms and are these similar to those identified by the children in Part 1 of this study (Mealings, Dillon, et al., 2015)? Furthermore, are the teachers of the noisier open plan classrooms more distracted by these noises?
- 4) Do the teachers of the noisier open plan classrooms find speech communication significantly more difficult and think their children have more difficulty hearing them than the teachers of quieter enclosed classrooms think their children do? Do these perceptions match those of the children measured in Part 1 of this study (Mealings, Dillon, et al., 2015)?

- 5) What strategies do teachers use to cope with noise? Do the teachers of the noisier open plan classrooms need to elevate their voice and experience vocal strain and voice problems more often than the teachers in quieter classrooms?
- 6) Do the teachers of open plan classrooms agree more with the positive aspects and less with the negative aspects of open plan classrooms than teachers in enclosed classrooms? Do these perceptions depend on the acoustic conditions of the different types of classrooms?

### **Method**

#### **Schools Involved**

Four schools were chosen to be involved in the study. These were the same schools that were involved in an acoustic measures study (Mealings, Buchholz, et al., 2015), a speech perception test study (Mealings, Demuth, Buchholz, & Dillon, 2015b) and the children's questionnaires in Part 1 of this two-part paper (Mealings, Dillon, et al., 2015). The first school had two 8 x 9 m enclosed Kindergarten classroom and two enclosed Year 1 classrooms with approximately 25 children in each class. Three of the classroom walls were solid brick and one wall was a closed operable wall which had an open door storeroom that was shared with the adjacent class. The second school had a 15 x 9 m double Kindergarten classroom which consisted of 44 children divided into two classes with two teachers. The third school had a 37 x 11 m untreated fully open plan triple Kindergarten classroom and an untreated fully open plan triple Year 1 classroom. The Kindergarten classroom had 91 children divided into three classes with three teachers and the Year 1 classroom had 83 children

divided into three classes with three teachers. The fourth school consisted of one 32 x 27 m purpose-built '21st century learning space' that contained Kindergarten-to-Year 6 (i.e. 205 children in total split into 7 classes). This included one Kindergarten class with 29 children and one Year 1 class with 21 children. Both of these classes were located in a semi-open plan area (i.e. only one open wall). More details on the classrooms can be found in Part 1 of this study (Mealings et al., 2015) and the classroom acoustics study by Mealings, Buchholz, et al. (2015).

#### **Participants**

The Kindergarten teachers of the children who had completed the children's questionnaires in Part 1 of this study (Mealings et al., 2015) were invited to participate in the present study. In order to increase participant numbers, we also invited the Year 1 teachers to participate that had classrooms very similar to the Kindergarten classrooms tested. Sixteen out of 18 teachers invited became involved in the study: four from the school with enclosed classrooms (two Kindergarten teachers and two Year 1 teachers), three from the school with a double classroom (two permanent Kindergarten teachers and one relief Kindergarten teacher), six from the school with triple classrooms (three Kindergarten teachers and three Year 1 teachers), and three from the K-6 school (one Kindergarten teacher and two part-time Year 1 teachers). All teachers were female. Details on the teachers and children are found in Table 1 along with the average noise levels and average unoccupied reverberation times recorded in the Kindergarten classrooms by Mealings, Buchholz, et al. (2015).

**Table 1.** Demographic and acoustic information for the participating classrooms.

Classroom	Teachers			Children			Acoustics			
	Number of participants	Years taught in enclosed classrooms	Years taught in open plan classrooms	Total number in area	Average number in each Kindergarten/Year 1 class	Average number with special educational needs in each Kindergarten/Year 1 class	All classes unoccupied (dBA)	Noise level Adjacent classes occupied (dBA)	All classes occupied during group work (dBA)	Average unoccupied reverberation time (s)
Enclosed	4	3-7 M = 4.50	0-1 M = 0.25	25	25	6 ESL	41.8	43.1-48.8	71.0*	0.50
Double	3	5-10 M = 7.67	1-3 M = 2.00	44	22	1 learning disability	36.7	46.0-50.3*	69.7*	0.60*
Triple	6	0-5 M = 1.75	0.5-5 M = 2.25	91	30	21 ESL + 3 learning disability	36.0	57.5*-62.1*	67.7*	0.70*
K-6	3	0-15 M = 5.33	1.5-15 M = 7.50	205	25	2 ESL	46.3*	60.5*	72.4*	0.58*

Note. \* indicates unoccupied noise levels are outside 35-45 dBA limit (Australia/New Zealand Standard, 2000), occupied noise levels are outside of the maximum 50 dBA recommended level (Berg et al., 1996) and/or reverberation time is outside 0.4-0.5 s limit (Australia/New Zealand Standard, 2000). These acoustic measurements are from the Kindergarten classrooms as found in Mealings, Buchholz, et al. (2015).

## Questionnaire Design

The teachers' questionnaire was based on those used in similar studies (Greenland, 2009; Wilson, 2002) and investigated the following areas:

- 1) Teacher and student demographics
  - Consisted of the questions shown Table 1.
- 2) Teaching style
  - Asked teachers what their main teaching position is (front, centre, or walking around the classroom).
  - Asked teachers what amount of time is spent in different teaching styles (didactic, table work, group work, other style).
- 3) Room characteristics
  - Asked teachers to rank lighting, ventilation, acoustics, equipment, and space from most important (1) to least important (5).
  - Asked teachers to tick which descriptors (comfortable, clear, relaxing, confusing, echoes, harsh, irritating, or specify their own) represent the classroom listening environment.
  - Asked teachers to rate the overall classroom listening environment as 1 = very poor, 2 = poor, 3 = acceptable, 4 = good, or 5 = very good.
- 4) Noise sources inside
  - Asked teachers if internal noise is a problem (yes/no), and if so, what noise sources are heard in the classroom and what is the most intrusive noise.
- 5) Noise sources outside
  - Asked teachers if external noise is a problem (yes/no), and if so, what noise sources are heard outside the classroom and what is the most intrusive noise.
  - Asked teachers if internal or external noise is more problematic.
  - Asked teachers if eliminating or reducing internal and external noises is unimportant, not very important, important, or critical for the children.
- 6) Speech communication in the classroom
  - Asked teachers if they think the students have difficulty hearing them, and do they think the acoustics of the classroom have a direct effect on the children's learning.
  - Asked teachers how easy they find speech communication (from 1 = very difficult, to 7 = very easy) in the classroom during different teaching scenarios.
- 7) Coping with noise
  - Asked teachers what actions they take to cope with noise (raise their voice, gather the class close around them, arrange a compatible activity schedule with other teachers, change the seating arrangement, stop or change the teaching activity, use visual cues for attention, or any other actions).
  - Asked teachers if they need to elevate their voice for different teaching styles, how often they elevate their voice, and how often they experience vocal problems (1 = never, 2 = sometimes, 3 = often, 4 = always).

- 8) Perceptions of open plan versus enclosed classrooms
  - Asked teachers to rate how much they agree with general statements about open plan classes on a five point Likert scale from "strongly disagree" to "strongly agree". The statements were those used by Greenland (2009) which were based on a questionnaire developed by Bennett, Andreae, and Hegarty (1980).

## Questionnaire Procedure

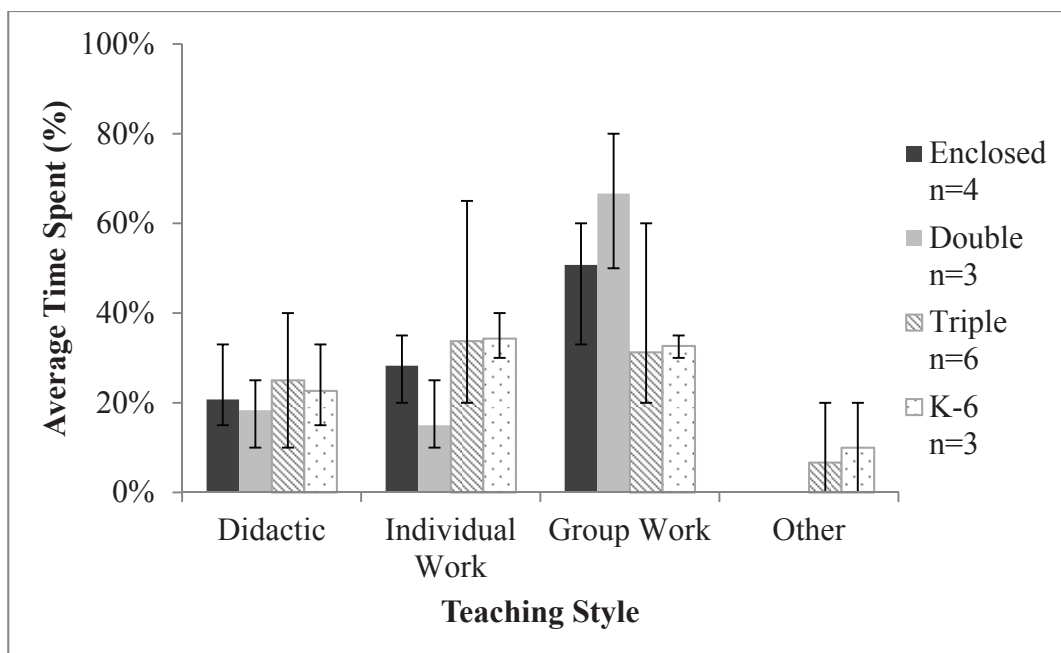
The questionnaires were distributed to each of the teachers with a consent form and information sheet outlining the project approved by Macquarie University ethics. The researcher also gave a brief summary verbally to each of the teachers and asked them if they had any questions. The teachers were asked to complete the questionnaire (which took less than 10 minutes) in their own time. The questionnaires were collected after a fortnight. On return of the survey, each teacher received a small gift as a thank you for their time.

## Results

### Teaching Style

The main teaching position for the surveyed teachers was walking around the classroom. This was the case for all surveyed Kindergarten/Year 1 teachers from enclosed and double classrooms. Two of the three surveyed teachers from the K-6 classroom reported that they usually walked around when teaching while the other teacher reported teaching mainly from the centre of the class. In the triple classrooms, three of the six teachers said their usual teaching position was walking around the classroom, two teachers said they mainly taught from the front of the room, and one teacher reported usually teaching from the centre of the classroom.

Figure 1 shows the average percentage of time Kindergarten/Year 1 teachers spend in different teaching styles for each classroom. Interestingly, the teachers of the larger open plan classrooms (i.e. the triple and K-6 classrooms) spent less time in group work than the teachers of the enclosed and double classrooms, despite the belief that open plan classrooms better facilitate group work (Brogden, 1983; Shield et al., 2010). The teachers in the large open plan classrooms, however, spent roughly an equal amount of time in each of the different teaching styles rather than favouring group work. While Figure 1 averages the teaching time over the Kindergarten and Year 1 teachers, it was interesting to note that the Kindergarten teachers in the triple classroom spent 40% of their time in didactic-style teaching but then this dropped to 10% for the Year 1 teachers.



**Figure 1.** Average percentage of time teachers spend in different teaching styles by school. “Other” includes team teaching and teaching a small group separately. Error bars show range.

### Room Characteristics

The participating teachers were asked to rank different aspects (lighting, ventilation, acoustics, equipment, and space) of their classroom from 1 (most important) to 5 (least important). The acoustics of the classroom was given the highest average rank in the K-6 classroom, the second highest rank after space in the double and triple classrooms, and the lowest rank in the enclosed classrooms.

The teachers were also asked to choose which descriptors (comfortable, clear, relaxing, confusing, echoes, harsh, irritating, or specify their own) represented their perceptions and experiences in their classroom. All teachers from enclosed classrooms said that the environment was comfortable (although it could be noisy at times). Two out of three teachers from double classrooms said that the environment was comfortable but the other teacher said it was distracting. In contrast, five of the six teachers from the triple classrooms found the environment confusing and four of the six teachers said the classroom echoed. Two out of three teachers from the K-6 classroom said that the environment was comfortable, but one teacher said it echoed and was harsh.

Additionally, the teachers were asked to rate the classroom listening environment overall where 1 = very poor, 2 = poor, 3 =

acceptable, 4 = good, 5 = very good (see Table 2). Interestingly, the best average rating was by the teachers of the double classroom (average rating of 4.3 = good to very good) despite it having some of the highest percentages of children who said they could not hear their teacher very well or at all, especially when the adjacent class was being noisy (Mealings, Dillon, et al., 2015). The average ratings of the enclosed classrooms (4 = good) and triple classrooms (2.5 = poor to acceptable) were generally in consensus with the acoustics of the classrooms (Mealings, Buchholz, et al., 2015; see also Table 1) and the children’s perceptions (Mealings, Dillon, et al., 2015). Again, the triple classrooms had the worst report of the schools with four of the six teachers surveyed (i.e. 67%) rating the listening environment as poor. All of these teachers said that this was because the classrooms were open plan. Three of the four teachers said it was also because of the noise levels, and one of the teachers said it was also because it echoed. Interestingly, the teachers in the K-6 classroom thought their classroom was an acceptable listening environment (i.e. average rating of 3), however, the results from the classroom’s acoustic measures (see Table 1) and children’s questionnaires suggested noise is a problem (Mealings, Buchholz, et al., 2015; Mealings, Dillon, et al., 2015).

**Table 2.** Teachers' ratings of their classroom listening environment.

Classroom	Percentage/proportion of teachers selecting each rating					Average rating
	1 Very Poor	2 Poor	3 Acceptable	4 Good	5 Very Good	
Enclosed	0	0	0	100% (4/4)	0	4 Good
Double	0	0	0	67% (2/3)	33% (1/3)	4.3 Good to very good
Triple	0	67% (4/6)	17% (1/6)	17% (1/6)	0	2.5 Poor to acceptable
K-6	0	0	100% (3/3)	0	0	3 Acceptable

**Noise Sources Inside**

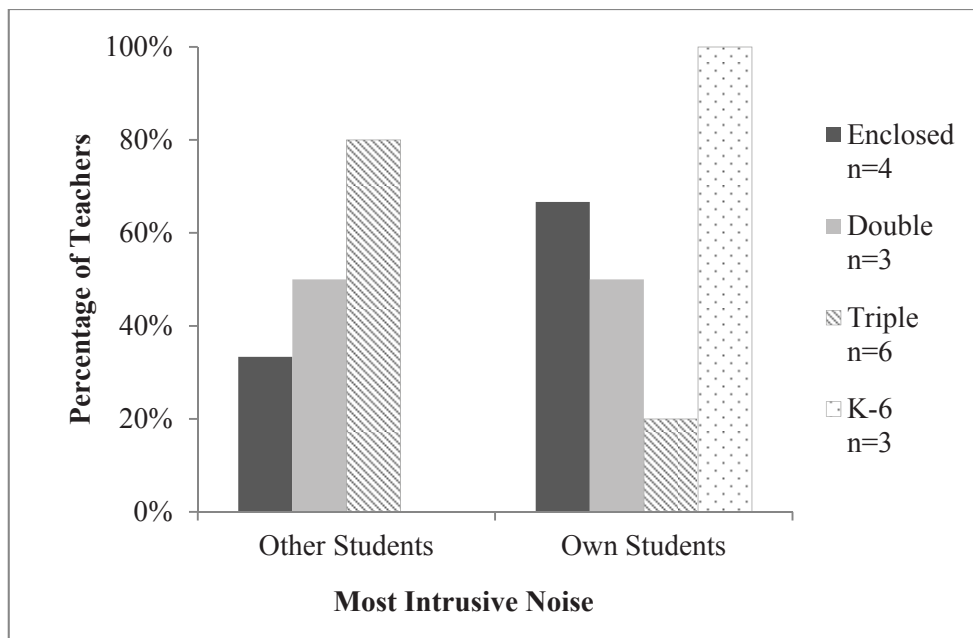
In this section of the questionnaire, the teachers were asked whether they thought noise from inside the classroom was a problem. If so, they were asked to identify what noise sources they heard in the classroom and what proportion of noise was student generated. Three out of four teachers from enclosed classrooms, two out of three teachers from the double classroom, five out of six teachers from triple classrooms, and all three teachers surveyed from the K-6 classroom believed internal noise was problematic. Three teachers from enclosed classrooms and two teachers from the double classroom thought that most of this noise was student generated. In the triple classrooms, three out of five teachers thought most internal noise was student generated while the other two thought only some of it was. For the K-6 classroom, one teacher thought most of this noise was student generated while another teacher thought only some of it was. The other noise sources the teachers found problematic are shown in Table 3. The noise sources the teachers identified were a close match to those identified by the children in each of the classrooms (Mealings et al., 2015). Noise from air-conditioning units and equipment were also recognized by Mealings, Buchholz, et al. (2015) as contributors to the high unoccupied ambient noise levels in the enclosed and K-6 classrooms (see Table 1).

Figure 2 shows what noise source the teachers reported as the most intrusive. All teachers chose either the children of other classes or the children of their own class. Surprisingly, all of the teachers in the K-6 classroom reported that the children in their own class was the most intrusive noise rather than the children in the other classes despite this classroom reporting some of the highest intrusive noise levels from the other classes sharing the area (Mealings, Buchholz, et al., 2015; see also Table 1). Interestingly, however, the teacher percentages for the other classrooms followed a trend. As the number of children in the entire area increased, so did the percentage of teachers who reported other children as the most intrusive noise. Furthermore, as the number of children in the entire area decreased, the percentage of teachers who reported the children in their own class as the most intrusive noise increased. Noise from children in other classes was also the most frequently reported noise source heard by the children in these classes and the proportion of children reporting this also increased as class size increased (Mealings, Dillon, et al., 2015).



**Table 3.** Teachers’ report of problematic internal and external noise sources.

Classroom	Percentage/proportion of teachers reporting noise source problematic						
	Air-conditioning units	Equipment	Lights	Other teachers	Other classes	Children outside	Traffic
Enclosed	75% (3/4)	0	0	50% (2/4)	25% (1/4)	25% (1/4)	25% (1/4)
Double	0	0	0	66% (2/3)	0	33% (1/3)	0
Triple	50% (3/6)	33% (2/6)	0	83% (5/6)	83% (5/6)	67% (4/6)	17% (1/6)
K-6	33% (1/3)	33% (1/3)	0	0	33% (2/3)	33% (1/3)	0



**Figure 2.** Teachers’ report of what they find the most intrusive noise in the classroom.

**Noise Sources Outside**

The teachers were asked whether they thought noise from outside the classroom was a problem and if so, what noises they could hear. One out of four teachers from the enclosed classrooms, one out of three teachers from the double classroom, five out of six teachers from the triple classrooms, and two out of three teachers from the K-6 classroom believed external noise was problematic. The specific noise sources the teachers found problematic are also shown in Table 3. The most intrusive outside noise reported by the teachers was children outside for the enclosed, double, and K-6 classrooms, which supports the findings from the children’s questionnaires (Mealings, Dillon, et al., 2015). Other noise sources identified by teachers of the enclosed and triple classrooms included noise from children in other classes and noise from traffic which largely agree with the noise sources identified by the children in these classrooms (Mealings, Dillon, et al., 2015).

The teachers were also asked whether internal or external noises were the most problematic, or if noise was not a problem when teaching in the classroom. In the enclosed classrooms, two teachers believed inside noise was the most problematic while the other two did not believe noise was a problem. One teacher from the double classroom reported outside noise the most problematic whereas the other two did not believe noise was a problem. Three out of six teachers from the triple classrooms reported inside noise the most problematic whereas the other three reported outside noise was. In the K-6 classroom, two out of three teachers thought inside noise was the most problematic noise while the other teacher thought outside noise was. Additionally, the teachers were asked to rate how distracting they find inside and outside noise. As shown in Table 4, there was lots of variability in the teachers’ ratings, but the general trend was that the teachers of the triple and K-6 open plan classrooms found both inside and outside noise more distracting than the teachers of the enclosed and double classrooms.

**Table 4.** Teachers’ ratings of how distracting they find inside and outside noise from 1 = not at all distracting to 7 = extremely distracting.

Classroom	Teacher ratings					
	Inside noise			Outside noise		
	Mean	Range	SD	Mean	Range	SD
Enclosed <i>n</i> = 4	3.50	1-5	1.91	2.50	1-5	1.91
Double <i>n</i> = 3	2.67	2-3	0.58	1.67	1-3	1.15
Triple <i>n</i> = 6	5.33	4-6	0.55	4.33	2-6	1.63
K-6 <i>n</i> = 3	4.33	3-6	1.52	4.00	1-6	2.65

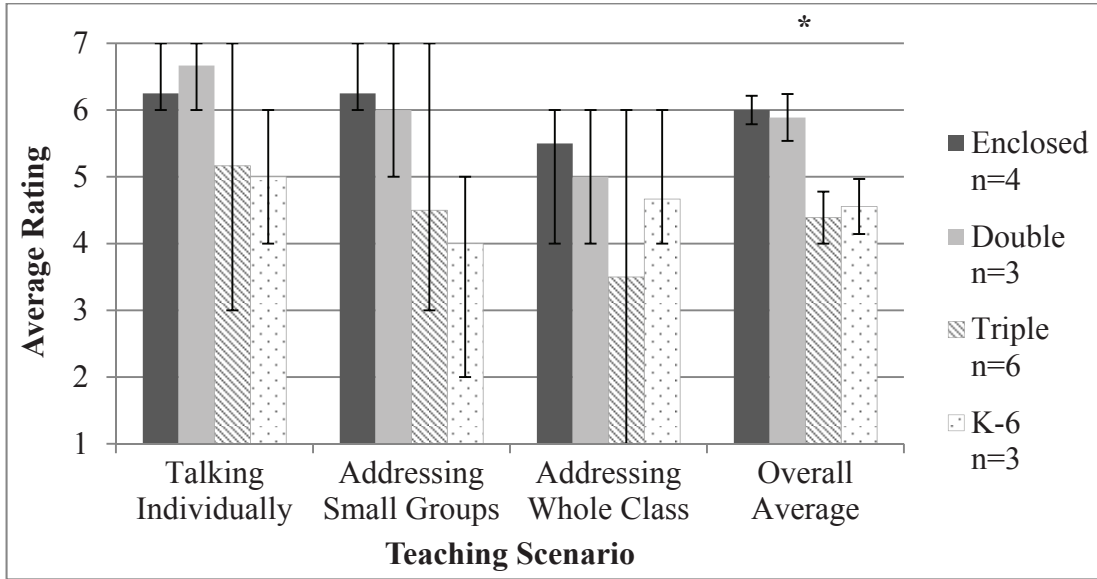
The teachers also rated whether they thought eliminating or reducing internal and external noises was unimportant, not very important, important, or critical for the children. All four teachers from enclosed classrooms believed it was important to eliminate noise. Only one teacher in the double classroom thought it was important to eliminate or reduce noise in the classroom. The other two teachers said it was not very important which is concerning as this classroom had some of the poorest ratings of how well the children reported they could hear their teacher, particularly when the adjacent class was being noisy (Mealings, Dillon, et al., 2015). Three of the six teachers surveyed from the triple classrooms thought it was critical to eliminate noise and the other three teachers thought it was important. All three teachers in the K-6 classroom believed it was important to eliminate noise.

### Speech Communication in the Classroom

The teachers were asked if they thought the children in their class had difficulty hearing them, and if the acoustics of their classroom had a direct effect on the children’s learning. None of the teachers in the enclosed classrooms believed the children in their class had difficulty hearing them. Furthermore, none of the teachers in the double classroom believed the children in their class had difficulty hearing them despite high proportions of children reporting that they could not hear their teacher very well or at all during many classroom activities (Mealings, Dillon, et al., 2015). In contrast, all of the teachers from the triple classrooms believed

that the acoustics had a direct effect on the children’s learning. Additionally, all teachers from the triple classrooms believed that the children in their class had difficulty hearing them, with three of six teachers saying this was irrespective of where they stood. This is consistent with the children’s perceptions (Mealings, Dillon, et al., 2015). In the K-6 classroom, all teachers believed that the children had difficulty hearing them, which was also revealed in the children’s questionnaires, indicating that noise is perceived as a problem in this classroom (which is also shown objectively by the noise levels in Table 1).

Figure 3 shows the teachers’ average ratings of how easy they find speech communication in the classroom for different scenarios. The trend shows that the teachers of the two larger classrooms (i.e. the triple and K-6 classrooms) found speech communication more difficult in each scenario compared to the teachers of the smaller enclosed and double classrooms. Figure 4 also combines the three teaching scenarios to give an overall average rating of ease of speech communication in the classroom. A Kruskal Wallis test revealed a statistically significant difference between the classroom types  $H(3) = 14.01, p = .003$ . A post-hoc test using Mann-Whitney U tests with Bonferroni correction  $p < .05/6 = .0083$  showed speech communication in the enclosed classrooms was significantly easier than in the triple classrooms  $U = 40.00, Z = -2.97, p = .003, r = 0.43$  and K-6 classroom  $U = 15.50, Z = -2.97, p = .004, r = 0.43$ .

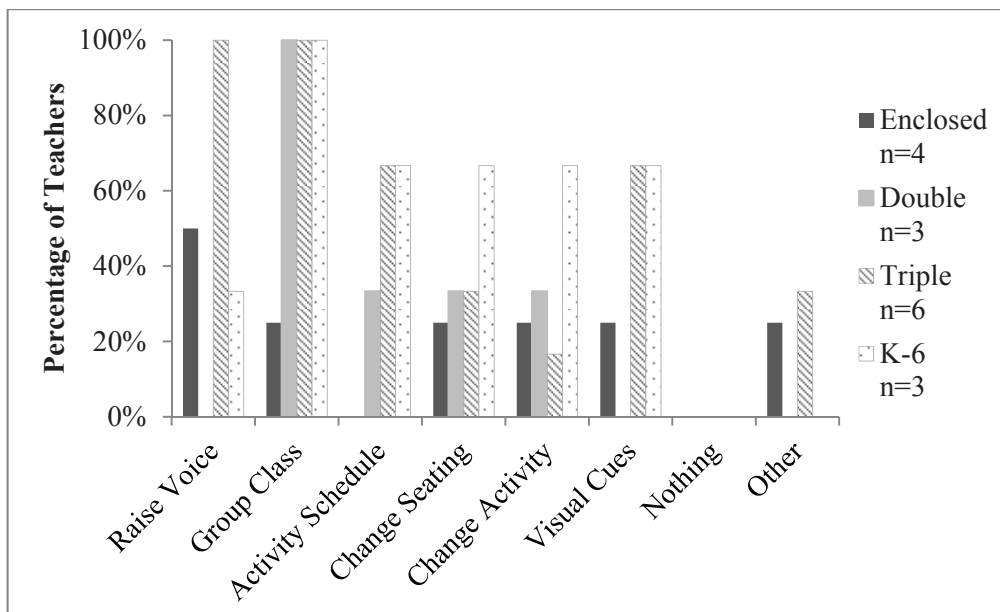


**Figure 3.** Teachers’ average ratings of ease of speech communication for different scenarios and the overall average rating (1 = very difficult, 7 = very easy). Error bars show range for the separate scenarios and standard error of the mean for the overall average. Brackets show significance at  $*p < .05/6 = .0083$ .

**Coping With Noise**

Figure 4 shows the actions teachers take to cope with noise in the classroom. All teachers reported using at least one strategy rather than taking no action. The actions taken included raising their voice, gathering the class close around them, arranging a compatible activity schedule with other teachers, changing the seating arrangement, stopping or changing the teaching activity, and using visual cues for attention. It was positive that the teachers

in the K-6 classroom used many different strategies to cope with the high noise levels in their classroom rather than always raising their voice. It is concerning, however, that all teachers in the triple classrooms raised their voice to cope with noise. These teachers were also using other coping strategies, but unfortunately they were not effective enough for the teachers to not have to raise their voice as well.



**Figure 4.** Actions teachers take to cope with noise in the classroom. “Other” includes ringing a bell to get the class’s attention, using a traffic light noise scale, rewarding children for quiet voices, and gaining the class’s attention to remind them to work more quietly.

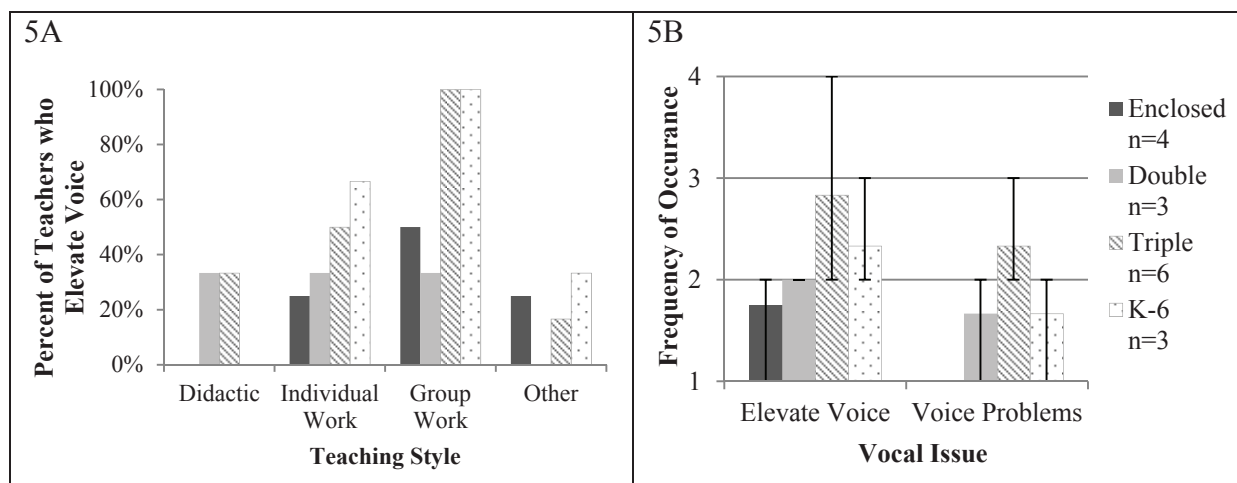
Figure 5A shows the average percentage of teachers who reported that they needed to elevate their voice to be heard clearly for different teaching styles. All of the teachers in the triple and K-6 open plan classrooms reported that they needed to elevate their voice during group work, compared to only 50% or less of the teachers in smaller enclosed and double classrooms.

Figure 5B shows the average ratings of how often teachers needed to raise their voice overall when teaching, and how often they experienced vocal problems. The surveyed teachers from the triple classrooms had to elevate their voice often, and also experienced vocal problems more than teachers in the other classrooms. All six teachers surveyed from this school reported that the level they needed to speak at strained their voice. This contrasts with the responses of the teachers in the enclosed and double classrooms; none of these teachers reported that the level they usually spoke at strained their voice and none of the teachers surveyed in the enclosed classrooms had ever experienced voice problems. Finally, the responses from the teachers in the K-6 classroom were in between those from the enclosed, double, and triple classrooms. Only one of the three teachers in this classroom experienced vocal problems, so it is likely that the acoustic treatment and semi-open plan style is beneficial for the teachers compared to the fully open plan non-treated triple classrooms.

### Perceptions of Open Plan versus Enclosed Classrooms

Teachers were asked to rate how strongly they agree or disagree (on a five point Likert scale) with the following statements about open plan classrooms compared with enclosed classrooms. The statements were those used by Greenland (2009) which were based on a questionnaire developed by Bennett et al. (1980). For clarity, the statements below are organized so statements 1-9 are the positive statements about open plan classrooms and statements 10-12 are the negative statements. Note, however, that these were randomized for the questionnaire.

- 1) The environment provides for a wide range of activities
- 2) The children are more independent and responsible
- 3) Standards of work tend to be higher
- 4) Children benefit socially
- 5) There is greater continuity for students
- 6) There is better pastoral care for students
- 7) Teachers feel more confident
- 8) The environment facilitates better student supervision
- 9) The environment makes students feel more secure
- 10) Children are more easily distracted by noise
- 11) Children are more easily visually distracted
- 12) There are discipline problems



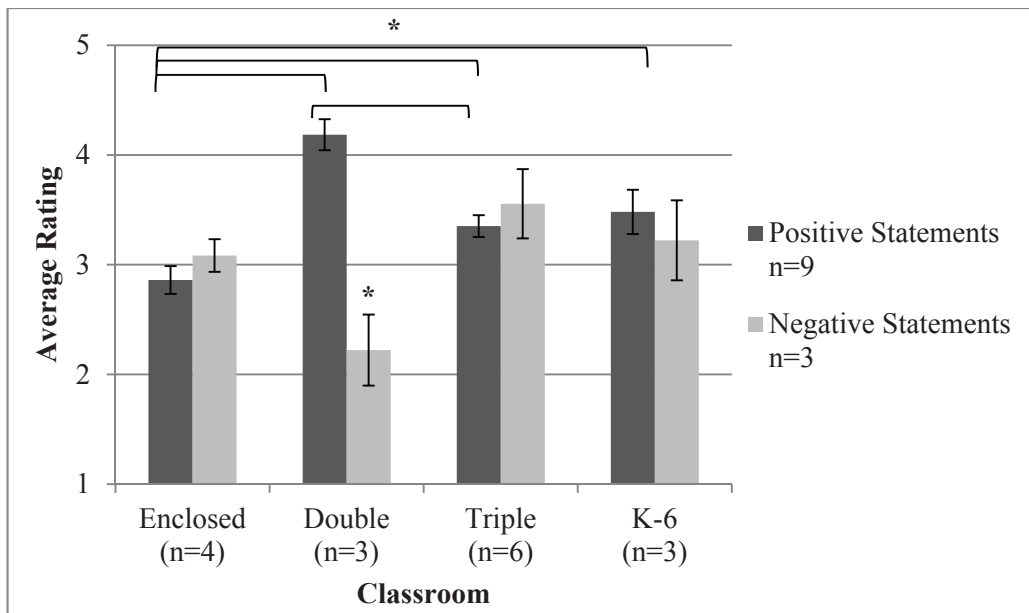
**Figure 5A.** Percentage of teachers reporting they needed to elevate their voice to be heard clearly for different teaching styles. “Other” includes when trying to get children to stop a group activity or trying to control children while moving between learning spaces.

**Figure 5B:** Average ratings of how often teachers needed to raise their voice overall and how often they experienced vocal problems (1 = never, 2 = sometimes, 3 = often, 4 = always). Error bars show range.

Figure 6 collapses these results into the positive compared to negative statements about open plan classrooms. A Kruskal Wallis test revealed a statistically significant difference between classrooms for their agreement on positive statements about open plan classrooms  $H(3) = 33.97, p < .0005$ . Post-hoc Mann-Whitney U tests with Bonferroni correction  $p = .05/6 = .0083$  showed the teachers of enclosed classrooms had significantly lower agreement with the positive statements about open plan classrooms compared to those teaching in them from the double  $U = 122.00, Z = -5.27, p < .0005, r = 0.66$ , triple  $U = 639.50, Z = -3.02, p < .003, r = 0.32$ , and K-6 classrooms  $U = 301.50, Z = -2.69, p = .007, r = 0.34$ . The teachers from the double classroom also had significantly better agreement on the positive open plan statements compared to the

teachers of the triple classrooms  $U = 330.50, Z = -4.28, p < .0005, r = 0.48$ . No significant difference between schools was revealed for the negative statements about open plan classrooms  $H(3) = 7.74, p < .052$ .

A Wilcoxon signed-ranks test was run to determine significant differences between agreements on positive versus negative statements about open plan schools for each classroom type. The teachers of the double classroom agreed significantly more with the positive statements than with the negative statements which they generally disagreed with  $Z = -2.71, p = .007, r = 0.90$ . No significant difference was found for any of the other classrooms  $Z_{\text{enclosed}} = -0.83, p = .405; Z_{\text{triple}} = -0.28, p = .783; Z_{\text{K-6}} = -0.53, p = .595$ .



**Figure 6.** Mean ratings of teachers' opinions about positive and negative statements comparing open plan classrooms with enclosed classrooms where 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree. Error bars show standard error of the mean. Brackets and asterisks show significant difference at  $p < .05/6 = .0083$ .

## Discussion

Recent changes in teaching methods has resulted in the re-emergence of open plan classrooms. This study investigated the teachers’ perceptions of their classroom listening environment in four different types of open plan/enclosed classrooms and compared these to the children’s perceptions in Part 1 of this study (Mealings, Dillon, et al., 2015).

One of the main reasons for having open plan classrooms is that they better facilitate group work (Brogden, 1983; Shield et al., 2010). However, it was interesting that the teachers in the triple and K-6 open plan classrooms only spent a third of their teaching time in group work activities compared to the teachers of the enclosed and double classroom types who spent 50-67% of time in group work activities. It is possible that the teachers of the larger open plan classes spend less time in these activities as they generate the most noise (Mealings, Buchholz, et al., 2015, see also Table 1) which makes listening difficult for both the children of that class and the other classes in the same area (Mealings, Dillon, et al., 2015). Therefore, the benefit of having these classes which are designed to better facilitate group work also has the downfall that these activities produce high levels of noise. It was also interesting that the Kindergarten teachers of the triple classroom spent 40% of their teaching time in didactic-style teaching. This shows that didactic-style teaching can still be an essential way of teaching new concepts to young children especially when they are starting primary school. This supports Rowe (2006) who raises the need for young children to learn basic literacy and numeracy skills first before they can engage in more child-centred constructivist learning. This further emphasizes the importance of having favourable acoustic conditions for these critical listening activities, which are hard to achieve in open plan classrooms (as shown in Table 1).

The results of the teachers’ questionnaires, like the children’s questionnaires, showed that the main noise source heard in the classroom was child generated noise. In the enclosed classrooms, this was largely from children in the teacher’s own class, while for the open plan classes (with the exception of the K-6 classroom) it was from children in the other classes sharing the same open plan area. These were also the main noise sources reported by teachers in semi-open plan classrooms in the study by Greenland (2009). Children outside, air-conditioning units, and equipment were other identified noise sources which were also identified by the children (Mealings, Dillon, et al., 2015), and by Mealings, Buchholz, et al. (2015) as contributors to the high unoccupied ambient noise levels in the K-6 classroom (see Table 1). The teachers in the triple and K-6 classrooms tended to find both inside and outside noise more distracting than the teachers in the enclosed and double classrooms. The teachers of the triple and K-6 classrooms also found speech communication significantly more difficult than the teachers in the enclosed and double classrooms, and all of the teachers surveyed from the triple and K-6 classrooms believed that the children had difficulty hearing them, whereas none of the teachers in the enclosed and double classrooms did. This is expected given the high intrusive noise levels from the adjacent classes in the triple and K-6 open plan spaces (see Table 1).

Overall, the teachers of the K-6 classroom and even more so the untreated triple classrooms needed to elevate their voice more often than the teachers in the enclosed and double classrooms. The teachers of the triple and K-6 classrooms also experienced vocal strain and voice problems more often than those in the enclosed and double classroom. In response to this, the teachers tried to use other strategies to cope with noise including coordinating activities between classes (which minimizes intrusive noise if all classes are doing quiet critical listening activities at the same time) and using visual cues. All of the teachers in the double, triple, and K-6 classrooms also tried to group the children close to them when they were teaching. This was also the most common action taken by teachers in semi-open plan classrooms in the study by Greenland (2009). Using this strategy is important as being far away from the teacher can be detrimental to the child’s ability to hear and understand their teacher, especially in noisy conditions (Mealings, Demuth, Buchholz, & Dillon, 2015a; Mealings, Demuth, et al., 2015b). It was positive that the teachers in the K-6 classroom used many different strategies to cope with the high noise levels in their classroom rather than always raising their voice. It was interesting that the teachers in the double classroom did not report raising their voice as a coping strategy (Figure 4), however Figure 5B shows that they did have to elevate their voice sometimes. This discrepancy may be related to the teachers having a lack of awareness of the strategies they use to cope with noise.

Of most concern, however, were the responses from the teachers of the untreated fully open plan triple classrooms. Most teachers in these classrooms rated the listening environment as poor, and believed the children had difficulty hearing them. Despite using a range of other methods to cope with noise, the teachers still needed to raise their voice above a comfortable level to be heard and experienced vocal strain. This puts them at high risk of vocal abuse and pathological voice conditions (Gotaas & Starr, 1993; Smith et al., 1997).

The overall poor ratings of the listening environment from the teachers in the triple classrooms largely agreed with the children’s perceptions of noise and their difficulty hearing their teacher from Mealings, Dillon, et al. (2015). These poor ratings are even more concerning as this school has the largest proportion of children with special educational needs (see Table 1). These children are reported to be even more adversely affected by poor classroom acoustics so it is highly likely that they will struggle learning in this environment (MacKenzie & Airey, 1999; Nelson & Soli, 2000; Shield et al., 2010). Unfortunately, when the classrooms in this school were converted to open plan no additional acoustic treatments were made. As a result, these classrooms have high noise levels and long reverberation times (Mealings, Buchholz, et al., 2015; see also Table 1). This is likely to explain why the teachers of this school struggled teaching in this environment and shows the impact of having poor classroom acoustics on the teachers and children. This suggests that this classroom should be acoustically modified to make speech communication easier. Furthermore, it is likely that improving the acoustic conditions in this classroom will help children to adequately progress in their education, and

create a more positive environment for the teachers so they can teach more effectively. The K-6 classroom provides an example of a classroom that is still open plan, but has been purpose-built with some acoustic treatment and dividers between classes. This may explain why the teachers in this '21st century learning space' found the environment more acceptable than those in the triple classrooms. However, because it was still semi-open plan and had over 200 children sharing the area, it still had consistently high noise levels (Mealings, Buchholz, et al., 2015; see also Table 1) which the teachers found problematic. As a result, some of the teachers still experienced vocal strain and believed the children had difficulty hearing them. This is consistent with the results of the children's questionnaires where 56-60% of children reported that they could not hear their teacher very well or at all when other classes or their own class was being noisy (Mealings, Dillon, et al., 2015). Therefore, more acoustic modifications and better divisions between the classes would be beneficial to further reduce noise.

A positive finding of the study was that the teachers of the double, triple, and K-6 classrooms ranked the classroom's acoustics as being an important aspect of the learning space and thought that reducing or eliminating noise in the classroom was important for the children. It is likely that the low ranking from the teachers of enclosed classrooms is because the acoustics in the tested classroom were mostly acceptable (Mealings, Buchholz, et al., 2015, see also Table 1). Therefore, the teachers may take the good acoustics for granted and not realize how detrimental poor acoustics can be on children's learning. Interestingly, however, two out of three teachers from the double classroom did not think noise was a problem, hence did not think it was important to reduce or eliminate it. The children in this classroom, however, thought very differently. Sixty-five percent of children found the noise from the children of the other class annoying, 43% found the noise from the teachers of the other class annoying, and 48% of found the noise from children outside annoying. Additionally, 39% of children surveyed could not hear their teacher very well or at all when the other Kindergarten class was working at their tables and 70% of children could not hear their teacher very well or at all when the other Kindergarten class was engaged in group work that involved movement. These were the largest proportions of children of all the classrooms tested (Mealings et al., 2015). Furthermore, 43% of children could not hear their teacher very well or at all when their own class was being noisy. These are all unacceptable proportions of children (i.e. over 32%) according to the dissatisfaction criterion used by Shield et al. (2008) which is based on previous research into noise annoyance in open plan offices and classrooms which propose a minimum of 68% of people need to be satisfied with the environment for it to be acceptable (see p. 12). This was also the only classroom type to have an unacceptable proportion (43%) of children who could not hear their classmates very well or at all when they were doing group work. Since this classroom had a smaller amount of space per child and a much smaller distance of only two meters between the classes compared to six to seven meters in the triple and K-6 open plan classrooms, it is likely that this close proximity combined with noise affects the children even

more as the interfering speech would be intelligible. However, as shown by their greater agreement with the positive statements about open plan schools, the teachers of this school have very positive views about open plan learning spaces. The difference in the children's and teachers' perceptions about the listening environment show that we cannot rely completely on the teachers' perceptions as they may not accurately reflect how the children feel and how they cope with noise in the classroom. This is because children are more affected by poor acoustics than adults as their brain is neurologically immature (Boothroyd, 1997; Nelson & Soli, 2000; Wilson, 2002). Therefore, these findings emphasize the importance of considering children's perceptions and capabilities in the classrooms as well as the teachers' perceptions.

In contrast to the teachers of the open plan classrooms, all of the teachers surveyed from enclosed classrooms found the listening environments comfortable and none of the teachers had experienced vocal problems. This shows the benefit of having even just an operable wall between classes to minimize the intrusive noise from the adjacent class/es. However, even though intrusive noise from the other classes was minimized, the noise levels when their own class was engaged in group work were still excessive (Mealings, Buchholz, et al., 2015, see also Table 1). Most of the teachers reported that this noise was problematic, as did the children, with over half saying that they could not hear their teacher very well or at all during these noisy periods (Mealings, Dillon, et al., 2015). Therefore, controlling noise during group work activities is still important in all types of classrooms.

Overall, the results of these studies show the importance of having good acoustic conditions in classrooms. This is needed so young children can hear their teachers and classmates, but also to increase teachers' job performance and job satisfaction (McCoy & Evans, 2005; Vischer, 2007). The results suggest that the best classroom design is an enclosed classroom as it minimizes the intrusive noise from adjacent classes which is of vital importance when the children are engaged in critical listening activities. While a classroom with four solid fully enclosed walls is likely to provide the best listening environment, single classrooms with operable walls should provide adequate listening conditions the majority of the time. This type of classroom also gives the flexibility of opening the operable wall for the activities the teachers prefer to have a more open plan space for, but then closing it for critical listening activities to minimize intrusive noise and enhance speech perception. Having quiet rooms as suggested by Shield et al. (2010) is also beneficial so children who are more vulnerable to noise can work in those areas away from the other children when needed.

### **Limitations of the Study and Future Directions**

As this study compared the perceptions of teachers from four case study schools, it only allowed a relatively small number of participants to be involved for a questionnaire design. As a result, these findings need to be interpreted cautiously and not be overgeneralized. Therefore, it would be beneficial to examine a wider range of classrooms and group them together by type of



design to provide more participants and hence more power for statistical analysis. This would allow us to draw more generalized conclusions about how teachers cope in different sized classrooms. It would also provide information to help us understand how classrooms should be designed in order to maintain adequate speech perception and minimize vocal health problems for teachers.

It would also be interesting to examine whether the demographics of the children in the classroom affect teachers’ perceptions of the listening environment. For example, children with ESL are typically more affected by poor classroom acoustics (Nelson, Kohnert, Sabur, & Shaw, 2005; Nelson & Soli, 2000). Furthermore, teachers have been found to have less close student-teacher relationships with children who have ESL and/or learning difficulties than their peers (see McGrath & Van Bergen, 2015, for a review). These factors may affect both teachers’ and children’s perceptions of their listening/learning ability in noise and/or ease of speech communication in the classroom, and may have contributed to the poorer perceptions from the teachers and children in the triple classroom which had a high number of ESL learners and several children with learning disabilities.

In addition, it would be worthwhile to conduct further research on what teaching styles are used in different classrooms. It was interesting in this study that the teachers in the triple and K-6 open plan classrooms spent less time in group work activities than the teachers in the enclosed and double classroom, despite open plan classrooms being designed for more collaborative work (Brogden, 1983; Hickey & Forbes, 2011; Shield et al., 2010). This study only included a small number of participants, however, so it would be beneficial to investigate this with a large number of different types of classrooms and assess the effectiveness of different teaching approaches. It would also be interesting to examine if teaching methods change as children progress through school. Rowe (2006) raises the problem of using constructivist methods for young children as children need to have learned the basic literacy and numeracy skills first before they can engage in more child-centred self-directed learning activities. This may have been one reason why the Kindergarten teachers in the triple classroom spent 40% of their teaching time in didactic-style teaching, but the Year 1 teachers only spent 10% of their time in didactic-style teaching. Furthermore, it is recommended that children with learning difficulties have highly structured teacher-directed lessons rather than child-directed activities (see Rowe, 2006). This is another factor that needs to be taken into consideration when designing classrooms and assessing teaching practices. In addition, it would also be interesting to examine if teachers’ past experience in open plan versus enclosed classrooms affects their teaching style, perceptions of different listening environments, and how easy they find speech communication in the classroom.

Finally, it would be worthwhile to examine the relationship between teachers’ reports of raising their voice with actual recordings of their vocal use and level throughout the day. This would allow us to assess if teachers’ perceptions of their vocal use match their actual vocal use, and better understand how this

may relate to the type of classroom and its acoustic conditions. This research would also help provide insight into how teachers’ vocal quality may change as a function of how long they have been teaching. These findings will help us understand more about how different types of classroom acoustic conditions may lead to vocal abuse and how this can be potentially be prevented by designing classrooms appropriately.

## Conclusion

The results of this study showed that teachers of larger, noisier classrooms (especially those that were fully open plan and not acoustically treated) were more distracted by noise and found speech communication significantly more difficult than the teachers of smaller, quieter classrooms. The teachers of larger, noisier classrooms also thought their students had more difficulty hearing them than the teachers of smaller, quieter classrooms thought their students did. These teachers also needed to elevate their voice and experienced vocal strain and voice problems more often. While the teachers in the K-6 classroom (which had been purpose-built with some acoustic treatment and dividers between classes) found the environment more acceptable than those in the triple classrooms, noise levels could still be problematic as reported by the teachers and children. These results suggest that noise is a problem particularly in large open plan classrooms, and it negatively impacts teachers. This suggests that smaller enclosed classrooms, or at least classrooms that have the flexibility to be enclosed for critical listening activities, are more appropriate learning spaces both for the teacher’s vocal health and for enhancing young children’s learning.

Additionally, the results of this study show the importance of using multiple approaches when assessing the acoustics of classrooms to provide a more comprehensive view of the environment. In particular, the results of this two-part study show the importance of considering how the children perceive and learn in the classroom environment, as teacher perceptions may not always accurately reflect those of the child. It is especially important to be aware of this difference in perceptions in regard to new, innovative teaching methods and classrooms spaces which may excite the teacher but may not be beneficial for the child. Therefore, future research that examines the suitability of different types of classrooms needs to take into account the perspectives of all of the different people using the classroom in addition to the physical acoustic conditions and how they affect speech perception. Hopefully, with careful consideration of these results and the results of future studies, classrooms in the future will be designed with appropriate acoustics to enhance children’s learning and improve teachers’ vocal health and wellbeing.

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