Noise and acoustics in early childhood education in Taiwan and effects on the children and their teachers

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Executive summary

A research study in Taiwan was commissioned by the Taiwan Fellowship fund to investigate sound levels and sound exposure in early childhood education centres (preschools) and its effects on children and their teachers. Seventeen leaning spaces were selected in the cities of Kaohsiung and Taipei across a range of preschools for one year in 2019. These included public and privately owned kindergartens, institution-based preschools and special character early education centres.

General ambient sound levels in each classroom over a full teaching day and the personal sound exposure of selected children and teachers were measured using internationally certified sound measurement instruments. Personal sound exposures were assessed with Cirrus light weight noise doseBadges pinned to the clothing of children and teachers. Acoustical quality was evaluated by physical examination of the spaces and the measurement of reverberation time, in accordance with international practice. The completion of a simple questionnaire on the classroom acoustic environment and teaching practice was invited from teaching staff.

Results revealed a range of sound levels and personal sound exposure, from acceptable to excessive. Reverberation times were compared to international criteria for learning spaces. Rooms with acoustic tile ceilings displayed considerably better acoustical quality than rooms with hard reflective surfaces and no form of acoustical treatment. General sound levels and personal sound exposures were typically higher in the small rooms without acoustic treatment

The questionnaires generated a variety of responses, from teachers being satisfied to those highlighting concern about the levels of noise and how it was affecting their teaching and the learning of the children. Widespread dissatisfaction was expressed with an open plan teaching environment with the ready transmission of noise and disruption between the adjacent spaces. The noise and distraction from mobile vehicles operating near the facilities with amplified messages and music to promote their wares was a major source of complaint from the majority of respondents. Other noisy activities such as large construction works and aircraft flying overhead were also highlighted.

Despite the limitations of the study, the results emphasised the importance of having learning environments with good acoustics, along with teaching and management practice to manage noise generated in the facility. Control of unnecessary loud and disturbing noise from activities outside the facilities, needs to be addressed within the Taiwan regulatory structure. Due to the level of dissatisfaction reported with open plan classrooms, there were requests to revert to the traditional cellular classrooms.

Recommendations:

- Teachers and management need to facilitate the reasonable control of noise in teaching spaces to ensure that noise levels do no unduly interfere with normal speech and/or communication, and does not cause harm or distress to any child
- Resources are developed to implement noise awareness and hearing health programs for the children and teachers
- Acoustical design guidelines for the establishment of new preschools or the major refurbishment of existing facilities need to be developed

- Carefully consideration should be made of all the research and evidence on open plan learning environments before widely adopting this mode of education delivery in Taiwan
- Examine ways that the disturbing noise intrusion into learning spaces from mobile shops and other noisy activities can be mitigated.

Background

A Taiwan Fellowship was awarded in 2019 to conduct a research project over a one-year period in Taiwan on 'Noise in early education and the effects on children and their teachers'. The project ran from 20 February 2019 – 20 February 2010 and was hosted by the Research Centre for Environmental Medicine (Kaohsiung Medical University) under the Directorship of Professor Ming-Tsang WU. The School of Health Sciences (Massey University, Wellington, New Zealand) co-sponsored the project.

From 2000 to 2008 a large study by McLaren[1] was carried out on noise in early childhood education. The procedures and methods of this study were incorporated into the Taiwan study. Massey University's School of Health Sciences provided the specialist equipment needed for the study and also had the equipment serviced and calibrated in the UK as a contribution to the project. An application to conduct research was prepared in the Chinese language and an application made to the University's Institutional Review Board (IRB) to conduct the study. The Board approves and oversees all research involving human participants and clinical trials conducted by Kaohsiung Medical University and Hospital. The IRB sought clarification on a number of issues, the most pressing being the safety of the doseBadges on young children and the concern that radio signals, heat and other radiation could be emitted from these devices. International safety certification was provided by the manufacturer to satisfy the IRB. Approval was given on 19 April 2019 for the project to begin. The approval documents are listed in the Appendices.

Introduction and rationale to the project

A comprehensive study was conducted in New Zealand by Massey University researchers (2000-2008) into noise in early childhood centres (preschool), as no project of this nature had been previously conducted. Studies of regular elementary classroom noise levels suggested that noise is a serious issue for teaching staff and children and were raised by the International Institute of Noise Control Engineering (I-INCE) at the request of the World Health Organization. Voice strain, hearing loss and ability to learn effectively, are issues of concern for teachers and their children.

The policy of inclusive education adopted in many jurisdictions has implications for young children with special education needs, particularly those affected by noise and sensory stimulation. A range of disorders such as autistic spectrum of disorders (ASDs), hearing impairment, Down syndrome, developmental delay, development verbal dyspraxia and a subset of the gifted, are groups of children known to be adversely affected by noise and over sensory stimulation. Those children on the autistic spectrum were identified by questionnaire in the New Zealand study to be the most adversely affected by noise.

Aims

The aims of the project were to:

[1] McLaren, S. J. (2008). Noise in early childhood education and the effects on the children and their teachers, PhD thesis, Institute of Food Nutrition and Human Health, Massey University, Wellington.

- Evaluate the characteristics of building construction, internal finishing and resulting acoustics in preschool (early childhood centres)
- Measure typical noise exposure levels of children and teaching staff
- Investigate the physical characteristics of noise present in early childhood centres and assess the impacts on children and teaching staff.

Recruitment of preschools and participants

Schools and organisations were contacted and invited to participate in the study. A total of seventeen learning spaces from six preschools (early childhood centres) in the cities of Kaohsiung and Taipei participated in the project. These included:

- Private early childhood centres
- Public early childhood classes which were part of an elementary school
- Special character centre based on an established philosophy (e.g. Montessori and Rudolf Steiner)
- An open plan teaching environment.

The preschools were numbered Centres1-6 to preserve anonymity as required by the IRB approval to conduct the study.

Unlike New Zealand and other countries where such research has been undertaken, recruitment proved to be especially difficult in Taiwan. There appeared to be fear of the unknown and the lack of awareness that high levels of noise can be harmful to young children and also to teachers. Furthermore, so many layers of approval were required within many organizations including the teachers, managers, governing head office and parents. It was difficult to gain approval and consent from all parties involved. As a result, recruitment was very time consuming with only half the number of premises that had been envisaged, were able to be recruited.

Methods

For those that consented, the following evaluations were undertaken:

1. The physical survey of the learning environment and assessment of the acoustical quality of their learning spaces.
2. Fixed sound level measurements of the learning spaces.
3. Sound exposures of individual children and their teachers: Information sheets and consent forms were given to the schools for the teachers and the parents. The doseBadges were fitted to select children and teachers with consent. They were calibrated and fitted in accordance with the manufacturer's instructions and the current Australian and New Zealand Standard for occupational exposure.[2]
4. Confidential teacher survey questionnaires: A simple questionnaire in the Chinese language was given to teachers who wished to participate. Participation was completely voluntary.

[2] Australian / New Zealand Standard, AS/NZS 2169:2005. Acoustics – Occupational Noise Management, Parts 1 - 4. Standards New Zealand, Standards Australia. (Joint standard for both countries).

(See Appendices for Chinese and English versions).

5. The following legal requirements were obtained and examined:
   - Legislation standards and guidelines for early childhood education (preschools) in Taiwan
   - Legislation standards and guidelines for noise in the workplace

1. Physical examination of the learning spaces

A physical inspection of the learning spaces was conducted including the internal surfaces (floor walls ceiling). In particular, the presence of any acoustic materials was noted. Equipment which could contribute to noise levels was also identified such as cooling fans and air conditioning units. The room volumes were estimated as much as was possible for acoustics analysis.

Reverberation times (RT60 / T_{60}) were measured with an 01dB Solo^{TM} Sound Level Meter set to T_{60} mode (S/N 10650, Mic MCE 212, Preamp 11026). The trigger volume was set to 90 dB impulse sound and the sound source provided by a hard-wood clapper. The measurements were taken in triplicate from the centre of the room at a height of approximately 1.0 - 1.25 meters from the floor. The instrument gives the reverberation times in the standard frequency bands 63 - 4,000 Hz. See Table 1. The mid-frequency reverberation times (T_{mf}) were calculated by averaging the reverberation time values of 500 Hz (T_{500}), 1000 Hz (T_{1000}) and 2000 Hz (T_{2000}). {$T_{mf} = (T_{500} + T_{1000} + T_{2000}) /3$}.[3] Mid-frequency reverberation times are important because these occur in the normal, speech range and therefore excessive reverberation times will degrade speech intelligibility.

Table 1: Example of Reverberation times (RT 60 / T_{60}) in seconds taken in triplicate

		Reverberation times (RT 60 / T_{60}) in seconds (s)		
	Frequency (Hz)	*Reading 1	Reading 2	Reading 3
	63	0.00	0.00	0.00
	125	0.23	0.26	0.52
	250	0.63	0.5	0.63
Mid-frequency reverberation times (T_{mf})	500	0.66	0.65	0.62
	1,000	0.72	0.74	0.69
	2,000	0.75	0.73	0.74
	4,000	0.76	0.74	0.74
	T_{mf}	**0.71**	**0.71**	**0.68**

Readings of T_{500}, T_{1000}, T_{2000} were averaged to give an overall T_{mf} value. For example: *Reading 1: T_{mf} = (0.66+0.72+0.75)÷3 = 0.71 s. The same was carried out for Reading 2: (0.71s) and Reading 3: (0.68s). An overall mid-frequency determined from the average of the three T_{mf} readings (0.71s+ 0.71+ +0.68s)÷3 = 0.7s.

[3] Acoustics of Schools: A design guide. (2015). Institute of Acoustics (UK) and Acoustics and Noise Consultants (UK) (in https://www.ioa.org.uk)

An overall T_{mf} of 0.7s was determined.

Room acoustics

There are many building and acoustics standards used worldwide which vary slightly. The following standards were used with the following mid-frequency reverberation times (T_{mf}).

- Australian and New Zealand Standard [4]

  T_{mf} of 0.4 - 0.5s (for room volume 100 -150m^3)

  T_{mf} of 0.5 - 0.6s (for room volume 200 -250m^3)

- Acoustics Designing Quality Learning Spaces (2016). New Zealand Ministry of Education [5]

  T_{mf} of 0.3-0.5 seconds (for room volume 100 -150m^3)

  T_{mf} of 0.3-0.6s (for room volume 100 -250m^3)

- American National Standard (ANSI) [6]

  ANSI Standard S12.60 for Classroom Acoustics addresses the issues of both reverberation time and background noise and their effect on speech intelligibility by placing maximum permissible levels on each.

  Under the standard, the maximum reverberation time in an unoccupied, furnished classroom with a volume under 283 m^3 (<10,000 cubic feet (ft^3)) is 0.6 seconds, and 0.7 seconds for a classroom between 283 and 566m^3 (10,000 and 20,000 ft^3). The maximum level of background noise allowed in the same classroom is 35 decibels ($L_{Ap} \leq 35$ dB).

  Clause 5.3.2 of the standard further states that core learning spaces < 283m^3 (< 10,000 ft^3) shall be readily adaptable to allow reduction in reverberation time to 0.3 seconds. A classroom is readily adaptable if it can be readily improved through adding the required sound absorption.

  Combining the requirements of the above standards, a mid-frequency reverberation time (T_{mf}) was established to be used in this work. That was:

  A T_{mf} between 0.3 - 0.6s with 0.3 - 0.4s being the optimum time for cellular classrooms (learning spaces).

2. Fixed sound level measurements

A 01 dB sound level meter was placed in each learning space at a height of 2 - 2.5 meters above the floor and where possible away from walls and other reflective surfaces. Placement depended

[4] Australian / New Zealand Standard: AS/NZS 2107. Acoustics – Recommended design sound levels and reverberation times for Building Acoustics. Standards New Zealand, Standards Australia. (Joint standard for both countries).

[5] Designing quality learning spaces: Acoustics Version 2.0, (2016). New Zealand Ministry of Education. In https://www.education.govt.nz/assets/Documents/Primary-Secondary/Property/Design/Flexible-learning-spaces/DQLS-Acoustics V2.0.pdf

[6] American National Standard: Acoustical Performance Criteria, Design Requirements, and Guidelines for Schools, Part 1: Permanent Schools ANSI/ASA S12.60-2010/Part 1. Acoustical Society of America.

on the nature and construction of each room. While no standards of codes exist for measurement of general noise inside early education centres, the current standard [7] (based on best practice) was applied where possible. The standard recommends the location of the microphone as close to the height of the person's ear. However as the general sound levels apply to both the children and their teachers and the work/learning stations are not fixed (i.e. the movement of teachers and children around the room) the height of the sound level meter microphone was placed at 1-1.5 m above the floor where possible so as to not obstruct the free movement and learning activities in the teaching space. This also depended on there being a means to suspend the microphones from the ceiling space near the middle room.

3. Sound exposure of individual children and their teachers

For the teachers and children, information sheets and consent forms were given by the schools to parents. Lightweight personal sound exposure meters (Cirrus doseBadges™) designed to be used in confined spaces were used as these were small enough to be successfully pinned on the clothing of young children and have been certified internationally as completely safe by not emitting any kind of radiation including heat and microwaves. These were fitted to the children who had consent and a teacher. They were calibrated and fitted in accordance with the manufacturer's instructions and the current Australian and New Zealand Standard for occupational noise exposure.[2] Children wore the badges during their daily activities except during their sleeping time. The badges were removed prior to sleeping and placed on a table/bench close to the children. They were refitted to the children once they were awake. Teachers usually stay with the children while they sleep.

4. Confidential questionnaire

Staff were invited to complete a simple confidential questionnaire on aspects of their teaching space, teaching practice in the managing noise generated from activities within the classroom and centre, their teaching experience and intrusion from noise sources outside the centre. Respondents could also choose the questions they answered.

5. Legal requirements for Preschools (Taiwan and New Zealand)

In both the jurisdictions of Taiwan and New Zealand, the legal requirements for preschools/ early childhood centres are contained in principal legislation which is underpinned by standards and criteria. The New Zealand criteria are included for comparative purposes.

In Taiwan, the principal legislation is the *Early Childhood Education and Care Act.*[8] Underpinning this are the *Standards of basic facilities and equipment for kindergartens and their classes* (revised

[7] Australian and New Zealand Standard (AS/NZS 2169:2005), Occupational noise management: Part 1- Measurement and assessment of noise immission and exposure. Standards New Zealand, Wellington.

[8] Early Childhood Education and Care Act (2018 June 27 – amended date): in Laws and Regulations Database of The Republic of China. https://law.moj.gov.tw/ENG/LawClass/LawAll.aspx?media=print&pcode=H0070031

July 10 Minguo 108. (2019) (稱：幼兒園及其分班基本設施設備標準).[9] These have been promulgated pursuant to Article 8, Item 6 of the above Act.

In New Zealand, the *Education Act 1989* is the principal act under which the *Education (Early Childhood Services) Regulations 2008* [10] are made pursuant to this Act. The ***Licensing Criteria for Early Childhood Education & Care Services 2008 and Early Childhood Education Curriculum Framework***) [11] have been promulgated under the above regulations.

In New Zealand a child may begin school (compulsory education) at aged 5 but must be at school by their 7th birthday. Most children in New Zealand start school on turning 5 years of age. In Taiwan, a child aged 6 must attend school, which is the usual age to begin school.

In Taiwan while there are many private stand-alone preschools in Taiwan, the public preschools are often part of national elementary schools. In New Zealand it is rare to have a similar integration of early childhood centers with the state or private primary (elementary) schools. Most kindergartens and other early education centres are stand alone. If they are part of a school, university, hospital or similar operation they are usually physically separated.

Class numbers and age

Taiwan (*Article 16)* [8]

There is no limit of total children that can be enrolled, but the higher the number of enrolments additional facilities and resources are required. Limitations apply to class sizes according to age with smaller numbers for the children less than 2 years of age.

Kindergartens (Early Childhood Centres) for children 2-3 years old (over 2 but less than 3 years) old are limited to 15 children per class and cannot be mixed with children of other ages. For children over 3 years old class numbers are limited to 30 children per class.

There is provision for kindergartens in remote islands, partial towns and indigenous ethnic areas where age separation is not possible because of small numbers of aged 2-3 in the area. Special approval can be given on application to the municipal competent authority for mixed age classes where each class is limited to 15 people.

New Zealand [10]

A maximum of 25 children under 2 years of age may be enrolled in any one center. For those over 2 years of age a maximum of 150 children may be enrolled without approval of the Secretary (of Education).

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9 Standards of basic facilities and equipment for kindergartens and their classes in in Laws and Regulations Database of The Republic of China. https://law.moj.gov.tw/LawClass/LawAll.aspx?media=print&pcode=H0070037

10 Education (Early Childhood Services) Regulations 2008 (New Zealand Legislation data base http://www.legislation.govt.nz/regulation/public/2008/0204/latest/DLM1412501.html)

11 Licensing Criteria for Early Childhood Education & Care Services 2008 and Early Childhood Education Curriculum Framework (amended 2016), Ministry of Education – New Zealand, In https://www.education.govt.nz/assets/Documents/Early-Childhood/Licensing-criteria/Centre-based-ECE-services/ECE-Licensing-Booklet-Early-Childhood-June2018.pdf

Regulation 23 requires no more than 50 children (of mixed age) to attend at the same time (without Secretarial approval. The Secretary may approve a maximum roll of 150 children of mixed age with the provision that no more than 75 children under 2 years old may be enrolled. The provision of service must ensure all children will be adequately catered for and the different needs of children attending will be met.

Space requirements

Taiwan *Article 10* [9]

Indoor Activity Rooms - space requirements.

1 For classes with 15 children or less, the dedicated indoor activity room shall be a minimum of 30 square meters.

2 For classes 16 - 30 children, the dedicated indoor activity room shall be a minimum of 60 square meters.

The area of the first indoor activity room may be calculated by the number of individual children. The indoor activity space for each child is a minimum of 2.5 square meters.

New Zealand Licensing Criteria [11]

A minimum indoor area free space of 2.5 square meters per child is required (equivalent ratio to Taiwan).

Outdoor activity areas

Both jurisdictions have requirements to provide outdoor activity areas. In Taiwan outdoor activities spaces much be set at the ground floor level of the kindergarten but if this is not possible it can be set on the second floor or a terrace on the third-floor level (an uncovered platform). The land adjacent to the street frontage may also be used with specific conditions. (Article 11). There should not be dangerous obstacles on the ground, a game space with items such as playground equipment, sandpits and paddling pool etc. This must meet the needs of all children in attendance. In addition, there should be a non-playing space for plants, garden etc.

Article 12 requires an outdoor space requirement of 3 square meters (m^2) per child. For private kindergartens set-in high-density administration areas this space requirement is reduced to 2 square meters per child. There is provision for the local municipal education authority to approve alternative requirements in high density administration areas.

A minimum outdoor activity space of 22 square meters has been prescribed which can cater for 44 children. A requirement to increase this by 1 square meter for every 2 enrolled students is required. In other words, an outdoor activity area for 50 enrolled children needs to be a minimum of 25 square meters.

In New Zealand, a minimum outdoor activity space of 5 square meters per child is required which is to be suitably equipped, well drained, secure and easily accessible by children. It must be for exclusive use of the children (and not shared with others during operating hours). Most facilities

will provide an outside secured playground but where this is not possible (for example in high density city areas) a dedicated space must be provided which can include a dedicated covered or uncovered area such as a secure platform.

Planning requirements

Taiwan and New Zealand require compliance with urban planning and land use for the establishment of early childhood centres. In New Zealand environmental noise provisions for particular zones, must be taken into account when establishing early education facilities as children's outdoor experiences cannot be restricted by Resource Consent (urban planning) conditions with regards to its use (PF13).[11] This has been an issue with the establishment of early childhood centres in quiet residential neighbourhoods where the typical noise levels generated by the centre could exceed the noise criteria for the zone. In such cases and application to establish the facility should be declined. Restricting the use of outdoor play areas on account of the environmental noise provisions for the location is not permitted.

In Taiwan the standard requires special provision for the establishment of buffer distances between hazardous operations such as gas stations dangerous goods and flammable high-pressure gas installations.

Specific requirements requiring noise control

In Taiwan, there is a specific requirement to control noise and odour from the kitchen preparing food for the children.

In Taiwan, Article 19 [9] requires that parking spaces provided for early childhood centres to be properly separated from outdoor activity spaces to reduce noise and vehicle emissions. On and off-street parking requirements and vehicle access to the facility are governed by the District Plan (zoning) requirements in New Zealand. Depending on the zone requirements, some childcare centres in New Zealand may be required to provide adequate and safe off-street parking with suitable conditions to pick up and drop children safety without causing undue traffic congestion or hazards.

Indoor activity space environmental requirements

Taiwan

Article 21 outlines a number of age appropriate requirements which include appropriate facilities teaching tools, materials and equipment for education and development.

Appropriate uniform lightning, free from glare is required with a minimum lighting intensify of 350 lux in learning activity spaces. A requirement of 500 lux is required over teaching boards (white/black boards) which is free from glare from the sun and lights.

In areas with a high background (ambient) sound level (L_{Aeq}) of 60 dB or more, sound proofing should be installed. Noise from floor slab vibration noise (foot pounding) operating noise of electric fans air conditioning and other equipment should be effectively controlled.

There appears to be no general noise control requirements for the noise generated by the children and their activities.

New Zealand

Regulation 45 includes the *Premises and Facilitates Standard* contains a variety of requirements which include suitable and sufficient heating, lightning, ventilation and noise control. In Regulation 46, *Health and Safety Practices Standard*, noise is covered under the clause to promote the good health and safety of children in the service. Unlike the specific requirements in Taiwan, the New Zealand legislation and criteria cover all aspects of noise within the control of the operation.

Environmental, conditions including noise control and provision of quiet spaces are further disseminated in the licensing criteria.

To achieve compliance with Regulation 45, *Premises and Facilities Standard,* the licensing criteria require the following:

- In areas where children sleep must be designed and located to minimise fluctuations in temperature, noise and lighting levels.
- Areas used by children inside the building are required to have appropriate natural or artificial lighting, ventilation (natural or mechanical) that allows fresh air to circulate, a safe and effective form of room heating (at a minimum of 16°C).
- Acoustic absorption materials, if necessary, to reduce noise levels that may negatively affect children's learning or wellbeing. This applies to attenuating noise generate outside the centre as well as that generated inside by the activities of the centre.
- The provision of quiet spaces: This was introduced with the current legislation and standards in recognition of the need for children to be able to retreat from the din and also for activities such as speech language therapy which are offered to children often individually with speech and hearing issues, developmental delay verbal dyspraxia, autism or any other condition requiring assistance with speech and related development. The necessity to conduct individual therapy sessions involving speech and hearing without noise intrusion is paramount.

To achieve compliance with Regulation 46 *Health and Safety Practice Standard*, the licensing criteria[11] require the following:

- All practicable steps are to be taken to ensure that noise levels do not unduly interfere with normal speech and/or communication, or cause any child attending distress or harm" (HS 15).
  This is one of the few requirements in any jurisdictions which require teachers and the facility to take reasonable steps to control noise including that made by to a level that will not interfere with normal speech or communication. In the presence of children who are adversely affected by noise (with auditory function deficits such as hearing loss, autism etc.), which will cause harm or distress to the child, special provision has to be made for them.

There was a level of debate in the setting of noise criteria as to whether sound level limits should be prescribed. (For example, a time-average level (L_{Aeq}) of no more than 70 dB). This is problematic if the necessary specialists and resources are not available to evaluate compliance with such prescriptive criteria. Furthermore, a standard method for assessing ambient sound levels in education facilities would be needed. The Ministry of Education sought advice from us (the authors) as to how noise criteria could be included in the criteria when they were under development.

Noise levels which clearly interfere with speech and communication or causes distress is a measurable descriptor which was adopted in favour of setting prescribed sound level limits.
A buy-in by teachers to include noise management in their teaching practice was seen as an effective strategy both to protect the health and education of children as well as conservation of their own aural health.

Noise criteria in the workplace

Occupational noise legislation in Taiwan

Health and safety in the workplace of Taiwan is governed by the recently enacted *Occupational Safety and Health Act*.[12] Article 6 requires that employers have necessary safety and health equipment and measures that comply with regulations for a range of items including the prevention of risk of posed by radiation, high temperature, low temperature, ultrasonic waves, noise, vibration, and abnormal atmospheric pressure. Article 6 allows the competent regulatory authority to establish standards and rules for the necessary safety and health measures. An occupational safety and health facilities rule for noise exposure requires the following:

- Time-average level (A-weighted) over an 8-hour day of no more than 90 dB ($L_{Aeq,8h} \leq$ 90 dB) with a 5 dB exchange rate
- A peak level (impact / impulse level) from a shot gun, blast, door slamming etc.) of no more than 140 dB ($L_{Cpeak} <$ 140 dB).

This rule adopts a 5 dB exchange rate (in acoustic terms). This means for halving the exposure time an increase of L_{Aeq} of 5 dB is permitted. This method has been adopted as a less stringent evaluation in some jurisdictions including the Occupational Health and Safety Administration (USA) and Taiwan. However, the National Institute for Occupational Safety and Health *(*NIOSH*)* of the USA recommends the international workplace criteria (below) be adopted as exposure levels in excess of the international criteria are deemed to be hazardous.

The following table from Article 300 of the *Occupational Safety and Health Facilities Rules* (standard) is included.[13]

[12] Occupational Safety and Health Act (amended date - 15 May 2019). In Laws and Regulations Database of The Republic of China (https://law.moj.gov.tw/ENG/LawClass/LawAll.aspx?pcode=N0060001)

[13] Occupational Safety and Health Facilities Rules (2020). In Laws and Regulations Database of The Republic of China. In https://law.moj.gov.tw/LawClass/LawAll.aspx?media=print&pcode=N0060009

Table 2: The Time-average level and the permitted daily exposure time of workers are shown in the following table:

Permissible exposure time in working days (hours)	A-weighted noise sound pressure level ($L_{Aeq,\,T\,h}$ dB)
8	90
6	92
4	95
3	97
2	100
1	105
1/2	110
1/4	115

International Workplace Criteria for noise

The following international standard for workplace noise has been adopted by New Zealand, Australia and most other jurisdictions:

- Time-average level (A-weighted) over an 8-hour day of no more than 85 dB ($L_{Aeq,8h} \leq$ 85 dB) (3 dB exchange rate), equivalent to 1 Pa^2h or 100 % dose;
- A peak level (impact / impulse level) from a shot gun blast, door slamming etc.) of no more than 140 dB ($L_{Cpeak} <$ 140 dB).

Table 3 Comparison of the exposure difference between Taiwan and the international noise criteria.

Exposure time (in a working day)	Time-average level	Taiwan and USA (5 dB exchange rate)	% Dose (Taiwan)	International Workplace criteria limit	Dose % International Workplace Criteria (3 dB exchange)
8 hours	$L_{Aeq\ 8h}$	90	320%	85	100 %
4 hours	$L_{Aeq\ 4h}$	95	504%	88	100 %
2 hours	$L_{Aeq\ 2h}$	100	800%	91	100 %
1 hour	$L_{Aeq\ 1h}$	105	1260%	94	100 %

For comparison, a time-average level for 8 hours of exposure ($L_{Aeq,\ 8\,h}$) of 85 dB using the International workplace criteria = 100% dose. Based on the criteria used in Taiwan (using a 3 dB exchange rate) a time-average level for 8-hour exposure of 90 dB ($L_{Aeq\ 8h}$) = 320% dose.

This means that a worker in the USA/Taiwan is permitted to receive over three times the noise exposure for an 8-hour working day than workers in most other jurisdictions. Many workers subjected to this level of prolonged exposure would potentially suffer a very high level of hearing loss and injury. This is something that requires urgent attention in Taiwan which should adopt the international workplace criteria to bring it into line with the accepted international criteria and provide a higher level of hearing protection to their workers.

Individual susceptibility to hearing loss due to noise exposure is a major factor with individuals affected very differently with the same level of exposure. Using the international criteria, it is expected that 16-20 % of the workforce will suffer hearing loss over their working life.

The above workplace criteria are for adult workers assuming that they work 8 hours a day with 16 hours of quiet time. There are no such criteria or recommendations for children although there has been significant debate over the setting of appropriate criteria. This is because it is extremely hard to determine by medical investigation (other than animal studies) the likely levels that will damage the hearing of young children. However, it is recognised by hearing specialists that children are likely to suffer significant damage if exposed to workplace noise criteria. As stated in a review by Picard and Bradley,[14] acute cochlear damage can occur in children's hearing while the same level will have no such affect in adults. In setting appropriate levels in international standards (ISO, EN etc.) for noise producing toys, the workplace levels are generally used as a proxy and then adjustments are made to allow for the sensitive hearing of young children.

In determining suitable criteria for young children exposure levels of 50 % or below were deemed to be of little concern well below the 100 % maximum dose of international workplace criteria. Levels 50–99 % were of significant concern especially the higher exposure readings 80–99 % (amber alert). Those exposure levels which exceeded 100 % for children are of serious concern (red alert) as the children were exposed to levels in excess of the international adult workplace criteria for noise.

Although the legislation and standards were never envisaged to be used in educational institutions, it is never-the-less appropriate that adults workers be assessed against workplace criteria.

Results

The six preschools (Numbered Centres 1-5) and their learning spaces which participated are described below.

Centre 1

The kindergarten is part of a large academic institution providing education to the children of staff and mature students. It is located on campus. The kindergarten is in a two storied building with the entrance (Floor 1) facing North. It is located on a corner right on the street front. The entrance through a double sliding glass door leads to the main assembly area. Staff offices and administration are located on the west side of this area. On the east side is a piano for music tuition and accompaniment, a data projector and PA (Public Address) system. At the rear of this area (south) is an internally covered playground. The area is covered by clear glass sheathing for weather protection.

On the west side of the playground area there is a stair way leading to the second floor where there are 4 separate teaching classrooms off an open corridor. This overlooks the playground on the first floor). These rooms are for smaller group instruction activities and resting.

[14] Picard, M., Bradley, J. (2001). Revisiting speech in classrooms. Audiology, 40, pp.221-244.

The external playground is located on campus directly across the road. The preschool is also able to use the university facilities such as the track and field for structured exercise and athletic activities.

These learning spaces were evaluated including:

- Room description and acoustical quality
- Fixed sound level measurements
- Personal sound exposure of selected children and teachers

To begin with, short periods were monitored in the classroom. This is because many activities were being conducted outside the kindergarten at the time in preparation for the end of the academic school year activities. This made a full day of monitoring difficult at this time. Monitoring over a full day was subsequently conducted in the new academic year, in two rooms, to gain daily representative samples.

Questionnaire Survey of teaching staff

Six of the teaching staff competed questionnaires. A summary of the results is given below.

Room description

The upper floor classrooms are of similar size design and finishing.

- **Room volume** (of each Floor 2 teaching room): ≈ 125 m^3
- **Floor:** polished tongue and groove timber (hard surface).
- **Walls**: plastered /painted concrete. However much of wall surface is covered by cupboard space to a height of 2 meters and remaining areas by wooden panels to a height of 1.1 meters.
- **Ceiling**: There are suspended ceilings in all teaching spaces. This is very common design in Taiwan. The ceiling tiles appear to have acoustic properties but details of the specifications are unknown.
- **Room acoustics**
    - The mid-frequency reverberation times (T_{mf}) for each room was 0.7s. This was slightly higher than the established (T_{mf}) of 0.3 – 0.6 s.

Fixed sound level measurements

These were carried out with a *Solo 0.1 dB Sound Level Meter* ^{TM} in 2 rooms.

- Room 1: (844 – 1603 hours - 30 August 2019). Time-average level L_{Aeq} = 70 dB **(**for the full session)
- Room 2: (851 – 1605 hours- 3 September 2019). Time-average level L_{Aeq} = 73 dB (for the full session).

In the session on 3 September, the children vacated the room in the morning session to do some outdoor activities. They had an afternoon sleep after lunch (as shown in Figure 1b).

Figure 1a: Centre 1- Time history - Fixed sound level measurement. Room 1

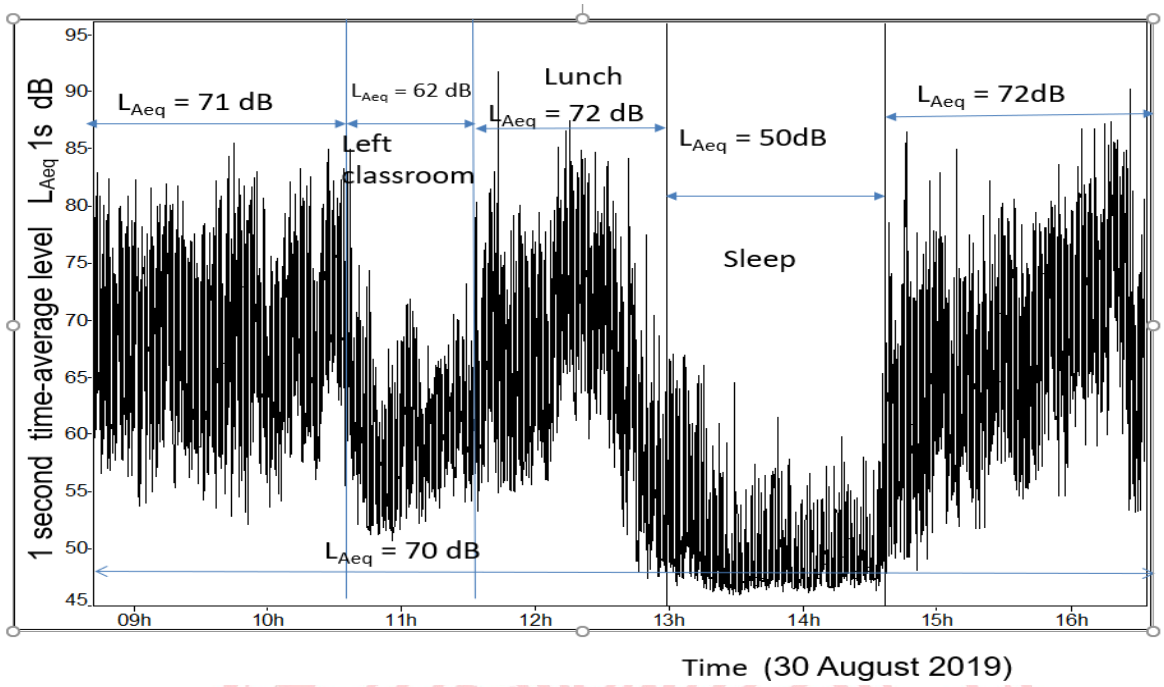
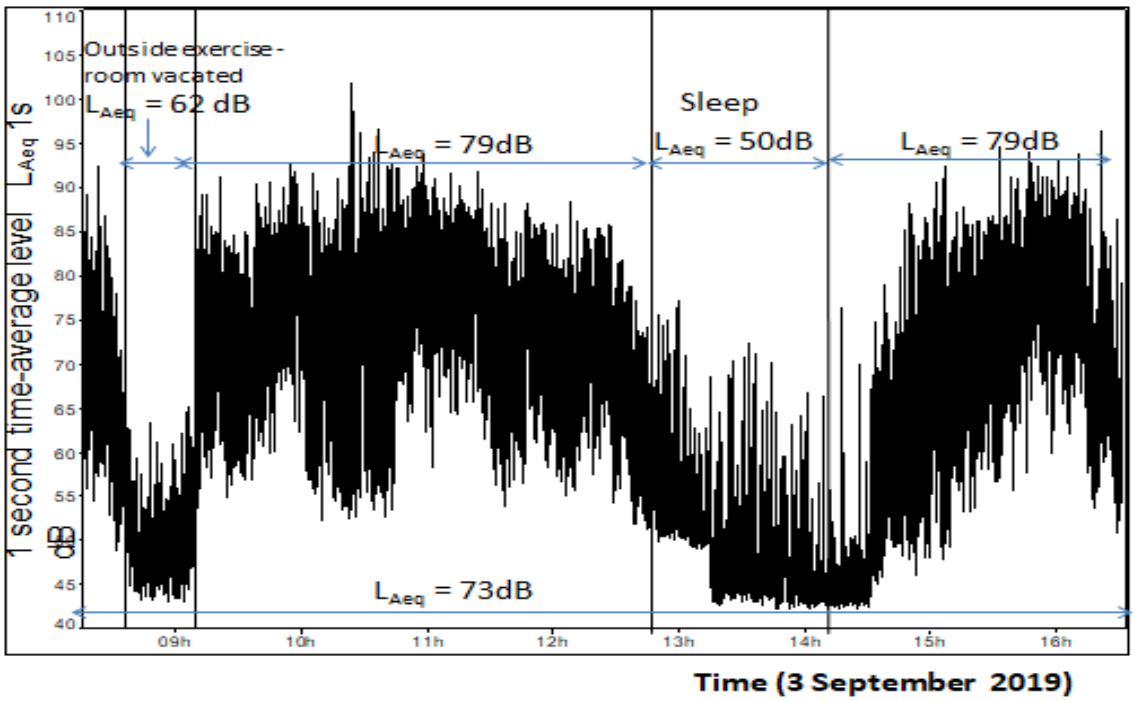


Figure 1b: Centre 1- Time history - Fixed sound level measurement. Room 2



Individual sound exposures of Children and their teachers

A total of 8 personal sound exposure measurements were made on each day. Some results were discarded due to children tampering with or speaking into the badge which will give elevated results.

There were children in this centre which spent up to 8.5 hours in the centre. This is a comparatively long period of time for children to be in childcare which is due to work demands of their parents. Length of exposure as well as sound levels contribute significantly to overall personal exposure.

Table 4 Centre 1 Personal sound exposures of teachers

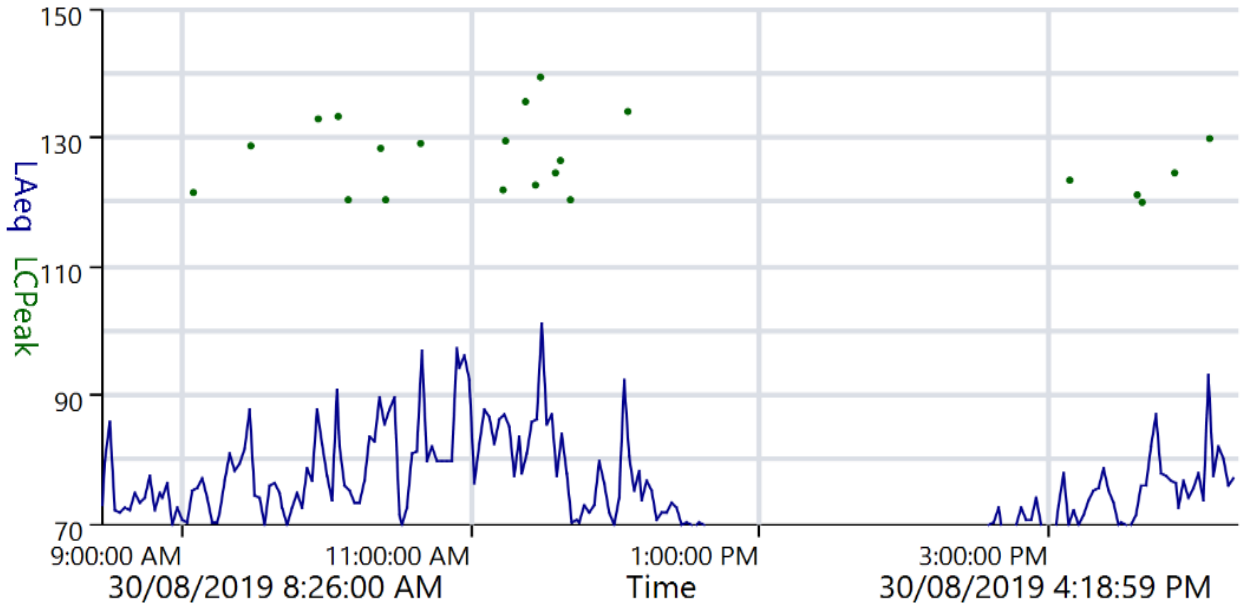
Number	Date	Time period (hours: mins)	Dose %	$L_{Aeq\ t}$ dB	L_{Cpeak} dB
Teacher 1	30 August	7:57	24	79 dB	123
Teacher 2	3 September	7:52	44	81 dB	143

The above levels are well below the international workplace criteria of $L_{Aeq\ 8h}$ of 85 dB and 100% dose and certainly well below the legal workplace criteria in Taiwan equating to 320% dose.

An example of doseBadge readings for a teacher is given in Figure 1c - Teacher: dose Badge 1 (S/No CA024)

- Time duration = 7 hours: 57 mins
- $L_{Aeq,\ t}$ = 79 dB
- Dose = 24 %
- L_{CPeak} = 123 dB

Figure 1c: Centre 1 – Time history-doseBadge – Teacher



Personal sound exposures of children

The personal sound exposures for the children who wore the doseBadges are given in Table 3. Monitoring was done over 2 full days.

Table 5: Centre 1- The doseBadge results for the children (over 3 days)

Number	Date	Time (hours: mins)	Dose %	$L_{Aeq\,t}$ dB	L_{Cpeak} dB
1	30 August	8:05	33	80 dB	143
2	30 August	7:59	38	81	130
3	3 September	8:21	43	81	129*
4	3 September	7:56	48	82	135
5	3 September	8:28	48	82	141
6	30 August	8:04	49	82	126
7	30 August	7:52	66+	83	127*
8	3 September	8:26	66	83	141
9	30 August	7:57	68	83	143
10	30 August	8:05	72	84	143
11	3 September	8:28	146*	87	137
12	30 August	7:55	156	87	143
13	3 September	8:08	194	88	132
14	3 September	8:05	239	89	133

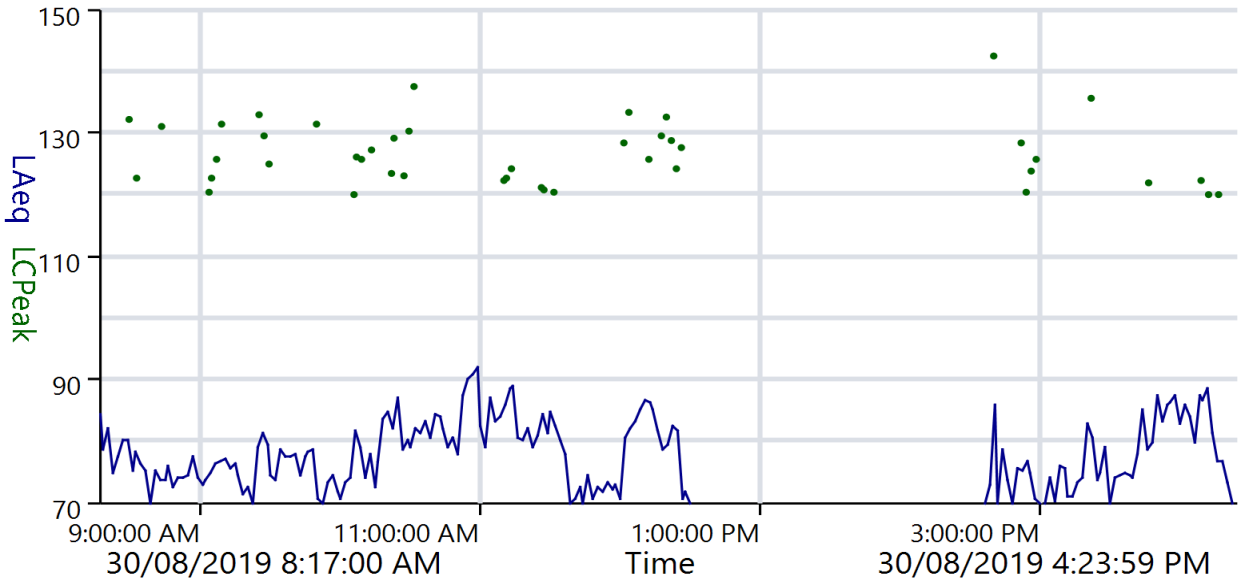
Amber coloured text+ - exposure levels 50- 99% (Amber alert)

Red coloured text* - exposure levels over 100% (Red alert).

An example of a doseBadge reading for a child is given below

- Time duration = 8 hours: 06 mins (30 August)
- L_{Aeq} = 80dB
- Dose = 33%
- L_{Cpeak} = 143dB

Figure 1d: Centre 1- Time history – doseBadge - child



Teacher Questionnaires

Questionnaires for teachers were distributed and all the teachers responded in this voluntary survey. Teachers were asked rate in order the following teaching aspects:

- Lighting
- Ventilation
- Acoustics (listening environment)
- Equipment
- Adequate space.

Each was given a score of '5' for the most important to '1'for the least important. The results for all five teachers were collated with the following results:

Order of Priority (importance)	Aspect	Score
1	Ventilation	21
2	Space	20
3	Lightning	15
4	Equipment	13
5	Listening environment*	9

*Misinterpreted in translated version to hi fi - music. However later in the questionnaire the listening environment, echo was identified by 2 teachers.

When asked to indicate how they experienced the teaching environment, all but one teacher rated it well describing it as *comfortable, clear, acceptable volume,* and that they were *accustomed to it*. Only one teacher commented on the degree of echo.

When asked to rate their teaching spaces all except one rated their teaching spaces highly (*good* or *just right)*. Only one rated the teaching space as poor.

Of the acoustic problems in their room, three teachers did not indicate any problems. The other two found echo and the noise that children make as being the most significant and had to continuously remind children to keep the noise level down. One teacher found that noise depended on the activity and how the teacher controlled them. Of the noise generated in the room, all indicated that most noise was generated by the children. Of this, free play was identified along with children coming into the centre in the morning and in the afternoon. Teachers were asked to give some indication of the extent of time noise was found to be excessive. Two staff indicated 1-2 hours while one found it to be as high as 75% of the time. One identified the beginning and end of the week as being significant.

Weather, wind and similar conditions were not identified as major contributors of noise.[15]

Teachers identified other sources of noise as echo, intrusion from other classroom the corridor, people talking perhaps such as parents leaving or collecting children.

This school has an open corridor on Floor 2 which overlooks the playground below. This is likely to be source of significant noise from free play in the playground and also activities in the main entrance assembly (having no sound barrier to the upstairs area). While the concrete walls will provide a good barrier to sound entering the classrooms the doors, even if closed, will be the main entry point of noise intrusion. Besides door leading to the main classroom there are doors between adjacent classrooms which appear not to be used.

As the school fronts on to a relatively busy suburban shopping street noise from traffic machines and noise vehicles such as motor bikes were identified as an issue. Of particular note were the promotional vehicles (mobile shops) used to sell products, electioneering and others using amplified announcements and music to attract customers. This appears widely accepted or tolerated in Taiwan as it is in Japan. Excessive use of this form of advertising is viewed in many other countries as a public nuisance and disturbing the peace and quiet of the locality. Others identified noise from road works and building projects. However, while such perpetrators may feel it is their right to conduct their business in a public place, there appears little thought for the

[15] Clear (polycarbonate) plastic roofing is often use to cover outside areas and in skylights to allow natural light in but protect from rain. Many of these products are now tinted and offer UV protection. This type of roofing has the advantage of being lightweight and flexible making it easy to install on a light frame. However, being plastic, it can be very noisy from rain strike and also in heavy wind where it rattles. During heavy rain the clear roofing over the playground area, we were able to confirm it was glass as it did not cause any noise issues from heavy rain. As these products are widely used in Taiwan the decision to cover this area with glass was a good choice despite the higher cost in this option.

sensitive activities like kindergartens, schools and hospitals where they have to tolerate noise and distraction intruding into their private premises from outside (sometimes several times a day).

When asked how noise affects children, one teacher said when children become excited, the noise levels rise and were unable to get children to concentrate. One teacher felt that noise did affect the children's hearing. In response to how noise affects them as teachers some teachers found it to be a nuisance, irritating and creating negative mood as well as affecting their hearing.

The teachers who completed the survey had not worked or had contact with special needs children.

This appears to be very different to NZ, Australia and other similar jurisdictions where the vast majority of early childhood teachers have experience of teaching and supporting special needs children in their classrooms due to the policy of inclusive education. This is practiced in many countries where those with special education needs are included with additional support in regular education rather than being educated in separate special schools. Inclusion is most prevalent in early education.

Centre 2

Introduction

The kindergarten is well appointed in a single 4 storied building with a small exterior playground. The rooms face the main road so noise from passing traffic can intrude on the operation and delivery of education.

Three learning spaces were evaluated on each of floors 2, 3 and 4. This included:

- Room description and acoustical quality
- Fixed sound level measurements (Sound level meter placed in the room)
- Questionnaire Survey: Teaching staff were invited to complete a short confidential questionnaire
- Personal sound exposure of selected children and teachers wearing noise doseBadges. The children wore the doseBadges as they went about their learning activities. The badges were removed for sleeping as and left on a table but continued to record for the duration of the sleep time. They were refitted to the same children once they were awake and ready to commence their activities.

Physical survey

The three rooms assessed on each floor were small rooms with a volume of 100 - 150 m^3. The floors were tiled wall and ceilings were smooth plastered. There was no form of acoustics treatment. This together with the small room size could lead to a significant level of reverberation.

Results were taken in triplicate and averaged. For each of the rooms on floors 2, 3 and 4, the following T_{mf} times were 0.8 seconds for each room. The level of reverberation is confirmed by the T_{mf} times which were well above the optimum for best practice of T_{mf} 0.3 - 0.5s and in excess of the maximum time of 0.6s.

Teaching staff extensively used portable PA systems which they carried on their person. This alone suggested that there could be difficulties with the acoustic environment as staff striving to overcome the acoustical conditions.

Fixed sound level measurements

These were carried out with a 'Solo 0.1 dB Sound Level Meter ™' in 2 of the 3 rooms.

- Room - Floor 3
  Time-average level L_{Aeq} = 81 dB for the full session on 19 August 2019. A time history is given in Figure 2a

Time-average level L_{Aeq} = 78 dB for the full session on 19 August 2019
Time-average level L_{Aeq} = 73 dB for the full session on 21 August 2019

Figure 2a: Centre 2 – Time-history-Fixed sound level measurement - Room Floor 3

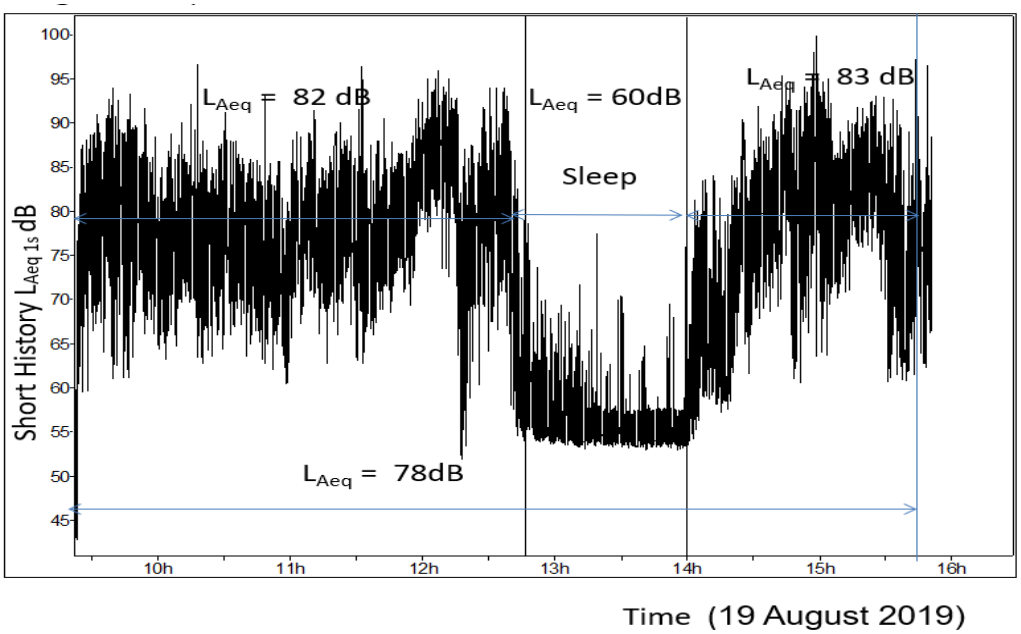
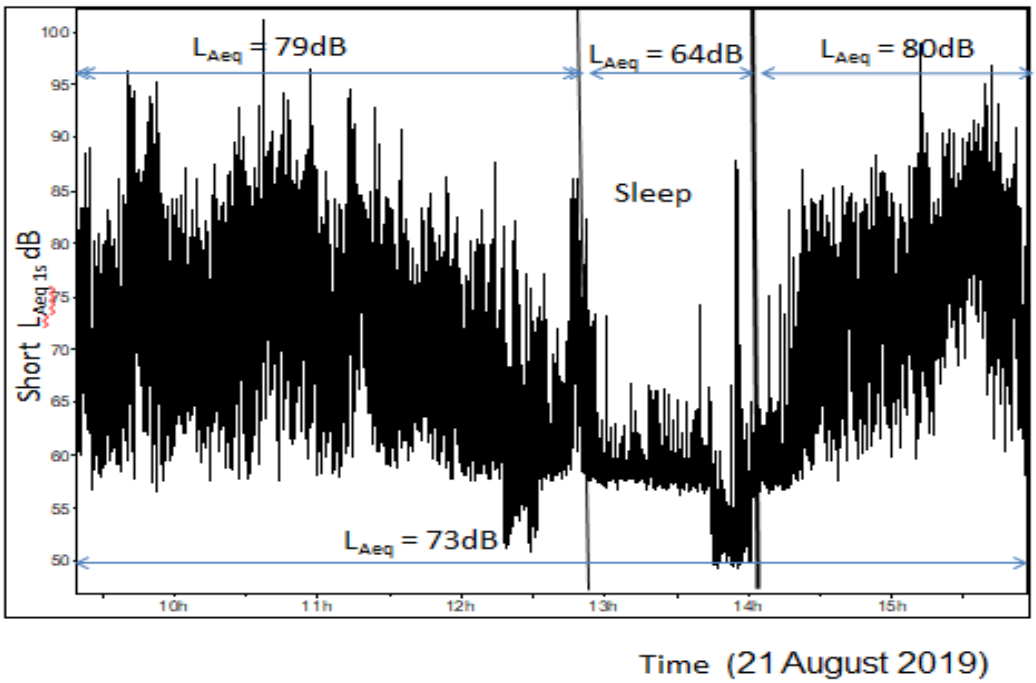


Figure 2b: Centre 2 – Time-history-Fixed sound level measurement - Room Floor 2



These results give a general indication of the noise levels in the room. Figure 2a was higher (L_{Aeq} = 78 dB) for the full day was high when compared to readings in other centres.

Table 6: Centre 2 DoseBadge results for teacher

Number	Date	Time (hours : mins)	Dose %	$L_{Aeq\,t}$ dB	L_{Cpeak}
1	16 August	6: 12	106	86	142
2	19 August	6:26	156	88	132
3	21 August	6:26	144	88	136

Figure 2c: Centre 2 - Time history - doseBadge - teacher

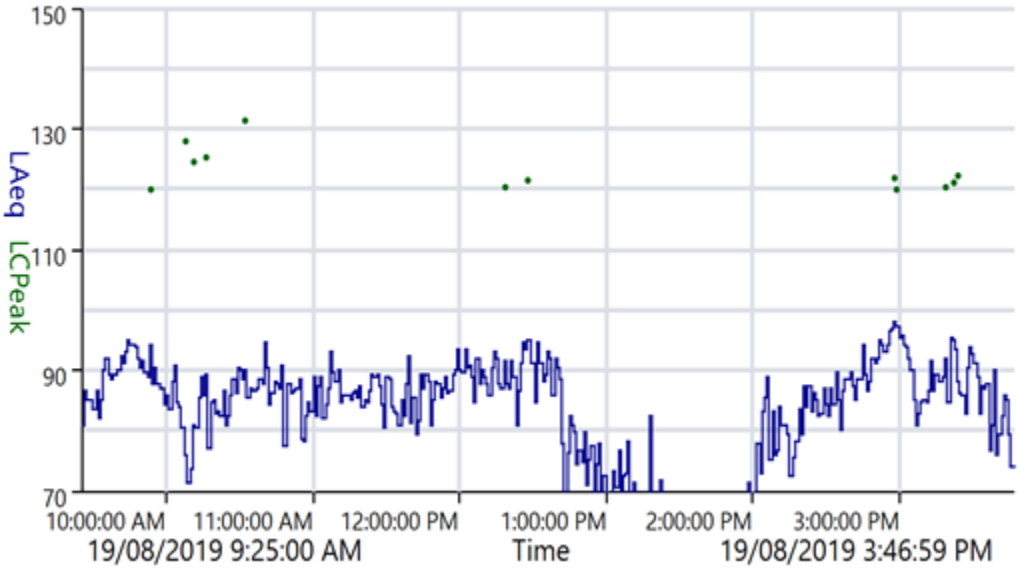


Figure 2d: Centre 2 - Time history - doseBadge – teacher 1

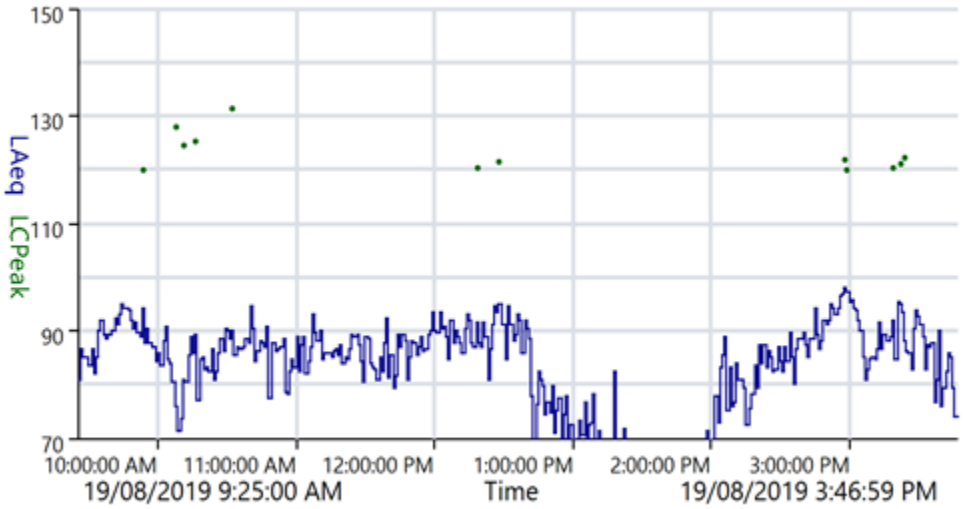
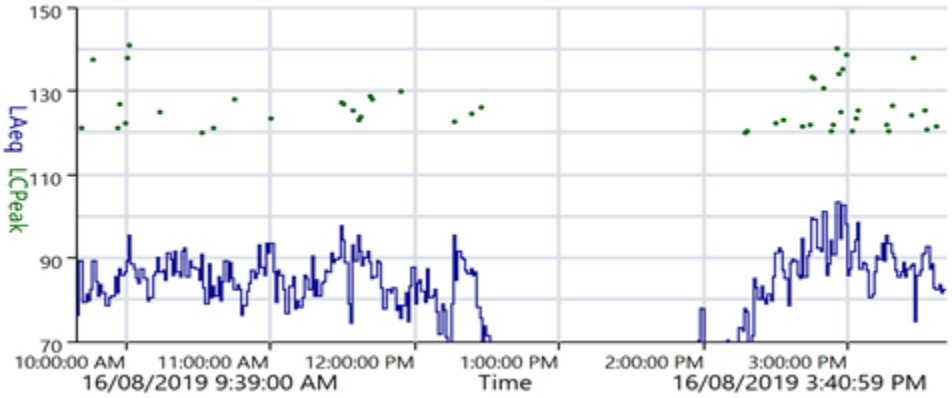


Figure 2e: Centre 2 Time history doseBadge - teacher 2



Noise exposures (doseBadge) results for children

Table 7 DoseBadge results for Children

Number	Date	Time (hours : mins)	Dose % (lowest – highest)	$L_{Aeq\ t}$ dB	L_{Cpeak}
1	21 August	5:50	12	77	124
2	21 August	6:0	20	79	136
3	21 August	6:15	33	81	130
4	21 August	6:25	49	83	142
5	19 August	6:14	60^{+}	84	124

6	21 August	6:16	60	84	137
7	21 August	6:17	70	85	140
8	16 August	6:05	71	85	140
9	19 August	6:14	82	86	139
10	16 August	6:08	89	86	137
11	21 August	6:20	94	86	129
12	19 August	6:15	94	86	128
13	19 August	6:16	96	86	138
14	19 August	6:14	96	86	141
15	16 August	6:08	108*	87	140
16	16 August	6:08	**122**	87	140
17	16 August	6:02	**130**	88	137
18	21 August	6:26	**144**	88	136
19	19 August	6:17	**188**	89	143
20	19 August	6:12	**198**	89	140
21	16 August	6:02	**164**	88	141
22	16 August	6:07	**268**	90	138

Amber coloured text+ - exposure levels 50- 99% (Amber alert)

Red coloured text* - exposure levels over 100% (Red alert).

Summary of findings

The physical survey found hard reflective surfaces in relatively small rooms between 100 – 150m^3. These mid frequency reverberation times (T_{mf}) of 0.8s for each room were considerably higher than recommended by the standards for optimum conditions of 0.4 to 05s and a maximum of 0.6s. These times indicate a reverberant environment.

Teaching staff extensively used portable PA systems. This suggested that the acoustic conditions in the rooms were difficult with teaching staff amplifying their voice to rise above the din.

The fixed meter time-average levels in the room measured L_{Aeq} 78 dB and 86 dB. These were higher values than recorded in other facilities.

The doseBadge reading for the three teachers exceeded the international workplace criteria of L_{Aeq8h} of 85dB (100% dose). They did not exceed the requirements of Taiwan for occupational noise exposure ($L_{Aeq\ 8h}$ = 90dB which equates to 320% dose when compared to the international criteria).

1 $L_{Aeq\ 6.25h}$ = 86 dB (106% dose)
2 $L_{Aeq\ 6.25h}$ = 88 dB (156% dose)
3 $L_{Aeq\ 6.5h}$ = 86 dB (144% dose)

With the use of portable PA systems, the teacher's voice is amplified. This will contribute to the overall noise dose received by the teacher. This is in part the likely reason for these elevated noise exposure levels.

Personal Exposure (doseBadge results of children)

Twenty children were tested over the three days and based on % dose the following were obtained

- Eight children received personal sound exposure of 12 – 71% dose. These results are satisfactory as well below 100% dose (International workplace criteria)
- Six children received personal sound exposures between 82 – 96% dose. Although still below the industrial workplace exposure there is some cause for concern as these were received by young children (Amber alert).
- Eight children received personal sound exposures over 100%. These results are well over the workplace criteria and therefore are of significant concern for young children (Red Alert).

The situation occurring in this this learning is described by Tiesler and Oberdoster,[16] where reverberant classroom acoustics set a cyclic pattern in motion causing the noise levels to rise. This is despite the number of individuals speaking remaining the same (see Figure 5 below). An improvement in the room acoustics will often result in a substantially quieter teaching environment.

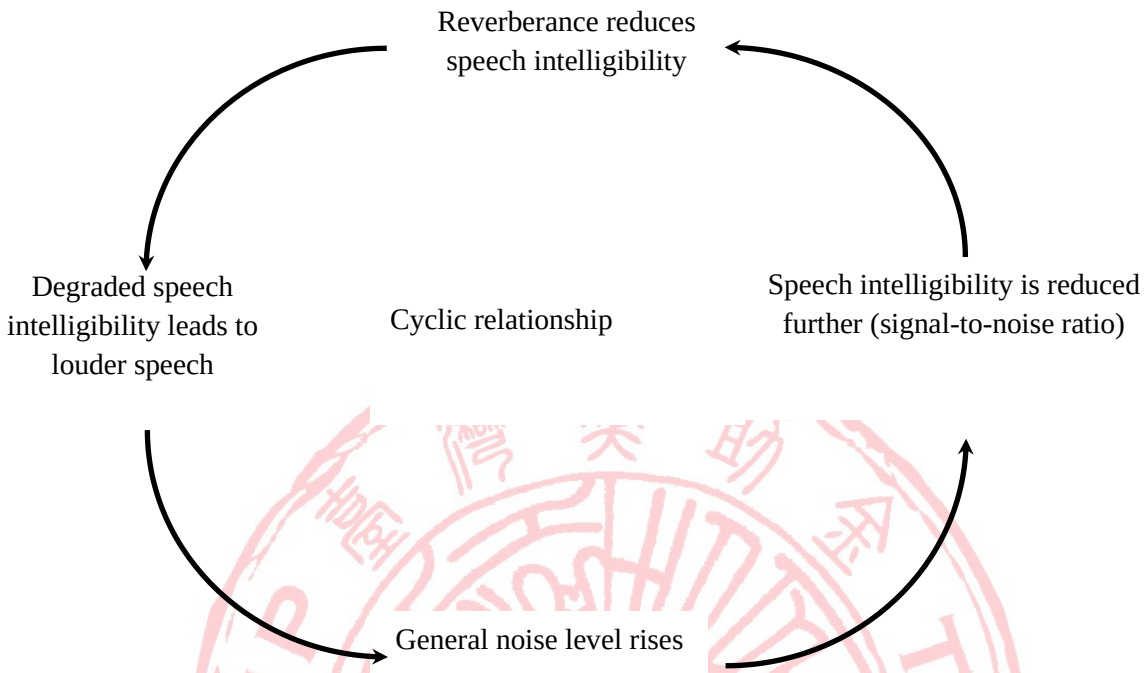
Improvement of the acoustic environment will be achieved by reducing the level of reverberation in this centre. As this is a relatively new centre, guidance on good acoustical treatment would have been invaluable to this operation in the building stage where acoustic treatment could have been installed. This this would also eliminate the need for plastering painting or otherwise decorating the wall and ceiling surfaces making it a cost-effective option.

In this case acoustic treatment, the ceiling space is desirable with an acoustic product of a high NRC rating. (NRC 0.85).[17] To further reduce reverberation, lining of the wall surfaces with a suitable acoustic material would also be effective.

[16] Tiesler, G, Oberdörster, M. (2008). Noise in Educational Institutes . Federal Institute for Occupational Safety and Health, D-44149 Dortmund, Germany. In http://www.inqa.de

[17] NRC refers to Noise Reduction Coefficient. An 0.8 NRC rating means that 80% of sound energy striking the surface will be absorbed and the remainder reflected back into the room.

Figure 2f: Cyclic pattern of reverberation times in relation to noise levels (from Tiesler and Oberdörster)[16]



Teacher Questionnaires

Questionnaires for teachers were distributed and seven teachers responded in this voluntary survey. Teachers were asked rate in order the following teaching aspects:

- Lighting
- Ventilation
- Acoustics (listening environment)
- Equipment
- Adequate space.

Each was given a score of '5' for the most important to '1'for the least important. The results for all 7 teachers were collated with the following results.

Order of Priority (importance)	Aspect	Score
1	Activity Space	28
2	Ventilation	24
3	Lightning	18
4	Equipment	13
5	Listening environment*	7

*Misinterpreted in translated version to hi fi - music. However later in the questionnaire, the listening environment, echo was identified by 2 teachers.

When asked to indicate how they experienced the teaching environment, all but one teacher rated it well describing it as *comfortable, clear, acceptable volume,* and that they were *accustomed to it*. One teacher commented on the degree of echo and three others commented on the levels of noise made by other children outside their classroom. When asked to rate their teaching spaces all rated their teaching spaces highly (*good* or *just right).*

Weather, wind and similar conditions were not identified as major contributors of noise. Teachers identified other sources of noise as echo, intrusion from other classroom the corridor, people talking perhaps such as parents leaving or collecting children.

The respondents indicated that they had issues with the noise generated in the rooms. These included children playing with toys having to go to the washrooms which are down a flight of stairs, children who cannot contain their emotions and high-pitched screaming. One respondent explained that at these times when they have to divert attention to a child in an agitated stated takes them away from task and working with the other children. This can lead to frustration on the part of other children.

The respondents indicated that some or most of the noise in their classrooms was caused by children and the amount of time during the day when noise was considered to be excessive ranged from 25% - 60% of their working day. Respondents indicated that events such as morning sessions (before lunch), physical exercise, free play/playing with toys, at the end of the school day just before dismissal, were times of excessive noise.

Noise from door opening and shutting food pounding and movement, bad weather (thunder and lightning) moving equipment and hi fi were all identified as noises generated outside the room but inside the facility.

As the centre is located in a multi-storeyed building on a busy street front and over a flight path to the local airport noise from these activities was highlighted by all the respondents. In particular road / air traffic and promotional vehicles using loudspeakers and music to advertise their presence caused considerable concern from the responses. Some teachers described the effects of these as fighting with the noise and had to stop lessons until the sound passed. Of major concern were road works which stop in one place without any warning and create persistent noise for a long period. Likewise, promotional vehicles stop in one place often with excessively loud music and advertising through a loudspeaker were a major source of irritation and a noise nuisance. Lawn mowing / tree trimming, loud music and dogs were identified by a couple of the responses.

When asked how noise affects children, one teacher said when the noise levels rise, they were unable to get children to concentrate. It also affects their train of thought when teaching. Children lose concentration and it raises their level of excitement (hypes them up) into a playful mood. It also distracts the children and their attention will turn away from the task at hand and towards direct attention to the noise asking questions about it etc.). Two respondents found the noise level to be tolerable. In response to how noise affects them as teachers, some found it to be a nuisance, irritating and creating negative irritable disposition as well as affecting their hearing.

Two of the respondents had described experience with special needs children. These children had emotional issues, developmental delay and hearing loss. The children with developmental delay and hearing loss showed no noticeable reaction. The other respondent indicated noise was an issue and in the presence of noise increased the anxiety of the child and caused them to withdraw, retreat to a concern and not join in activities.

When asked about strategies that are used all identified quiet times and rest times. When asked about what further work and investigation is required the following responses were obtained

- A study on how to improve the concentration of children and to stay on task.
- Lay carpet or a softer floor covering to reduce noise and double glazing to prevent noise intrusion from outside. The respondent commented that this would be of considerable eposes and beyond the financial capacity of many facilities.
- An education program for children and their parents. For children this could include instruction and guidance on how loudly they should speak and also managing and being aware of the noise they make. It can also include the harmful effects on children and the implications for their learning and living. If material was produced by the education authority, it could be introduced as part of the education program and disseminated through the childcare facilities to parents. A final comment was for the authorities to provide hearing tests for children to detect hearing levels and loss.

Centre 3

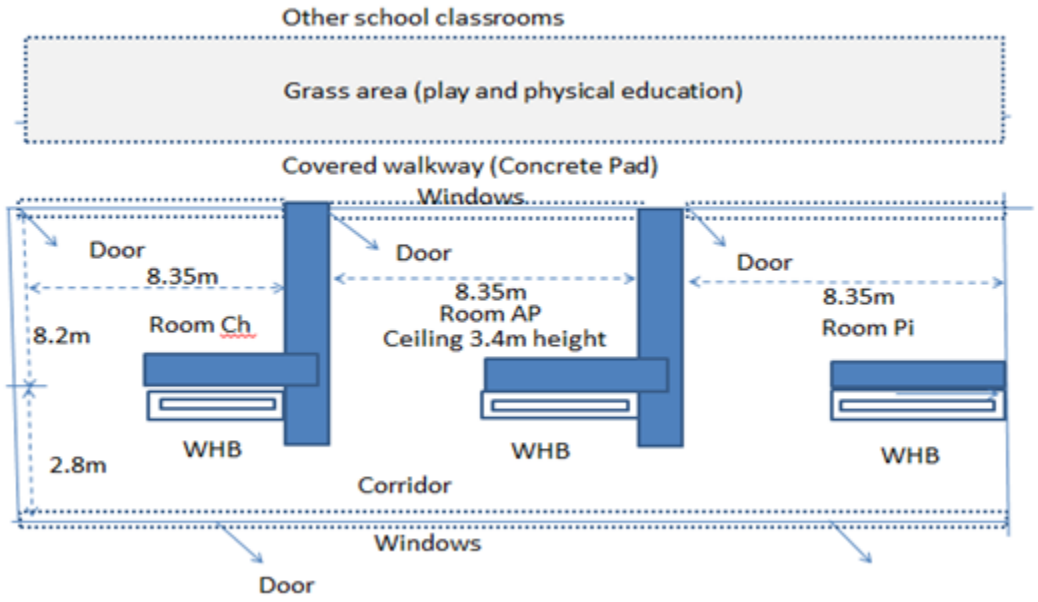
Introduction

The preschool is a part of a typical elementary school located on the same campus as the school. All the classrooms surround a grassed are where children can play and participate in outdoor physical education. The three preschool rooms are connected by an open corridor with no physical barrier to each classroom. This can be described as a form of open plan classroom which have been widely promoted in many jurisdictions. Taiwan appears to have no formal directive or national policy as to open plan learning environments, so this facility will provide valuable insight as to whether Taiwan should embrace this form of learning in the future. A schematic diagram of the three preschool classrooms is given in Figure 6. This appears to be built to the Ministry of Education building requirements of the time (as quoted by Chiang and Lai) for an elementary regular classroom minimum size of 7.5m x 9m = 67.5m^2 as a minimum measure with a minimum 2.5m width corridor.

Few studies of this nature have been reported in Taiwan preschools. However, a study by Chiang and Lai on the acoustical environment in open plan classrooms (referred to as joint classrooms) was reported in 2008.[18] Due to the age of the study, acoustical standards used at that time have undergone major revision with reverberation times being linked to room volume. Furthermore the mid-frequency reverberation times (referred to as reverberation times averaged across the critical frequency bands of 500, 1,000, and 2,000 Hz by McLaren[1]) are now widely used being in the region of speech production. Furthermore, the standardisation of nomenclature has been established in many standards with requirements that the metric has to be stipulated or explicit with all dB values. In the Chiang and Lai study stand-alone dB readings were quoted (e.g. exceeded 60 dB A-weighting), which we have assumed to be time-average levels over a stipulated period of time. This is an A-frequency weighted time-average level exceeding 60 dB, ($L_{Aeq\,t}$ > 60 dB).

[18] Chiang Che-Ming, Lai, Chi-Ming, 2008. Acoustical environmental evaluation of joint classrooms for elementary schools in Taiwan. Building and Environment, 43, pp 1619-1632.

Figure 3a: Centre 3- Preschool classroom layout and design



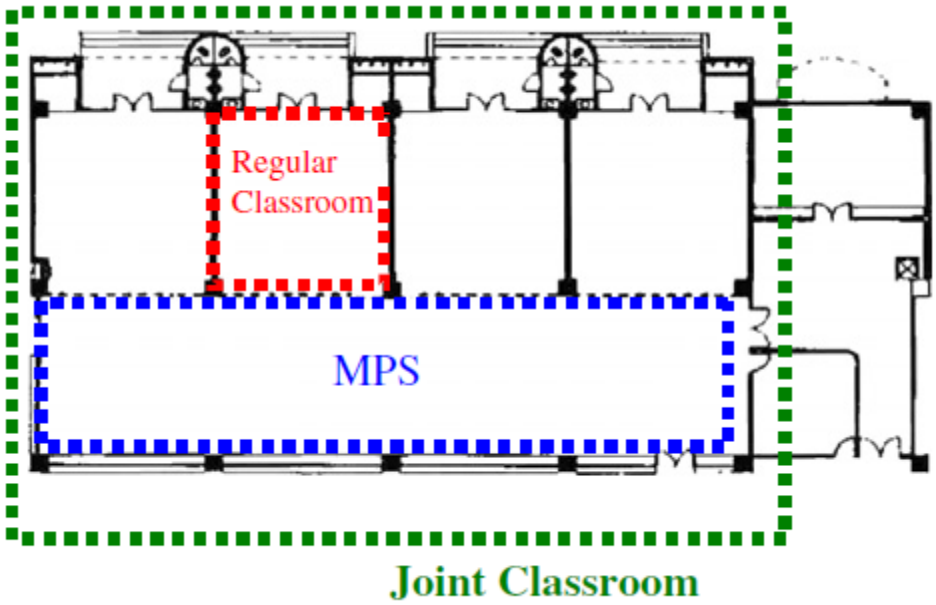
From Figure 6a, we can see the layout is strikingly similar to Figure 6b of the Chiang and Lai study (as shown below) with four classrooms opening out onto a multi-purpose space (MPS). In this work the corridor was too narrow to be practically used as a multipurpose space and only provides access for the delivery of food and to the washrooms. However, the same issues regarding noise intrusion from other classrooms are very likely in this work. It appears from information given in the Chiang and Lai study that acoustic partitions were not used. The use of moveable shields and cabinets was suggested. These are unlikely to have any significant noise mitigation properties at all. In this work, the construction of Centre 4 classrooms was never intended to be an open classroom as the classrooms on the two walls are separated by full height partitions. It is only on the internal walls leading to the corridor where full height partitions are not provided. This allows the free transmission of sound into each classroom from the others. In an informal statement with management it appeared that the design was intended to create an atmosphere of harmony and integration in the preschool but that the issues of noise was not considered in the initial stage.

The findings of the Chiang and Lai study largely mirrored the level of high dissatisfaction with the classroom set up as reported in this study. Furthermore, many of the health issues reported were similar to this work even though this work was conducted in preschool learning environments rather than that of elementary schools. Health issues included; annoyance, distraction, impaired concentration and voice strain (hoarseness) of teachers. These authors emphasise that children are not fully developed in language and so are more sensitive to noise interference. This is likely to be a greater issue with very young preschool children who are at an early stage of development. They quote an early study by Mills[19] that children are more sensitive to noise than adults due to lack of preparedness to environmental pressure. The study by Picard and Bradley[14] claim that noise levels which will not affect the adult population can cause acute cochlea damage in young children. These 2 studies alone emphasis the risk to young children of noise related issues.

[19] Mills, J. (1975). Noise and children, a review of literature. Journal of the Acoustical of America, 58,(4), pp 767-791.

The reverberation times RT60 reported in the Chiang and Lai study were very high ranging from 1.0 – 1 .3 seconds. Mid-frequency reverberation times were not reported due to the age of the study and acoustical standards in force at the time. However, the standard quoted of RT60 of 0.4 - 0.6s was used in many jurisdictions including Australian and New Zealand Standard (AS/NZS 2107:2000) for regular size classrooms.[20]

Figure 3b: The layout of a join classroom as provided by Chiang and Lai. [18]



Room Descriptions

As shown in Figure 3a (above), each room is open to the corridor with no full partition between the room and corridor. This means that sound from every classroom will be readily transmitted via the corridor to the other rooms and vice versa. Furthermore, activities in each classroom can be seen and heard from those in the corridor. The three rooms were of the same construction and size as follows

- Floor wood panel
- Wall hard concrete plaster
- Ceiling height 3.4 m
- Dimensions 8.2m x 8.35m ~ 68m^2 (wall to half wall).
- Opens into corridor a further 2.8 m to rear corridor wall
- Volume 8.2 x 8.35 x 3.4 = 233m^3

[20] Australian / New Zealand Standard, AS/NZS 2100. Acoustics – Recommended design sound levels and reverberation times for Building Acoustics. Standards New Zealand, Standards Australia. (Former joint standard for both countries).

Room and corridor acoustics

A T_{mf} of 0.8s was measured for the end rooms (Ch and Pi) whereas the T_{mf} of the central room (Ap) was 0.9s. The corridor gave a T_{mf} of 0.6s. Because the classrooms all open to a common corridor, room volume was difficult to determine.

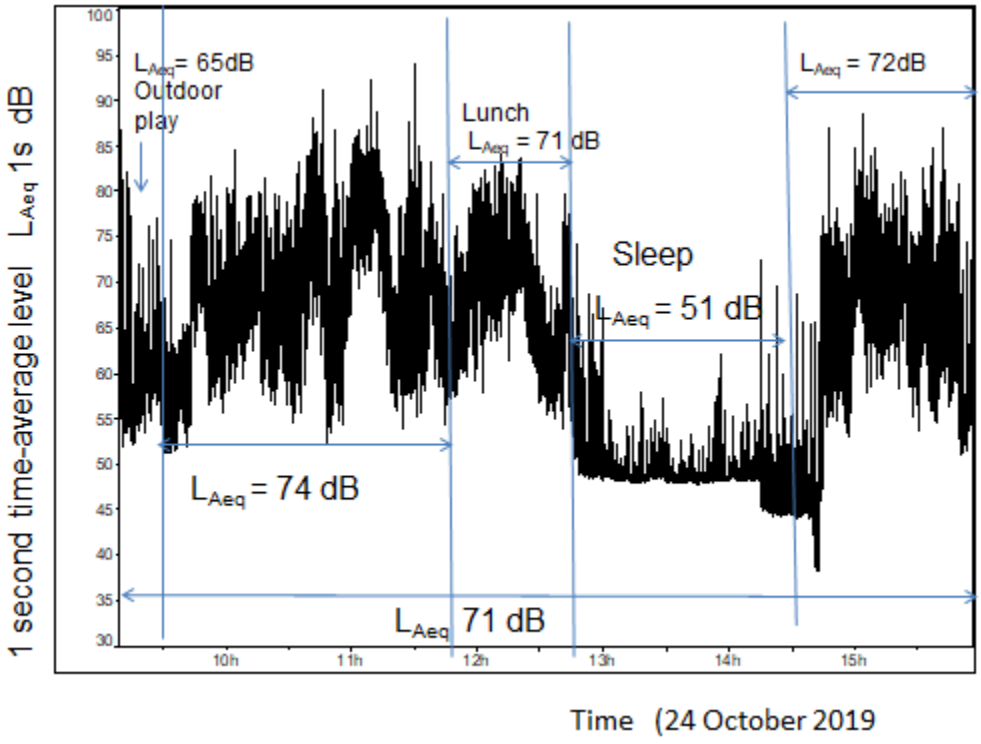
Fixed sound level measurements

These were carried out with a *Solo 0.1 dB Sound Level Meter* ^{TM} in the three rooms.

Room 3 (Pi)

Time-average level L_{Aeq} = 71 dB for the full session on 24 October 2019. A time-history is given in Figure 7a.

Figure 3c: Centre 3- Time history - Fixed sound level measurement-Room 3.



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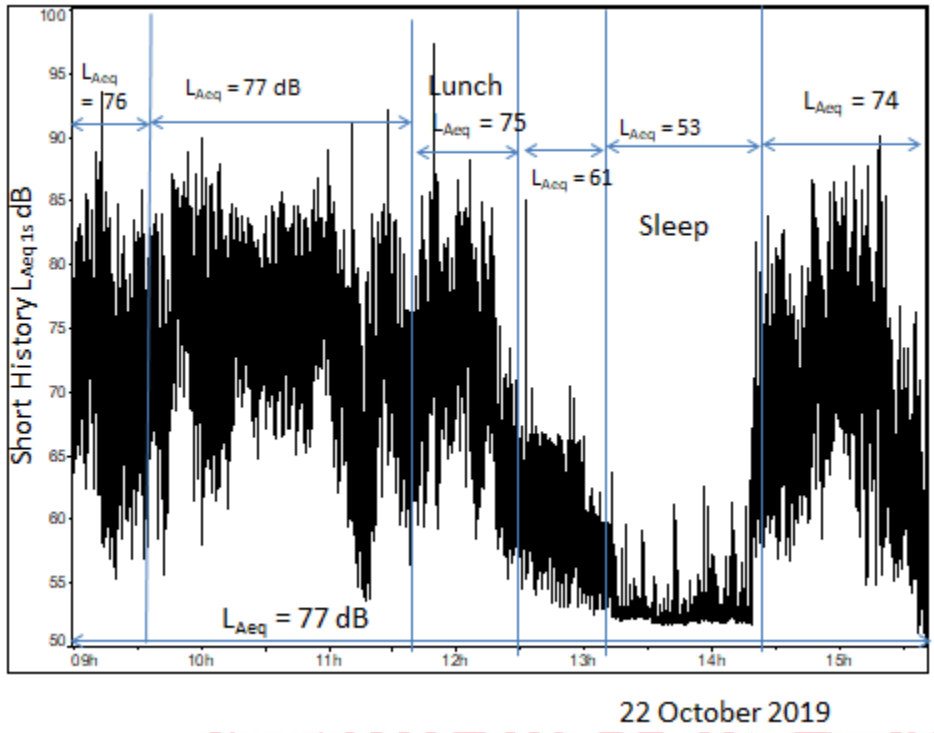
Room 2 (Ap) (23 October 2019))

Time-average level L_{Aeq} = 74 dB for the full session

Room 1 (Ch) (22 October 2019))

Time-average level L_{Aeq} = 74 dB for the full session

Figure 3d: Centre 3 Time history - Fixed sound level measurement-Room 1

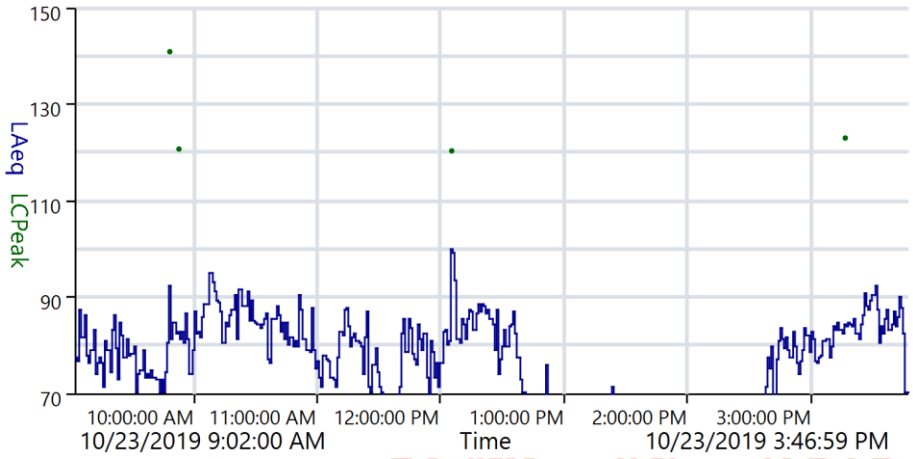


In addition, a fan was very noisy due to worn bearings. A 10-minute measurement was taken after the class had finished and the room vacated with a $L_{Aeq\ 10\ mins}$ of 67 dB. This suggests that as the dominant sound in the room at that time, this may cause annoyance and certainly be noticed. We were unable to turn the fan off to measure the remaining background sound level.

Table 8: Centre 3 - DoseBadge result for teacher

Number	Date	Time (hours: mins)	Dose %	$L_{Aeq\ t}$ dB	L_{Cpeak}
1	24 October	7:03	23	79	141
2	22 October	6:18	65	84	140
3	23 October	6:45	60	84	141
4	23 October	6.44	62	84	141

Figure 3d: Centre 3: Time history - doseBadge - teacher



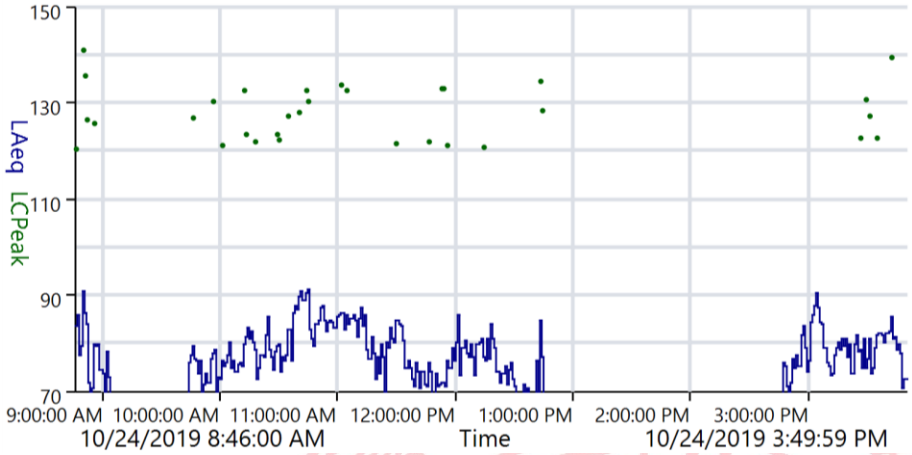
Noise exposures (doseBadge) results for children

Table 9: Centre 3- doseBadge results for children

Number	Date	Time (hours: mins)	Dose % (lowest – highest)	$L_{Aeq\,t}$ dB	L_{Cpeak} dB
1	23 October	6:28	3	70	143
2	23 October	6:25	4	72	112
3	23 October	6:26	5	73	129
4	22 October	6:16	14	78	132
5	22 October	6:15	19	79	131
6	22 October	6:18	20	79	141
7	22 October	6:09	23	80	139
8	24 October	7:04	27	80	132
9	22 October	6:18	27	83	140
10	23 October	6:47	50	83	142
11	23 October	6:45	51^{+}	83	142
12	24 October	7:04	53	83	142
13	24 October	7:06	53	83	142
14	23 October	6:45	60	84	141
15	23 October	6:46	61	84	143
16	23 October	6:44	62	84	141
17	24 October	7:06	68	84	140
18	24 October	7:02	88	85	142
19	24 October	7:06	166*	88	143
20	24 October	7:04	330	91	142
21	22 October	6:11	432	93	140

Amber coloured text+ - exposure levels 50- 99% (Amber alert)
Red coloured text* - exposure levels over 100% (Red alert).

Figure 3e: Centre 3-Time history – doseBadge - child



Teacher questionnaires

Questionnaires for teachers were distributed and six teachers responded in this voluntary survey. Not all questions were answered. Teachers were asked rate in order the following teaching aspects:

- Lighting
- Ventilation
- Acoustics (listening environment)
- Equipment
- Adequate space.

Each was given a score of '5' for the most important to '1'for the least important. The results for all 5 teachers were collated with the following results

Order of Priority (importance)	Aspect	Score
1	Lightning	28
2	Space	24
3	Ventilation	18
4	Equipment	13
5	Listening environment*	7

*Misinterpreted in translated version to hi fi - music. However later in the questionnaire the listening environment, echo was identified by teachers.

When asked to indicate how they experienced the teaching environment, all rated their listening environment as confusing harsh and unclear. Two respondents listed echo as an issue.

When asked to rate their teaching spaces three rated their teaching spaces as good and two rated their teaching space as poor. One of these commented on the open plan classrooms as being noisy and too much echo.

Two teachers responded that they didn't have an issue with noise created in their rooms but the other three did describing it as irritating and a distraction to the children. All the respondents described as some or most of the noise generated in the room was due to the children.

The amount of time when noise levels were found to be excessive ranged from 40% –75%. These were school starting and finishing times, free play and meal times.

Other sources of noise were identified as doors closing foot pounding moving equipment and the building design was a major causative factor being of open plan design. One respondent pointed out that it was not only the noise but the visual and other distractions of children walking past in the corridor to which all classrooms open into. Echo was again identified as were noise generated by the elementary school students during their recess times and also when they arrive at school or finish for the day. The recess and break times are different for the elementary school children and the preschool. The preschool centre is located in an elementary school campus with little separation between the two. On respondent identified the switch board room as a source of noise and appeared quite concerned from comments made saying circuits in the room could be quite loud and even frightening for some children. The switch board room was in a separate building and a question was raised if this was the actual source of the noise. A further inspection was made to the school with a visiting acoustic engineer from New Zealand. On inspection of the mounting of a number of large air conditioning units on the building façade, the fixing of these units contained no acoustic isolation mounts to prevent any sound or vibration from these units being transmitted into the building structure. It is possible that the source of noise was from these units switching on simultaneously and the sound being transmitted through the building structure rather than from a room completely separated from the main building. This will require further investigation.

Unlike other centres sounds such as road works or recreational vehicles were not identified by the majority of respondents. This is likely due to the location of the classrooms which were set well away from the road. Due to the nature of the surrounding environment, it was not likely to attract promotional vehicles.

When asked how noise affects children, the respondents described how it affected the children concentration and disrupted classroom activities. Two teachers stated that if the noise is created inside their own room, they can manage that but it was a considerably more difficult to manage the children if the noise was intruding into their classroom space from elsewhere. All respondents felt that noise affected both the children and teachers in some way. In response to how noise affects them as teachers, some teachers found it to be a nuisance, irritating and creating a negative mood. Other comments made were feeling inexplicable tension and pressure, causing them to become forgetful and a distraction from their teaching. The respondents also identified hearing damage and voice strain.

In responding to low cost and effective strategies they used quiet times, the ban on activities which generate excessive noise and compulsory sleep and rest times.

Two of the teachers who completed the survey had worked with special needs children. One respondent on teaching children with autism, found that they were not easily settled in the presence of noise and would become agitated and in some cases, scream. If necessary, it may be necessary to take the child out of class or change the activity. The other respondent had worked with children experiencing ADHD.

One respondent strongly indicated his/her dislike of the open plan concept describing it as very noisy and did not see any benefit for teaching from the present set up. This view was also reiterated by other respondents stating that they wanted classrooms enclosed to minimise noise transmission between classrooms. In addition, noise and disruption from the elementary school children were raised especially during their recess which was at different times to the preschool. This was often found to very disruptive to the younger children and their learning. They wanted the elementary children to be kept away from the kindergarten classes if they were playing. A suggestion was made that that a strategy be implemented or barrier erected to keep the elementary school children at a distance from disrupting the activities or sleep times of the preschool classes. Although not part of the survey two teachers indicated that the rooms need to be darkened to assist children to have a restful sleep.

Open plan learning environment

The open plan classroom concept while being widely promoted in many jurisdictions is also a very controversial development in education. Referred to by a variety of descriptions such as flexible leaning spaces, joint classrooms and modern or innovative learning environments, all these environments are essentially open plan learning styles. Described by some authors as a new fad,[21] it appears that the open plan concept has been implemented with little regard for any negative consequences. These are principally noise and visual distraction of having large number of children in one large open teaching room with multiple activities happening at the same time.

Mealings[21] described the emergence of these environments because they are perceived to be less authoritarian, enhanced group work and social development. Furthermore, it is seen to benefit children by sharing skills ideas, team teaching in a cooperative and supportive manner. In general discussion with the teaching staff on first being introduced to these classrooms, it appeared this design was conceived with similar objectives being aware of the emergence of these facilities overseas. However, they had not considered nor were informed of any consequences of open plan learning environments. The Chiang and Lai [18] study in Taiwan is one of the very few studies of this nature to be reported in literature.

As in other jurisdictions, early education (preschool) is the children's initial experience of formal learning and preparation for education in the school system. Here children learn and develop a variety of academic and social skills, engage in speaking and listening, and the fundamentals of mathematics and the complex writing system of the national language. The government of Taiwan has set a target of introducing English as an official language by the year 2020. English instruction

[21] Mealings, K. (2015). *Students struggle to hear teacher in new fad open plan classrooms*. The Conversation. (http://theconversation.com)

is already an integral part of early education with children being generally able to count simple numbers in English to a fluent level, learning and understanding simple words, phrases and the alphabet. Children's books in both English and Chinese are read to the children by the teachers. A number of schools already engage specialist teachers for English language preparation, delivery, and guidance for regular teaching staff. As Taiwan moves towards its goal of English becoming an official language, the level of English instruction from an early age is bound to substantially increase. This will prepare the young population to meet this future goal. A good foundation in early education is therefore vital in preparing the basis for competency in the language as children progress through the education system.

Taiwan therefore has large cohorts of children who are essentially English as second language learners. They will face similar issues as any child with learning a second language in noisy environments. In addition, a national debate is underway over the teaching of indigenous languages of Taiwan in formal education settings. Like New Zealand, indigenous language learning is now actively supported and promoted. Along with obtaining maximum benefit in the instruction of the national language of Taiwan, all these second language education initiatives require optimum learning environments if the substantial education investment is going to achieve the maximum benefit. The acoustical classroom listening environment has to be a critical part of this strategy.

It is therefore appropriate to compare the work in this centre to other open plan classrooms of similar size. While acoustic quality assessment (mid-frequency reverberation times) general noise levels personal sound exposure of children and their teachers, other indices such as speech transmission index (STI), signal to noise ratio (SNR) and levels of speech intelligibility could not be carried out due to language difficulties in a non-English speaking environment.

The Mandarin Chinese language is different in sound production to English and other similar languages of Europe, the Pacific region and Japanese. As a tone-based language, there are 4 tones - high (1); rising (2); low (3); falling (4) and a neutral tone. While English speakers do use similar tones, these are informally used in an expressive mode (indicating feeling, exclamation or confirmation) whereas in Chinese, tones are used as an integral part of the spoken language to primarily indicate meaning. As a number of sounds are similar and very soft, a question remains as to how speech perception will be affected in a noisy environment. Using studies in other languages such as English, may not accurately represent the situation in a Chinese speaking environment. Studies in this area are therefore warranted.

It is well understood from a number of studies that children experiencing hearing or auditory processing deficits second language speakers are more adversely affected by poor classroom acoustics. [22,23,24] During the monitoring session, a member of the research team was invited to briefly view a speech language therapy session in progress. There was some noise observed

[22] Mealings, K., Buchholz, J., Demuth, K., Dillon, H. (2014). *An investigation into the acoustics of an open plan compared to an enclosed kindergarten classroom.* Inter-noise 2014 Conference , Melbourne 16-19 November.

[23] Shield, B., Greenland, E., Dockrell, JE. (2010.*Noise in open plan classrooms in primary schools.* Noise and Health, 12 (49) pp 225-34.

[24] Nelson, P., Soli, S. (2000). *Acoustical barriers to learning: Children at risk in every classroom*. Language , Speech and Hearing Services in Schools. 31,pp 356-61.

coming from outside the therapy room. It is critical that optimum acoustic conditions are present along with minimum background noise levels for the delivery of this crucial therapy to children who need the help.

Noise levels were comparable to other centres. However, the teachers indicated in their questionnaires and in person to the research team, that their education delivery and activities must take into account, the impact any noise generated will have on the other classrooms. This is a major constraint on what activities they can carry out. For example, music and singing is likely to be disruptive to the other classes especially if they are engaged in activities requiring a high level of listening and speaking.

The respondents of the questionnaires expressed widespread dissatisfaction with their current teaching environment and a rejection of their open plan concept. No benefits or support of their current teaching rooms were expressed. Several of the teachers requested isolation of their classrooms (i.e. full height partitions and doors between the classrooms and corridor). Such was the concern raised that the research team invited a visiting acoustic engineer from New Zealand to view the classrooms while on a short conference visit to Taiwan. As a result of this visit, the school is advised that as a first step, it could acoustically isolate the middle room with a suitable full height partition and appropriate door leading to the corridor. The level of noise intrusion with the central room isolated and combined with distance between the two side rooms could significantly reduce noise intrusion to the two outer rooms. While it would be ideal to similarly isolate all rooms, the obvious expense would justify a trial of the centre room first.

In addition, an intermittent ‘start up’ electrical noise was cited as causing concern to the teaching staff as this affected the children. A later inspection revealed that this was probably coming from the incorrect mounting of a number of large air conditioning units on the side of the building. Because no acoustic buffers were included in the mounts this would mean that noise and vibration from these units could be readily transmitted through the building structure especially if multiple units switched on and operated simultaneously. This issue reinforced the need to properly include acoustic control of such units at the start for very small additional cost.

Centre 4

Centre 4 is located on an elementary school campus. However, the three adjacent rooms were completely partitioned and the rooms opened out on to a covered walkway. In addition, the classrooms were located away from the main play areas.

Room description

The three classrooms are of similar size, design and finishing.

- Room volume (of each teaching room) ≈ 225 m^3
- Floor: polished wood panel
- Walls: plastered /painted concrete.
- Ceiling: Hard plastered and painted

Room acoustics

The mid-frequency reverberation times (T_{mf}) for each room was 0.6 seconds. This is within the established criteria for a room volume of 225 m^3.

Fixed sound level measurements

These were carried out with a *Solo 0.1 dB Sound Level Meter* ™ in all three rooms.

1. Room 1
   Time-average level L_{Aeq} = 68 dB for the full session (18 September 2019)
2. Room 2
   Time-average level L_{Aeq} = 73 dB for the full session (20 September 2019)
3. Room 3
   Time-average level L_{Aeq} = 73 dB for the full session (24 September 2019)
   (Time history shown in Figure 4a).

In this preschool, the children are moved to a separate dining room away from the classrooms. For the first monitoring session (18 September) the sound level meter remained in the classroom but for the following 2 sessions (20 and 24 September) the sound level meter was taken into the dining room for the duration of the lunch sitting.

These results are very good when compared to others in this work and studies done elsewhere.

Figure 4a: Centre 4: Time history -Fixed sound level measurement-Room 1

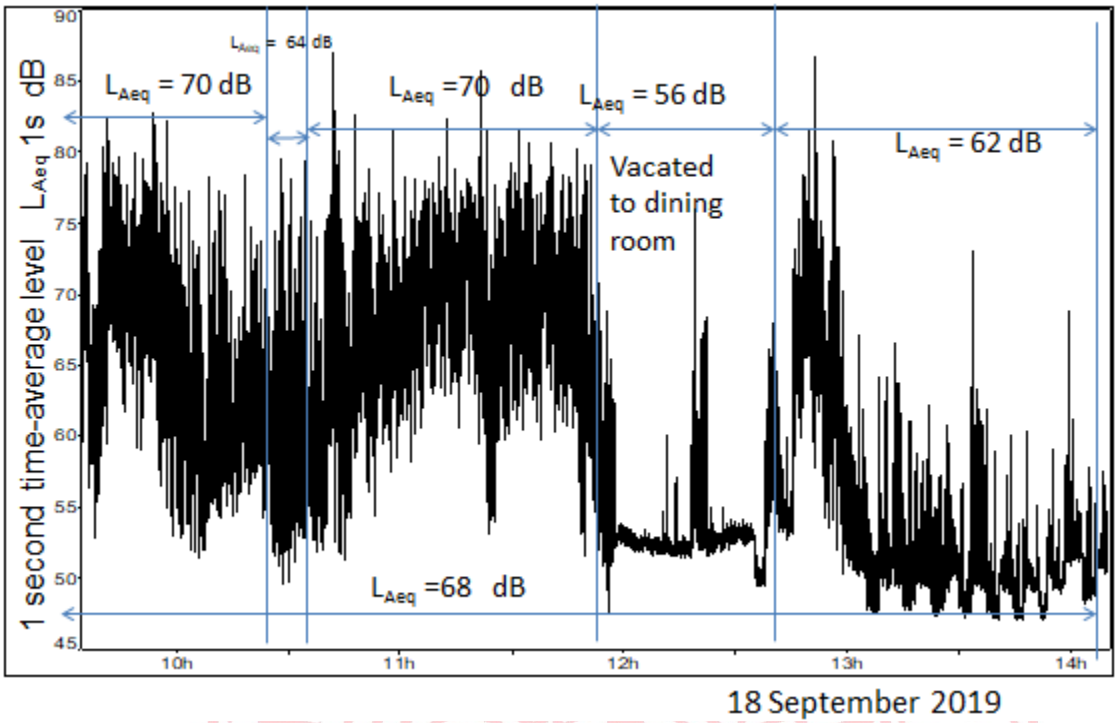


Figure 4b: Centre 4: Time history - Fixed sound level measurement- Room 2

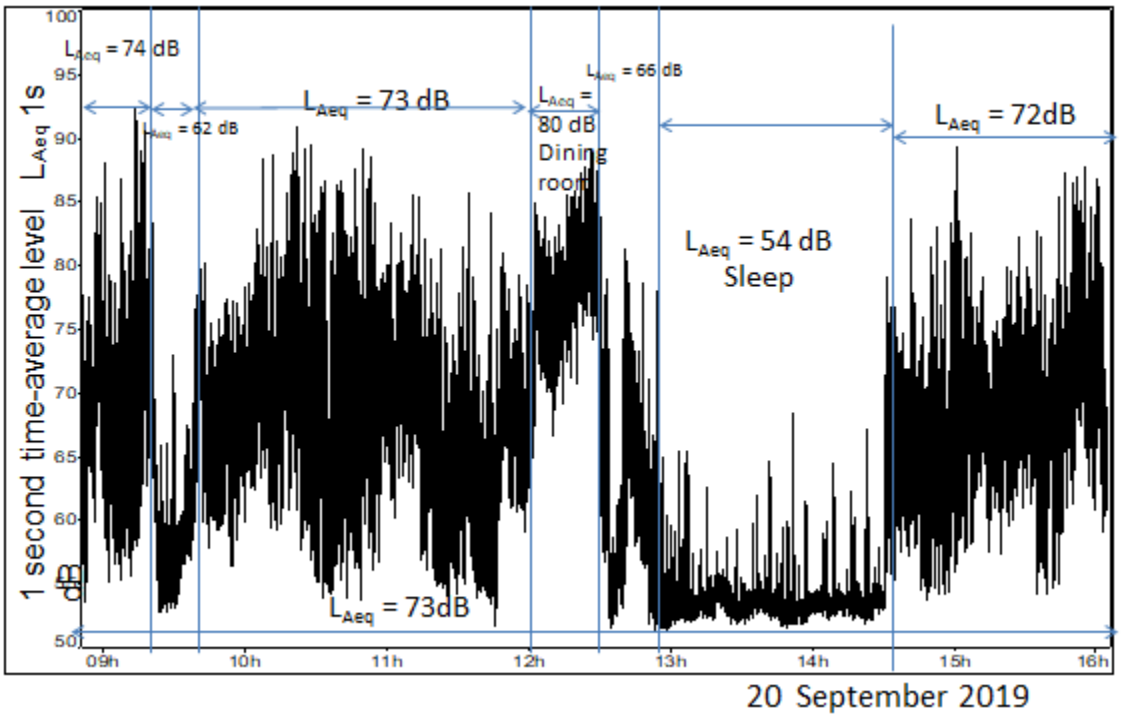
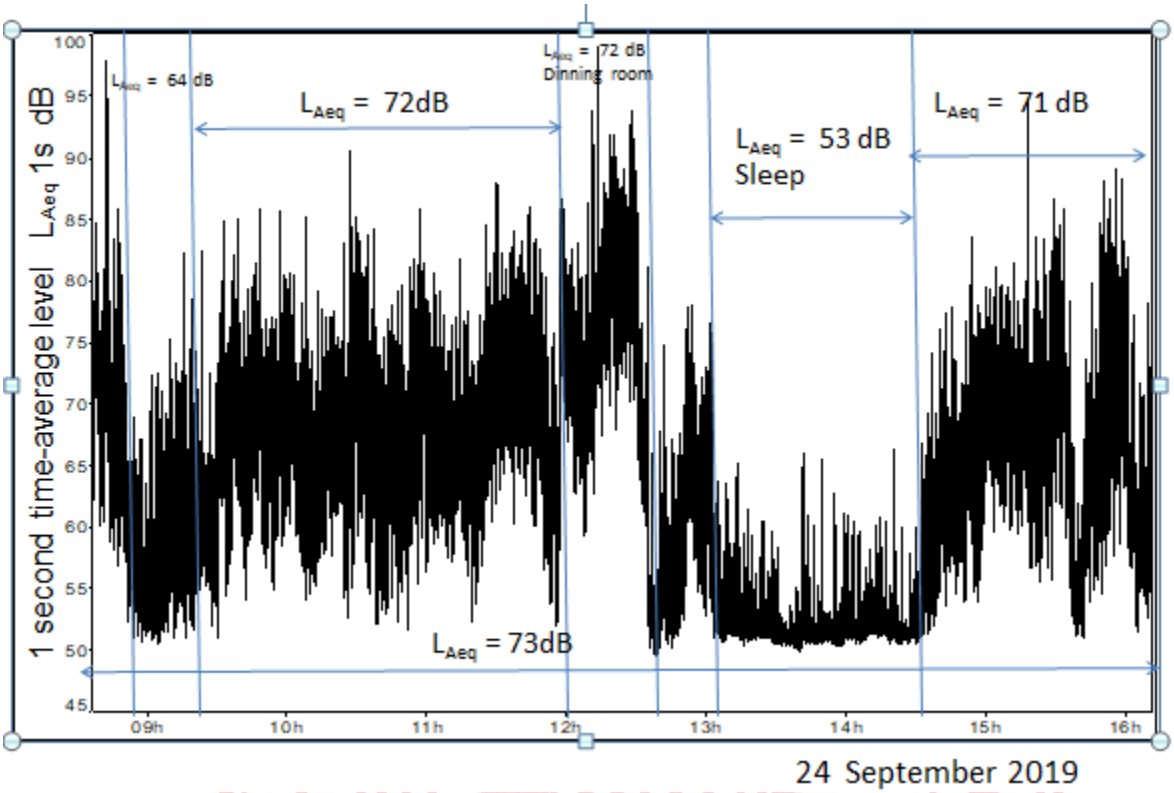


Figure 4c: Centre 4-Time history - Fixed sound level measurement - Room 3



Personal sound exposure of teachers

The teachers in 2 classrooms were monitored over the 3-day period. Due to error, the results of the third teacher were discarded.

Table 13: Centre 4 - doseBadge results for teachers

Number	Date	Time (hours : mins)	Dose %	$L_{Aeq\,t}$ dB	L_{Cpeak} dB
1	18 September *	7:25	17	78	141
2	20 September		Error		
3	24 September	7:50	125%	84	141

*See Figure 4d below

Figure 4d: Centre 4 - Time history doseBadge - teacher

Table 14: Centre 4- doseBadge results for children

Number	Date	Time (hours : mins)	Dose % (lowest – highest)	$L_{Aeq\ t}$ dB	L_{Cpeak} dB
1	18 September	7:36	14	77	131
2	18 September	7:35	24	79	143
3	20 September	7:44	33	80	131
4	18 September	7:37	34	81	144
5	20 September	7:44	44	82	142
6	20 September	7:42	60+	83	135
7	20 September	7:37	61	83	141
8	24 September	7:44	62	83	143
9	20 September	7:43	66	84	142
10	20 September	7:44	71	84	139
11	24 September	7:45	80	84	142
12	24 September	7:43	87	85	143
^13	18 September	7:37	95	85	142
14	18 September	7:27	95	85	143
15	24 September	7:44	**208***	88	143
16	24 September	7:44	246	89	144
17	24 September	7:39	**350**	91	143
18	18 September	7:38	662	93	143
#19	24 September	7:44	**2461**	99	143

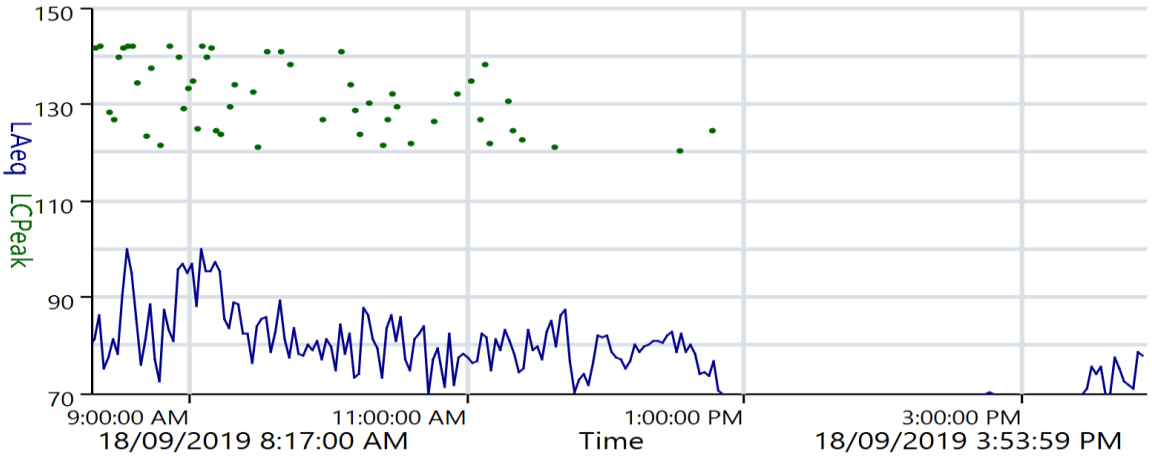
Amber coloured text+ - exposure levels 50- 99% (Amber alert)

Red coloured text* - exposure levels over 100% (Red alert).

#Discard as impossible reading

^ Time history example given in Figure 4d (below)

Figure 4e: Centre 4 - Time history – doseBadge - child^



Teacher questionnaires

A total of seven teachers answered the questionnaires for teachers. Not all questions were answered. Teachers were asked rate in order the following teaching aspects:

- Lighting
- Ventilation
- Acoustics (listening environment)
- Equipment Adequate space.
- Each was given a score of '5' for the most important to '1' for the least important. The results for all 5 teachers were collated with the following results

Order of Priority (importance)	Aspect	Score
2	Lightning	16
2	Space	16
1	Ventilation	21
4	Equipment	7
5	Listening environment*	13

*Misinterpreted in translated version to hi fi - music. However, later in the questionnaire the listening environment, echo was identified by teachers.

Two respondents rated their listening environmental in their teaching space as poor citing the noise from other children outside the classroom to be the major concern. Two other respondents described their listening environment as good (comfortable) and one as just right.

Most respondents did not have a major issue with noise generated within their classrooms. Two respondents described noise from the air conditioning fans and a fish tank pump as creating annoyance for them being continuous noise.

All the respondents indicated the some or most of the noise was generated by the children. The amount of time in the day that noise was perceived to be excessive ranged from 15% - 30% of the working day. As the preschool is a part of the elementary school, noise from the school children disturbing the class activities and sleep of the younger children was identified as a major issue. This included noise from recess times (play) and noise from both children and their parents at the end of the day. The weather was also highlighted as this affected the children's mood making them noisier.

All respondent indicated that there were issues with noise generated outside the school campus. Some electric drilling or similar equipment was highlighted but not elaborated further. As the school is under a flight path, noise from overhead aircraft was identified. As the classrooms are close to the road traffic, recreational vehicles, road works and sirens form emergency vehicles were highlighted. On respondent described road works as being so noisy as to completely mask or block out their verbal communication.

When asked to describe their feeling about noise levels in the room the respondents did not respond adversely. One stated that while noise exists, they had become accustomed to it. Others stated that it was acceptable and only an occasional problem. Nosie does cause children and staff to raise their voices and negatively affecting concentration and distraction from the task at hand.

Three of the staff outlined their experience with children having ADHD developmental and Asperger's syndrome. The children with ADHD and developmental delay cannot concentrate and is distracted from learning tasks the child wants to investigate where the noise is coming from. No other adverse effects have been noted. They have to provide a private space for the child to avoid being distracted. Noise can result in mood changes and loss of concentration and have a strategy have managed this with activities that don't result in sensory stimulation and mains tin a calm and quiet voice. They had noted improvements after exercise. The respondents had not noticed any significant effects on noise for these children when compared to their peers. It depended on the situation and that reducing environmental noise where possible benefited all children.

Al the teachers outlined quiet times and banning activities which create excessive noise. One respondent said teacher could pay more attention to arrange furniture etc. to improve the learning environment. More work is needed on strategies to teach children to be quiet, control their voices and that everyone should work to reduce noise. Finally, acoustic treatment was requested of the floor (with a soft absorbing cover suggesting foam tiles that were used in the nearby gym room and appropriate wall and ceiling surfaces.

Centre 5

A private kindergarten very well appointed and presented. It occupies the lower floor of a multi-storeyed relatively new building with a courtyard and playground with the classrooms to the side. One of the three classrooms was evaluated. However, all rooms were of similar size and construction.

The Floor was made of ceramic tiles with a ceiling height of 3.2 m and a room volume of approximately 130 m^3. The rooms had a suspended ceiling with acoustics tiles fitted. The NRC (Noise Reduction Coefficient) ratings for the ceiling tiles were not known but predicted to be at least NRC of 0.4 from observation. The kindergarten is in a busy commercial area although located in a side street away from the main road. The mid-frequency reverberation time measured at 0.6 s. For optimum quality the mid-frequency reverberation time (T_{mf}) for a room this size is 0.4- 0.5s. However, a mid-frequency reverberation time of no more than 0.6 s complies with the established standard.

Fixed sound level measurement

These were carried out with a *Solo 0.1 dB Sound Level Meter* ^{TM} in the junior room.

- Room 1: (9:03 – 16:49: hours - 25 July 2019): Time-average level L_{Aeq} = 71 dB

In this session, the children were outside the room prior to 9 am and again from 4 pm in the playground. As the playground is close the noise from this activity can be detected in the vacated room.

Figure 5a: Centre 5 - Time history - Fixed Sound Level measurement

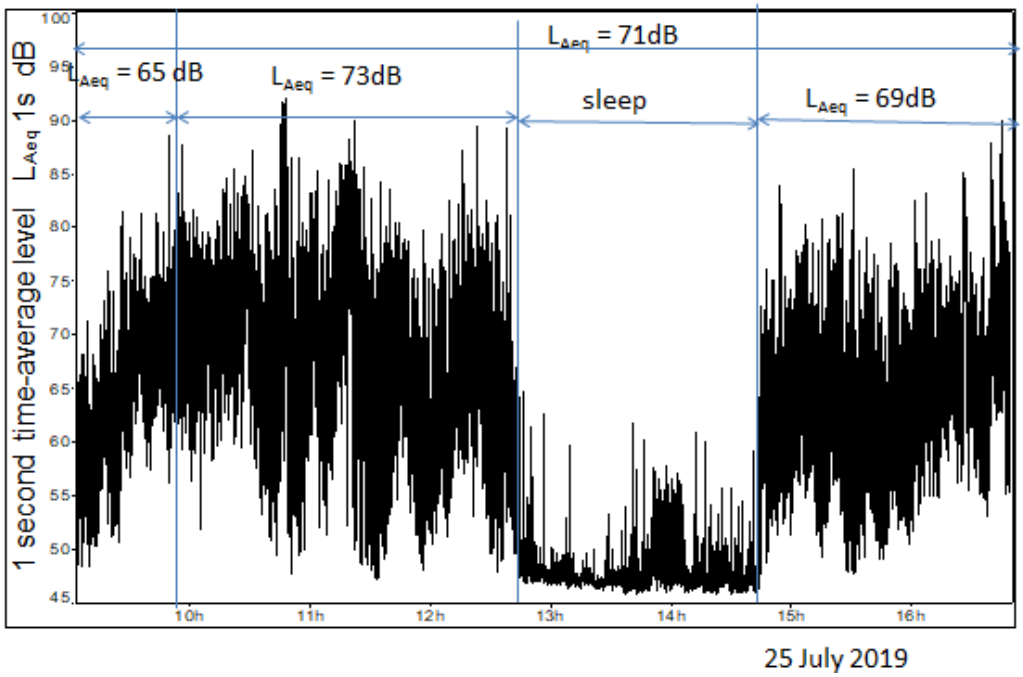


Table 15: Centre 5 - DoseBadge result for teacher

Number	Date	Time (hours : mins)	Dose %	$L_{Aeq\,t}$ dB	L_{Cpeak} dB
1	25 July	8:08	35	80	139

Result

Excellent with levels well below the International Standard Criteria of 100% dose ($L_{Aeq\,8h} < 85$ dB).

Figure 5b: Centre 5- Time history doseBadge - teacher

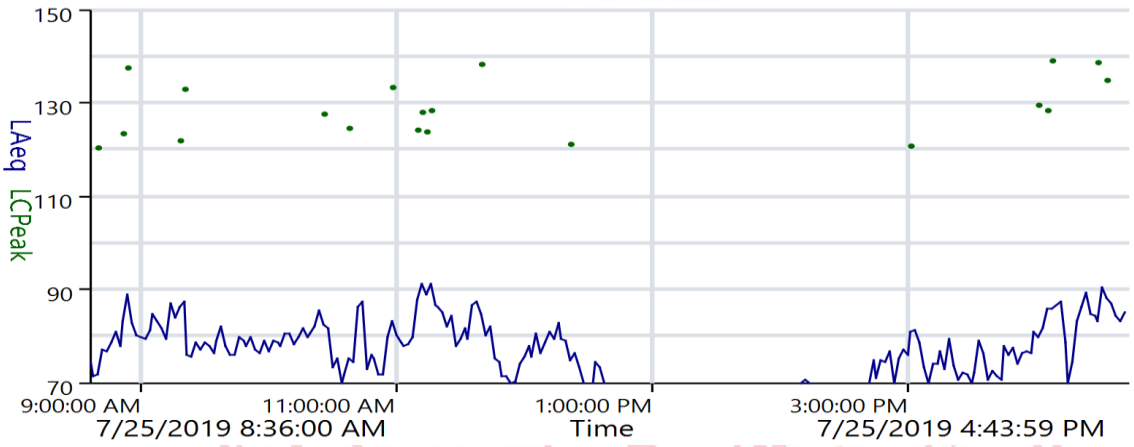


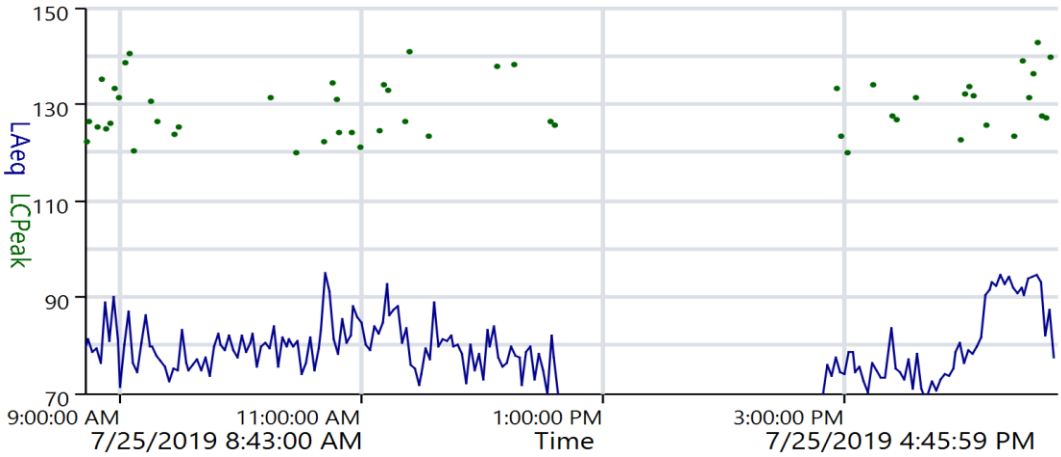
Table 16 Centre 5- doseBadge results for children

Number	Date	Time (hours : mins)	Dose % (lowest- highest	$L_{Aeq\,t}$ dB	L_{Cpeak} dB
1	25 July	7:58	29	78	134
2	25 July	8:03	57+	83	142
3	25 July	8:04	69	83	143
4	25 July	8:01	96	85	142
5	25 July	8:08	154*	86.8	138
#6	25 July	8:00	1071	95.3	143

Amber coloured text+ - exposure levels 50- 99% (Amber alert)
Red coloured text* - exposure levels over 100% (Red alert).
#Discard due to impossible reading

+ Time history example given below

Figure 5c Centre 5- Time history – doseBadge - child



Teacher questionnaires

In this centre the responses well reflected what was assessed in the monitoring programme.

A total of three teachers answered the questionnaires. Not all questions were answered. Teachers were asked rate in order the following teaching aspects:

- Lighting
- Ventilation
- Acoustics (listening environment)
- Equipment Adequate space.
- Each was given a score of '5' for the most important to '1' for the least important. The results for all 5 teachers were collated with the following results. One respondent listed four aspects as equally important so these were given an equal score.

Order of Priority (importance)	Aspect	Score
1	Space	14
1	Ventilation	14
3	Lightning	10
4	Equipment	9
5	Listening environment*	7

*Misinterpreted in translated version to hi fi - Music. However later in the questionnaire the listening environment, echo was identified by teachers.

All respondent rated their teaching environment as just right. One described the noise levels as being between above comfortable but below disturbing. This could be interpreted as tolerable.

Most respondents did not have a major issue with noise generated within their classrooms. Two respondents described noise from the air conditioning fans and a fish tank pump as creating annoyance for them being continuous noise.

One of the respondents indicated that everyone talking at once especially if no conclusion is reached or the matter was not resolved resulted in elevated levels of noise. The amount of time in the working day that noise was perceived to be excessive was low ranging from 15 minutes to one hour (3 – 13%). There were no issues identified with noise from other businesses or tenants in the same building.

When asked to describe their feeling about noise levels in the room the respondents did not respond adversely. One stated that why noise exists it was reasonable for the activities that were being undertaken. Outdoor play was identified as a noisy time and there was some noise from corridors, doors and gates.

The highest level of concern was raised about noise being generated outside the centre. Road works, building construction and promotional vehicles were identified as creating noise problems and a nuisance. One respondent described promotional vehicles as often too loud often staying for too long in the vicinity and emitting a piercing sound. The area is likely to attract these kinds of noise producing activities being in a busy commercial / education hub with building projects underway.

All respondents described the noise in the classroom as not high or to a level that affects the children. In general, they identifiable that noise do cause others to raise their voices (Lombard effect). The monitoring inside the classroom confirmed this with low noise levels recorded.

Two of the staff outlined their general experience with special needs children and ADHD was the only condition identified the children with ADHD cannot concentrate and is distracted from learning tasks and 'hypes' them up or over stimulates them. These respondents felt that special need children were more adversely affected by noise than other children and removal of the child as a better.

When asked how noise affected their teaching two respondents described it as causing them to lose patience. The third respondent was unaffected.

In approach to controlling noise teachers one favoured speaking to the children directly and by setting the example by not raising their voices and encouraging children to do the same.

Centre 6

Located in a quiet commercial and residential street with occasional traffic only. Noise intrusion from the outside was not evident and by observation this centre was located in one of the quieter environments of all participating childcare centres. However, there are external noise issues which emerge from time to time.

The centre is a special character-based facility on the philosophy of the Montessori governing organisation. The most common special character facilities include those with religious affiliations and those based on a prescribed philosophy such as the teachings of 19th Century Austrian Philosopher, Rudolf Steiner or the methods develop by 19th Century Italian physician and educator, Maria Montessori. Montessori and Steiner special character schools now operate extensively in Europe, UK, North America, Australia and New Zealand. They are now beginning to emerge as an alternative to the traditional forms of education in Taiwan

Due to the age of the children many of which were very young and under 5 years old management requested not to attach the doseBadges to the children. However, the rooms were small, and we were able to mount doseBadges in the room to gain a good estimate of likely personal exposure and also the general noise levels in the room.

There are two main areas of instruction. The main instruction area is on Floor 2 with a small room for four very young children present at the time to sleep and undertake special activities away from the rest of the group. However, in accordance with the philosophy the younger children are included with the main group wherever reasonable and feasible.

On Floor 1 there is an office receptionist at the entrance and a small area in the corridor by the stairs for staff meetings.

The other instruction room (Floor 1) is very small and is used for English instruction in a morning session from 11 am – 12.30pm then used from late afternoon 4.30- 6.30 pm for a special (Cram school) class for elementary children to complete homework, additional instruction, exam preparation etc.

The first and second floor classrooms are of similar size design and finishing.

Room description Floor 2 (main instruction room)

- Floor wooden panel
- Permanent walls hard concrete plastered. Internal walls wood panelling and wood panel to height 1m all round. Internal windows on 3 sides
- Dimensions (floor area) L shape = 27.4m^2 + 12.9m^2 = 40.3 m^2
- Celling height= 2.3 m (suspended ceiling tiles probably acoustic rated)
- Volume 93m^3 Assume 100 m^3

Room acoustics- Floor 2 (main instruction room)

The mid-frequency reverberation time (T_{mf}) was 0.7s. This was slightly higher than the established (T_{mf}) of 0.3 – 0.6 s.

Room Description - Floor 1

This room is very small used for English instruction + Cram School: 4.30-6.30pm

- Floor: wooden panel
- Walls hard concrete/permanent wall but wall panelling around to height of 1 m
- Internal wall partition wood panelling
- Has internal windows for viewing
- Ceiling height 2.4 m (suspended ceiling tiles probably acoustic rated)
- Dimensions 6.9m x 3.2.m x 2.4m (height)
- Volume 53 m^3

Room acoustics -Floor 1

The mid-frequency reverberation time (T_{mf}) was 0.6s

Comment

The reasons why the RT could be a little higher than expected were a lower than normal ceiling height and small room volumes. The higher the celling and the greater the room volume the sound has more time is decay before striking the internal surfaces. However, the acoustic ceiling tiles will have a significant impact. Considerable internal window coverage is present which will reflect sound. This is clearly a trade off as the internal windows service an important function to monitor and supervise children from outside the room.

If improvement if needed, a wall surface with an acoustic composition material or provision of a soft floor underlay.

Table 17 Centre 6-doseBadge results for teachers and observer

Number	Date	Time sampled hours: mins	Dose %	$L_{Aeq\,t}$ dB	L_{Cpeak} dB
*Teacher 1	19 November	8:48	41	81	138
Teacher 2		7:52	24	77	120
Observer		8.17	17	77	122

These results were excellent and well below the International workplace criteria of 100% dose.

Figure 10a: Centre 6 -Time history- doseBadge teacher 1

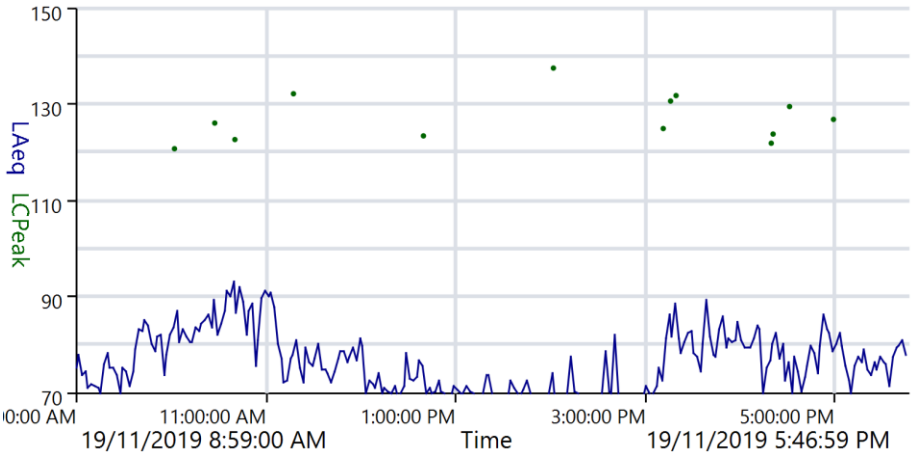


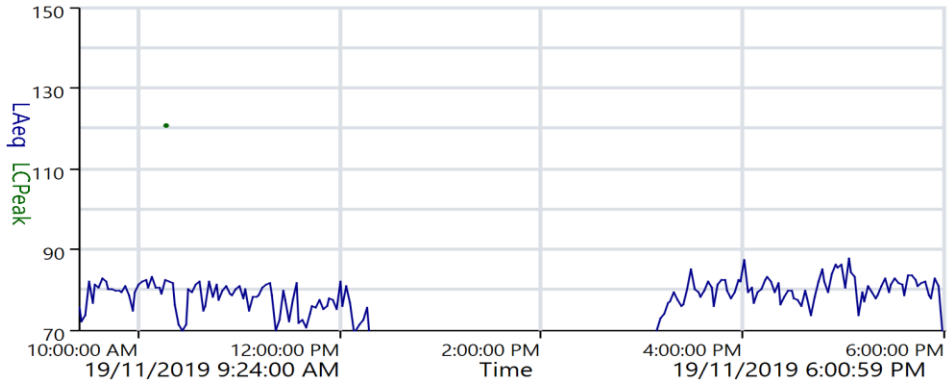
Table 18: Centre 6 - doseBadge results assimilated for the children

Number	Date	Time (hours :mins)	Dose %	$L_{Aeq\,t}$ dB	L_{Cpeak}
1	19 November	8:05	18	77	136
2		7:59	20	78	124
+3		8:21	24	78	121

+ Time history example given below

The dose badges were placed at each end of the room and a third close to the children. The sound was evenly distributed through the room. All gave favourable results. We can estimate that personal sound exposure of children is 25% or below for the full day which is well below the guideline value of 50% dose. Furthermore, general sound levels in the room were $L_{Aeq,8h}$ of 77-78 dB.

Figure 6b: Centre 6- Time history - doseBadge assimilated exposure child+.



Questionnaires

One teacher answered the questionnaire in English. He was asked rate in order the following teaching aspects:

- Lighting
- Ventilation
- Acoustics (listening environment)
- Equipment
- Adequate space.

  Each was given a score of '5' for the most important to '1'for the least important. The results were collated with the following results.

Order of Priority (importance)	Aspect	Score
1	Equipment	5
2	Ventilation	4
3	Acoustics	3
4	Lighting	2
5	Adequate spaces	1

Questionnaire completed in English

One respondent completed the questionnaire in English by interview. He rated his teaching environment as just right comfortable and relaxing but did comment on the rooms having a little reverberation. This could be interpreted as generally good.

Children screaming was identified as an issue along with cultural activities which occur outside the centre with noise intruding into the premises.

The respondent indicated that everyone talking at once resulted in elevated levels of noise. The respondent identified the noisiest times of the day being 9 - 10 am in the morning prior to going outside and excitement from children waking up from their afternoon sleep (2 - 3 pm). A figure of 30 % was suggested as the level of time noise was perceived to be too high.

When asked to describe their feeling about noise levels in the room the respondent identified some noise from other rooms and a door. A squeaky internal door was identified as being very annoying but it had not been repaired. The proprietor agreed to attend to this immediately.

A level of concern was raised about noise being generated outside the centre. Road works, building construction, promotional vehicles and cultural activities held outside the centre were identified as creating noise problems and a nuisance.

The highest level of concern was raised about noise being generated outside the centre. Road works, building construction and promotional vehicles were identified as creating noise problems and a nuisance. One respondent described promotional vehicles as often too loud often staying for too long in the vicinity and emitting a piercing sound.

Noise from children yelling and screaming was identified as being the most intrusive and annoying because it made it difficult to teach the children. The Lombard effects were identified as an issue when in a noisy environment and with many children talking at once and raising voices to be heard.

The respondent stated that some methods are needed to assist children to control their voice levels. Hearing loss in children was identified as a possible consequence of noise exposure and for teachers, voice strain in having to raise their voice over the din. Prolonged exposure could lead to hearing loss among teachers. The male respondent identified an issue he was aware of background noise exposure affecting the menstrual cycle of some female teachers. A study by Wijiyanto et al.[25] discussed this hypothesis but findings were inconclusive with further study needed.

The respondent outlined his general experience with three special needs children with ADHD and one with autism. He did not identify any particular sounds that these children found distressing but stated that they lose concentration and are distracted from learning tasks High levels of noise 'hypes them up' or over stimulates them. The respondent felt that special need children were more adversely affected by noise than other children and taking the child to a quieter area if distressed is a strategy used.

The respondent suggested that art works and visual tools (educational toys/games etc.) were used to help these children.

More time, attention, energy and effort were required to teach these children new skills meet their learning needs. This created some level of stress. However, this centre having two male teachers was identified as a major difference between this centre and the typical child care facilities and this may be a little easier in dealing with out of control behaviour or restraining them in case of serious physical danger such as running into the path of ongoing traffic.

While the centre did not have any specific policies on noise management, they subscribe to the Montessori philosophy, which has relevant policies of remaining calm and self-directed learning.

On the use of strategies to minimise noise levels, the centre uses quiets time and compulsory rest sleep times. If noise levels rise significantly due to excitement, the teachers use a calm voice and ask children to sit with their hands on their knees until they settle down. They ban activities using loud music and others which generate excessive noise. The respondent is careful to repeat speech as necessary to make sure the children understand. This is important in English instruction (the teacher has a native fluency).

In conversation with the researcher, the respondent expressed interest in the "noise traffic light as an interesting concept which he would like to see developed for use in his centre. He stressed the importance of keeping children busy and engaged in tasks and activities. Finally, he would like to see some development of skills and methods for teaching staff in the minimisation of noise.

[25] Wijayanto1, T., Tochihara, Y., Wijaya, A. and Hermawati, S. (2009). Combined factors effect of menstrual cycle and background noise on visual inspection task performance: a simulation-based task. Journal of Physiological Anthropology 28(6) pp 253- 259.

Development of noise and related provisions in the New Zealand current legislation and criteria

At the time of the New Zealand study[26], the Ministry of Education was conducting a review of the existing legislation for early childhood care facilities. Initial consultation identified noise as a pressing issue in early childhood education centres and services (kindergartens preschools etc.) with demands that action had to be taken. The Ministry's Criterion Review Team sought advice on suitable noise control measures which could be implemented without the specialist personnel and technical resources needed which were not available. We were able to able to recommend appropriate legislative control which was based on a cooperative model rather than proposing sound pressure level limits and criteria. The recommended clauses were widely supported in the following consultation meetings throughout the country. As a result, the recommendations became the basis for the following legal requirements to control noise levels and to protect children most vulnerable to noise exposure.[27, 28]

Premises and Facilities Standard General (Regulation 45)

Include quiet spaces, areas for physically active play, and space for a range of individual and group learning experiences appropriate to the number, ages, and abilities of children attending (PF1).

The provision of acoustic absorption materials if necessary, to reduce noise levels that may negatively affect children's learning or wellbeing (PF12).

Health and Safety Practices Standard General (Regulation 46)

All practicable steps are taken to ensure that noise levels do not unduly interfere with normal speech and/or communication, or cause any child attending distress or harm. (HS15)

The above criteria came into force with the enactment of the *Education (Early Childhood Services) Regulations 2008* as the underpinning licensing criteria.

This approach was deemed to be practicable, encouraging teacher buy in and not seen as a punitive measure. By imposing prescribed sound pressure level limits these have to be measured by competent personnel with precision sound level meters with current calibration certificates which are an expensive component to withstand the rigours of a court of law. Furthermore, a standard

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[26] McLaren, S. (2008). Nosie in early childhood education centres- the effects on the children and their teachers. PhD thesis, Massey University, Wellington.

[27] Education (Early Childhood Centres) Regulations 2008 (New Zealand legislation). (https://www.education.govt.nz/early-childhood/licensing-and-regulations/the-regulatory-framework-for-ece/licensing-criteria/)

[28] Licensing Criteria for Early Childhood Education & Care Services 2008 and Early Childhood Education Curriculum Framework (New Zealand). Ministry of Education, Wellington. (https://www.education.govt.nz/early-childhood/licensing-and-regulations/the-regulatory-framework-for-ece/licensing-criteria/)

as to how such measurements are to be made has to be promulgated along the specifications of the equipment to be used.

In overseas jurisdictions, some legislation is based on management or process control taking all practicable steps or similar (reasonable care) rather than stipulating operating control limits. Other examples in New Zealand and Australia include the health and safety at work legislation. The enforcement of any legislation should not rely on assessment procedures which are beyond the means of the enforcement agency meaning that compliance cannot be monitored. In the case of public nuisance such as odour, noise or other such hazards, reliable witness testimony of an existing nuisance such as excessively loud, disturbing and unnecessary noise can be of sufficient rigour to withstand the scrutiny of the legal process. As an example, one does not need a sound level assessment of excessively loud music which keeps nearby residents awake all night or clearly prevents them from enjoying the peace and tranquillity of their homes or lives. If on entering any childcare facility, the noise encountered is such that it clearly interferes with normal speech or communication that can be deemed valid and descriptive criteria in the legal process. Likewise, a young child clearly distressed by noise is unreasonable and unacceptable if that child has a right to be present. This is particularly the case if the child experiences a medical condition such as autism, which makes them extremely sensitive to noise. Why is it reasonable to expect children who are distressed and even hurt by noise to negotiate their way around a noisy over-stimulating environment when we never expect a child with physical disabilities to negotiate their way up a flight of stairs?

Discussion

Cities of Taiwan have been identified as noisy with Taipei, the Capital being reported as one of the noisiest in the World. While such reports are subjective as to how such assessments have been made, observation and a report by Lin et al.[29] show that the large cities such as Taipei are flooded with noisy activities. This paper reported that in the densely populated capital city, Taipei, the environment is bombarded with noise from various sources such as entertainment, building construction, road works and vehicle noise including exhaust pipe emissions. In addition, there are contributions from large traffic movements, street concerts, national festivals, traditional Chinese drums and fireworks. Advertising through loudspeakers in stores outside the premises, the variety of promotional vehicles and garbage trucks which blare out messages and music as they move around the streets are sources of every day noise. This type of noise increases during electioneering campaigns, evident in 2019 with the national presidential election early in 2020.

Since regulation was enacted after a 1975 public pollution poll revealed noise as the greatest source of environmental pollution.[29] Yearly noise complaints over the last 10 years have exceeded 50,000 across the territory. However, awareness of noise issues in society appear to be in the early stages which has been evident in observation of people attending very loud events with no apparent concern to the harm that this could be causing young children. One observed case of deafening e-

[29] Lin, I-Chun, Hsieh, Jen-Souh, Chang, Nai-Ren, Hsieh, Ping-Fei, Tsai, Hung-The. (2018). Development and Regulations on Noise Control of the Republic of China (Taiwan). Inter-noise 2018 - the 47th International Congress and Exposition of Noise Control, 26-29 August, Illinois, Chicago.

crackers (electronic firecrackers)[30] blasting in quick succession showed a mother with her hands over her young child's ears while staying in the vicinity and not retreating from what should have been perceived as serious potential harm. Activities have often been observed of children playing drums in unison, which appear to be deafening, especially when so close to their little ears. There appeared little awareness of the potential harm such exposure can cause. A protest march against pollution on Taipei[31] in the lead up to the general election focused largely on clean air and climate change with little mention of noise pollution. This was despite the number of noise complaints fielded each year. The workplace criteria for noise in Taiwan are far less stringent than the widely adopted international workplace criteria for noise permitting three times the level of exposure than what the international criteria allow. All these factors indicate that noise awareness, while increasing, is still in its infancy stages when compared to other forms of pollution. The overall message deduced from the questionnaires and from comments made to researchers was that noise was considered as part of the job. However, from comments offered, the issue of noise in their working day and its effects, noise intrusion from outside the premises and which they have no control over seems to have raised awareness among teachers in centres which took part in the study.

Review of literature

Literature has revealed a number of studies on the effects of noise in early education (preschools and the first years of elementary school (also referred to as primary school in some jurisdictions). However, as there is no standard method for the measurement of environmental noise (apart from personal exposure) there is likely to be considerable variation with reported results due to how the fixed sound environmental methods were undertaken. The use of environmental noise standards is not suitable as these are for outdoor measurements where the reflection from internal surfaces is not an issue. Furthermore, the placing the sound level meter microphone at a height of 1.2 - 1.5 meters above the floor is not feasible as it would cause obstruction from the free movement of the children and their teachers in their learning activities. While it would be ideal to provide suspend the microphone in the centre of the room above normal movement zone of staff and children it depended on the room having the means to adequately secure the microphone and extension cable in the central zone of the room. These factors as well as the individual characteristics of each room are obvious confounding factors.

A study by Waye et al [32] reported from questionnaires on how noise affected children's behaviour. These authors reported that noise levels were intermittent and unpredictable with levels reaching as high as L_{Aeq} of 84 dB for the duration of measurements. This is of the order of general noise levels measured in this work reaching $L_{Aeq\ 6.5\ h}$ of 81 dB. The general noise levels in this work included an extended sleep period in the room which would reduce the overall L_{Aeq} levels from other activities. Noise sensitivity of the personnel was reported as being important. A large number of respondents reported anxiety (worry insecure, sad and frightened) in a noisy environment. Children were reported as acting out, becoming angry and having conflict while

[30] Electronic Firecrackers In https://www.deccanchronicle.com/141022/technology-latest/article/electronic-firecrackers-what-it-and-how-it-works

[31] Hsiao, S, (2019). *Groups march to demand action against pollution*. Taipei Times, (30 December, 2019).

[32] Waye K., Fredriksson, S., Hussain-Alkhasteeb, L., Gustafsson, J., van Kamp, I. (2019), Preschool teacher's perspectives on how nosie levels at preschool affects children's behaviour. PLOS ONE (March 28, 2019). Available on https://doi.org/10.1371/jounal .pone.0214464

others reported avoidance behaviour such as retreating to a corner and withdrawing from class activities. All these responses were also reported in questionnaires received in this work.

A study of noise control in education facilities of children by Jeram et al[33] reports that an interdisciplinary approach to noise control is warranted dues to the complex functions in the delivery of education. In this study, the authors report that teachers while being aware of external noise; they were troubled by the building acoustics. This is in complete contrast not the results of this work where external nuisance noise such as promotional vehicles (a characteristic activity of Taiwan) showed a much higher level of annoyance than poor acoustics. The likely reason was that many of the respondents were unaware of the effects of reverberation in the enhancement of noise. Indeed, respondents of one centre which resorted to extensive use of portable PA systems in an effort to raise the teacher's voice above the din, had not understood the role of the building acoustics (the excessive reverberation time) in the creation of this environment. Furthermore, the PA systems in use were of poor quality, distorting the teacher's voice and probably exacerbating the problem. This situation was surprising as it is hardly normal practice to constantly use such systems except with properly designed sound field systems which transmit the teacher's voice evenly and in good reproductive quality throughout the classroom. These systems are widely used in many jurisdictions including Australia and New Zealand and a number of studies including that by McLaren and Humphries[34] attest to their effectiveness in school settings. However good acoustics of the space where these systems are in use is crucial to their effectiveness. The work reported by Jeram et al[33] could provide a good basis for future work in Taiwan. The goals of this paper were:

- to promote an interdisciplinary and collaboration in reducing noise levels in children's education as some noise is unavoidable while others forms of noise were welcome
- Increased efforts to raising awareness among teachers and children
- Increased action to improve existing acoustic conditions in individual schools and preschools.

The authors propose the following acoustic criteria:

1. Soundscape [35] in preschools and schools is a crucial factor in noise control. This includes external noise intruding into the setting and internal noise which is due to the acoustics of the space and the activities of students and their teachers.
2. Efforts to mitigate external noise in urban areas (strategic noise mapping). In this study where 3 preschools were subjected to unreasonable levels of background sound levels

[33] Jeram, S., Bazec, B., Pavlic, H., Plut-Pregeli. (2018). Interdisciplinary approach to controlling noise in children's facilities. Euronoise Conference, 27-30 May 2018, Crete.

[34] McLaren, S, and Humphries, S. A Pilot Study of a Soundfield System and Acoustical Quality in a New Zealand Primary School Classroom [online]. New Zealand Journal of Educational Studies, Vol. 44, No. 1, 2009: 59-68. Availability: <https://search.informit.com.au/documentSummary;dn=467949421792455;res=IELHSS> ISSN: 0028-8276. [cited 20 Mar 20].

[35] Soundscape is defined as the acoustic environment as perceived or experienced and/or understood by a person or people, in context. (Acoustics — Soundscape, ISO 12913-1:2014(en))

resulted in intervention by the local authority on noise challenged areas with residential buildings and educational facilities.

3. Noise conditions in schools and preschools. The authors describe an excellent initiative by the health and education authorities in the jurisdiction by preparing and distributing information for children, their parents and teachers. It is worthy of note that this was a specific request in one of the respondents of this work. The authors highlight a book for children which was distributed to school and preschools. A number of other initiatives which included presentations on noise in education in a number of events including National Noise Awareness Day.
4. Internal noise. Good acoustics is crucial in mitigating internally generated noise and can be achieved. According to the authors, there was considerably greater perceived awareness than what was found in this work in Taiwan. This was deduced by the major difficulty in recruiting participants for this study.
5. Pedagogical aspects of internal noise control. Information materials and staff development initiates on noise management which can include cognising lunch for small groups teaching children to be aware of their sound environment and rules around classroom education. In such forums teachers, expressed a need for increased knowledge of noise, the impact on children's development. An important observation was reported by the authors that many teachers had not released the children's auditory system does not fully develop until their mid teen years and that their listening process is different from adults. Others include the replacement of poor-quality noisy toys with those of higher quality and quieter toys. Other intervention put forward by the authors included noise monitors similar to the award-winning traffic light model noise monitor conceived by Ngahina Kindergarten in the Kapiti region of New Zealand. This concept was further developed and marketed to school and preschools in the country. These authors advise that no one strategy alone is the most effective but it is a combination of technical invention, organisation and pedagogical interventions. In other words, it is the combination of acoustic construction and treatment of the building, teaching practice and organisation interventions which is likely to achieve the best outcomes. They further confirm as a finding of this work that some preschools were not noisy despite having poor acoustics such as Centre 4 of these work. However, the consequence to this was the hampering or restriction of activities on the account that they would be disturbing to neighbouring classes.

Extending the initiatives promoted in studies by McLaren[37, 38] and Jeram[33] in building noise measures into current teaching practice and pedagogical strategies, it was clear from the questionnaires and observations in this work that some teachers are already implementing good initiative strategies. The management of one kindergarten strongly discourages the staff from raising their voices as an example to the children to emulate. Others had adopted strategies when noise levels were rising to ask the children to stop what they were doing and sit quietly to break the cycle.

Teaching staff are professionals with a wealth of experience and training in most jurisdictions. They are often in the best position with guidance and encouragement to identify and implement measures such as noise control as part of their teaching practice. However, it is always preferable to collectively formulate these initiatives into a noise management plan as a living document and

applied across the kindergarten as a formal policy. It enables the sharing of ideas and the cohort of teachers working together to achieve goals. It is hard to imagine that any formal assessment by the education authorities in Taiwan, would not welcome the implementation of such initiatives as a well-conceived written policy to deliver quality education while protecting the health and well-being of the children and the teaching staff.

By encouraging cooperation and buy in of teachers, it is obviously preferable to have them adopt noise management measures as part of their teaching practice which can also protect their own aural health. Furthermore, it should never be the purpose to cease educational and social activities on account of reducing noise. This is the case with music activities. Rather than ceasing music activities, consideration can be given as to how these can be conducted to deliver the obvious educational benefits without seriously compromising the aural health of the children which can manifest later in life. The obvious case here is drumming which can be very loud and potentially damaging to the little ears of young children. They are very close to the source of the noise from their own drum in combination of others beating in unison. We ask if practice sessions be modified with softer and quieter drum sticks and instruments. A particular case in the New Zealand study where drumming was conducted showed high levels of noise from the doseBadges worn in this session. A simple modification by using different drum sticks and by placing a softer pad on the drum skin saw a dramatic reduction in sound levels without affecting the obvious musical benefit of such important activities. An advantage of modern technology is that the volume of electronic musical instruments such as electric pianos and keyboards is easier to control than those of acoustic conventional instruments. In future, when musical instruments are to be acquired, this consideration could be given in the acquisition of new instruments.

Intrusive External Noise

It appears an issue in this jurisdiction with seemingly little control on the noise and disruption promotional vehicles and campaigns. While temporary activities such as election campaigning may be more readily tolerated as part of the democratic process, these activities should be conducted with the view to minimise nuisance and disruption to educational facilities in the delivery of education to their pupils. Unnecessary nuisance noise which occurs regularly on a permanent basis is more serious if it occurs outside sensitive activities such as education facilities. Excessive volume cannot be condoned if it persistently interrupts or degrades the education of young children. While perpetrators may argue that it is their right to conduct their business, but if this unreasonably disrupts and degrades the delivery of education on a persistent or continual basis, this cannot be deemed to be reasonable. Likewise, a local kindergarten has an equal right to conduct their business in the delivery of quality education. Isolated incidents are inevitable, but those that occur on a daily basis can cause serious impact on the delivery of education to children. As exists in other jurisdictions, some form of consultation between the parties in good faith can be mandated as part of licensing or consent process to conduct such activities. This can be an effective way to resolve any issues. Likewise, the use of sirens on emergency vehicles should only be used when it is necessary to alert other traffic and pedestrians etc. to give way and warn of possible danger. The use of sirens is of course, at the discretion and judgment of emergency vehicle drivers, but we question if it needs to be on for the entire journey when there is no imminent danger.

Construction sites while not permanent can be very disturbing for extended periods of time. Location is of importance as if this activity is to be conducted in a sensitive location containing schools, education facilities, hospitals and residential facilities will have different requirements to a large industrial zone with no such activities in the vicinity. Controls can include the use of construction methods which minimise impact from noise and vibration. Furthermore, if consent is to be given, a system in use in New Zealand [36] requires consultation with affected parties to reach a consensus if possible and that conditions are placed on consent. Feedback from some questionnaires revealed that to their knowledge many of these noise producing activities arrive unannounced. It appears that those making these noise producing activities do not consider the nuisance, annoyance or disruption they cause. Kindergartens and similar operations are also in the business of education and should have the right to conduct their business without excessive disruption that will affect the health and well-being of the children, the staff and the quality of education delivered.

We recommend that the authorities explore ways to ensure such activities when conducted are done so with due regard to the protection and education of children. Cooperation between parties, in our experience, maybe the best way to achieve results rather than imposing punitive measures. To give an example, when construction activities are planned which will be loud and disturbing, could negotiation with the affected schools and similar sensitive operations in the area be mandated to occur in good faith. Schools on being aware of such activities can make plans accordingly. There were cases in New Zealand when kindergartens were able to make alternative arrangements for an educational outing at a time a noisy activity was going to occur.

Developing noise management plans

The following text is a summary and adaption of documents by McLaren and Page.[37,38]

A noise management plan or policy is used in workplaces of many jurisdictions to identify noise issue and formulate a plan to reduce or mitigate the levels of noise and effects. It should be a living document which is regularly reviewed consulted and adapted to the ever-changing environment and developments in education practice. The following guide set out a model plan which can be used although there is no set format for a plan, this model services as a basis for discussion.

Essential Elements of a Noise Management Plan

The essential elements of a noise management plan can be broadly divided into 7 parts. The most important aspects of any plan are the legal and policy directives. Policy statements could be developed under the following themes.

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[36] Resource Management Act 1991. (New Zealand environmental legislation). In the New Zealand online legislation database http://www.legislation.govt.nz/act/public/1991/0069/211.0/DLM230265.html

[37] McLaren, S, Dickinson, P. (2005). Regulatory control and monitoring of noise in childcare centres – a discussion document. A report prepared for the Ministry of Education. Wellington, Massey University.

[38] McLaren, S. Page, W. (2013). Noise issues in inclusive learning environments. In "Inclusive education – Perspectives on professional practice". Dunmore publishing, Auckland.

Part 1- Policy statements

- A living document that is regularly used and reviewed. A commitment to ongoing review and amendments to the plan needs to be made.
- The philosophy that the centre will adopt in managing noise? For example:
- Educational, cultural and other beneficial activities which generate noise will not be suspended or curtailed. They will be carried out to deliver maximum benefit along with a commitment to manage noise levels as much as possible.
- Mitigation of unnecessary noise, which can be curtailed. E.g. lubrication of squeaky equipment, solutions to minimise noise from actions such as doors banging, furniture scrape etc. Noise as a result of worn components in fans air-conditioning and similar units can be remedied.
- Noise producing toys/games etc. (oaf appropriate)
- Inclusion and protection of special needs children (if present) who are known to be sensitive to noise.
- Noise induced hearing loss as an occupational issue for teachers and other contact staff.

Part 2 Noise issues in general

- A summary of the types of noise generally found in early childhood centres along with any noise specific to a particular centre
- Noise issues for the most at-risk children.
- Occupational exposure

Part 3 Strategies and practice

- A statement of recognition that plays is an important part of a child's learning and development, which generates noise, can be included. A commitment to strive to achieve a balance over what noise is a consequence of play and learning and what is excessive and detrimental. Teaching strategies could be introduced here such as the use of quiet voices inside and any technique for teaching attentiveness etc.
- Any noticeable noisy times such as transition times from on activity to another can be included and how this is to be managed?
- Sessions generating noise by their nature should be addressed. Music sessions such as the use of recorded music will be played to the volume for children to experience, learn from and enjoy the music, but not of a volume to cause distress or hearing loss. Other strategies could include the choice and type of percussion instruments (made of plastic or flax rather than hardwood to reduce the sharp piercing impact sound). In addition, teach the children to play musically and not to bash the instruments for the purpose of making noise. Music culture in Taiwan often uses drums even at preschool age for cultural activities, concert performances and entertainment. When these instruments are played in unison the resultant sound can be excessively loud even when some distance from the source. These activities will involve considerable time in preparation and practice sessions where consideration could be given to reducing the level of sound, if it is not possible for the actual performance.
- Specific noise issues such as furniture scape, squeaky equipment noisy toys can all be addressed. Simple strategies such as making sure caps are fitted to furniture to minimise scrape, lubrication of swings etc., and any playground equipment.

- Avoidance of the Lombard/Cafe effect where teachers addressing a noisy group will naturally raise their voices to be heard over the din. What other more positive strategies can be used rather than shouting at the children?
- Any other innovative ideas adopted by the centre to minimise noise. For example, a visual light system for noise developed by a local New Zealand kindergarten.
- As inclement weather often confines children indoors, the strategies for managing children could be outlined here.
- A plan for special needs children and/or those with high levels of sensitivity to noise. How will these children be managed?

Part 4 Noise attenuation through the building structure

In many centres this is an issue with excessive reverberation. The centre could identify any long terms goals to improve the acoustic environment.

Part 5 Externally generated noise intruding into the centre

Noise outside the control of the centre can is an issue from Feedback received. It needs to be raised with authorities which monitor noise and nuisance for consideration and guidance as to how such as activities can be monitored and restrained from causing a nuisance and disruption to the education of children.

Part 6 Education

The education of children at an early age is the core business or early childhood education centre and education about loud noise and hearing damage should be included. Feedback in this work has indicated a role in educating children and their families about noise and its effects. There could be education initiatives with key messages through notices to parents Education can also extend to the relevant law enforcement agencies such as the Taiwan Environmental Protection Authority for noise issues in the environment and City Council staff who may not be aware of the issues of externally generated noise for young children in education.

Part 7 Occupational Exposure

Staff exposed to occupational noise over a working life are at risk of hearing loss especially in the retirement years where the natural loss of hearing with age (Presbycusis) becomes more significant. Implementation of a strategy to alert staff to the possibility of hearing damage. Provision of information and a means for early detection should be included so that preventative measures can be taken to minimise noise-induced hearing loss. Taiwan has a well-developed National Health Insurance scheme which could be used in this circumstance. In addition, Taiwan needs to adopt the "International workplace noise criteria" to provide a greater level of protection from occupational noise exposure.

Acoustic Ratings and Treatment

Many of the internal office spaces and rooms in Taiwan are fitted with suspended tile ceilings. These are probably included to hide service pipes, cables etc. which are often installed in the upper

ceiling space. Furthermore, concrete walls are generally very good at preventing noise from other spaces being conducted into the learning space. In the classrooms observed noise will pass from one room to another through doors which are not acoustic rated, air gaps and spaces. However, concrete walls are of hard reflective surfaces and will have little effect in reducing sound generated within the room and therefore would benefit from soft acoustic panels fitted to the internal wall surface of the classroom. Glass is a popular choice for walls and doors to allow the light in. Glass reflects sound well. However, it has been fortuitous that many of the classroom ceilings have acoustic tile ratings where reverberation times were on the whole less than those with hard plastered ceiling surfaces.

The acoustic requirements are very different for concert halls and learning spacers such as a classroom. Sound in a room reaches our ears in two ways:

- Direct line of sight path usually the included and the quickest route
- Reflection off the internal floor wall and ceiling.

The more reflection that occurs, the longer the time that is taken and the weaker the signal becomes. If the time delay is greater than one tenth of a second (100 milliseconds) it will be perceived as an echo. The speed at which a sound dies down in one of the most important parameters in acoustic design of classrooms and this is referred to as reverberation time. The frequencies centred on speech production are known as the mid-frequency reverberation times. There are other indices such as speech transmission index which requires more advanced techniques which were not used in this study. However, with the national language being of a very different nature to English and European languages in which most of these studies have been carried out, it would be valuable to replicate these studies in Mandarin language settings. The optimum level of mid-frequency reverberation based on a room volume of approximately 100-200 m^3 is 0.3-0.5s, based on a combination of the three overseas standards[4,5,6] used in this work. As the room volume increases to less than 300 m^3 the optimum reverberation time can be increased to 0.6s. Reverberation times of 0.8s or higher especially in small rooms of 150 m^3 or less, are of poor acoustics and speech will be significantly degraded. In a New Zealand school, a project manager decided to save money and without consultation removed acoustic treatment in contrary to the specifications. The school principal sought assistance from the authors who measured the mid-frequency reverberation time of 1.7s. This equates to what would be measured in a gothic-style cathedral. A significant amount of money was spent painting and smooth plastering the internal surfaces. This cost could have easily been offset by the cost of fitting acoustic rated material to the walls and ceiling as part of the build.

Signal to noise ratio

This may be adequate in a domestic style setting with just a few people talking. If a domestic style premises or small office space is converted to a childcare facility without adequate consideration the space will become unusable in a teaching setting involving small group work and lively communication. For speech to be intelligently heard it has to be received at three times louder than the (15 dB higher than the sound level). This is referred to as the signal to noise ratio and an important parameter in determining the intelligibility of speech. If normal conversation is at a

sound pressure level of 65 dB the background levels need to be at 50 dB or lower (which is very quiet.) The higher the reverberance in learning space the poorer the speech intelligibility.

Acoustic treatment

Adapted from McLaren and Page[38]

Acoustic treatment is a complex building science and professional input is always strongly advised. Whenever possible it should be incorporated into the design plan and implemented as part of the construction. With many aspects of building, whether it be structural safety, weather tightness, or acoustics, it is critical to get right first time as undertaking remedial work down the track is costly, disruptive and often a less effective option. For classrooms undergoing a major redecoration, this is a good time to consider the application of acoustic materials rather than repainting or similar application. Acoustic material can easily be fitted on to an existing surface quickly and easily with minimum disruption to the operation.

There is a significant difference in costs of materials all with the same acoustic rating. It is therefore important to through investigate the products available. There are now reasonably priced and effective materials available through online and local suppliers in Taiwan.

The amount of surface coverage is important in achieving effective sound reduction. While the presence of soft furnishings heavy drapes etc. will have some effect, there is unlikely to make significant improvement in rooms of hard wall floor and ceiling surfaces.

All rated acoustic products have a noise coefficient rating (NCR) as part of the product specification. If an NCR of 0.4 it means that 40% of the sound waves which strike the surface will be absorbed and not reflected back into the room. However, the amount of sound absorbed is frequency dependent (effective in the mid-frequency range). This means that these products will be more effective in attenuating noise from higher frequency sounds such as human voice generated in the classroom rather than very low-pitched sounds.

If no acoustic treatment in a room, then treatment of the ceiling first is usually the most efficient and cost-effective measure. There are fibre-based panels acoustic blankets (in large sheets) which can be attached to a ceiling by adhesive or fasteners. Some of these products have an NCR of 0.8 making them very effective sound absorbers. They also can be applied in a decorative manner. A popular choice in many countries, including New Zealand, Australia and Europe are fibre composition panels for the walls. (see Figure 7a). These products usually have an NRC rating of approximately 0.4 but serve other purposes as well. They are aesthetically pleasing giving a soft ambience to the room. In addition, they provide a continuous pin up surface for display of notices teaching materials and children's artwork. As the surfaces are soft, they are less likely to cause injury than falling against a hard wall surface. Figure 7b shows the reduction in reverberation from fibre wall composition panels to the walls of a kindergarten to the high windowsill as shown in Figure 7a. The celling remained untreated. A mid-frequency reduction on in reverberation times of 0.2s has been achieved. Had a suitable acoustic treatment also been applied to the ceiling surface, there would have been a further reduction likely to achieve optimum acoustical quality of 0.3-0.4s in the mid-frequency range.

Figure 7a Acoustic composition wall panels applied to the wall surfaces in a New Zealand kindergarten

Note: Acoustic wall treatment above the upper windowsill

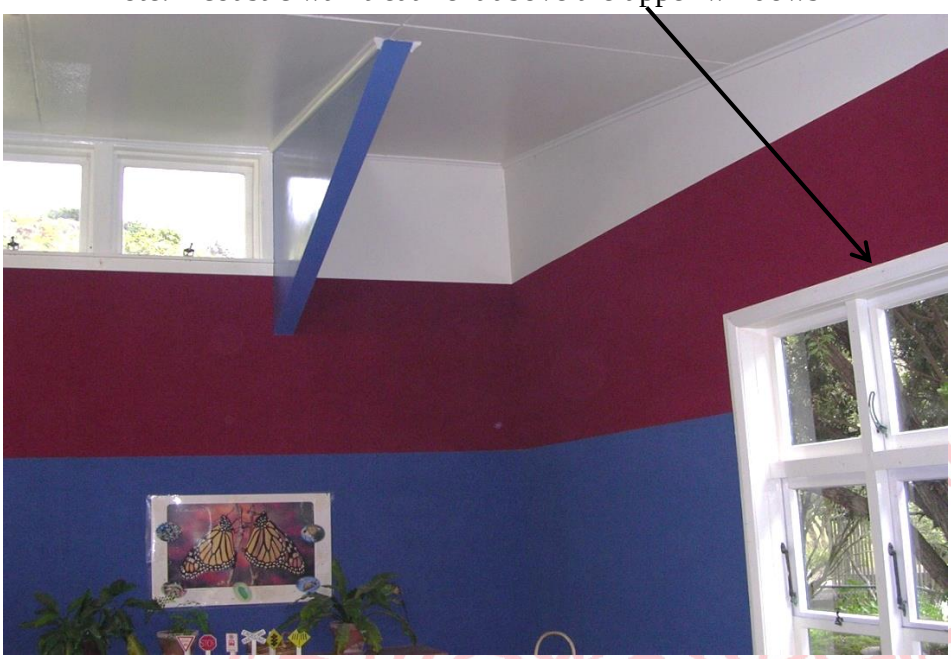
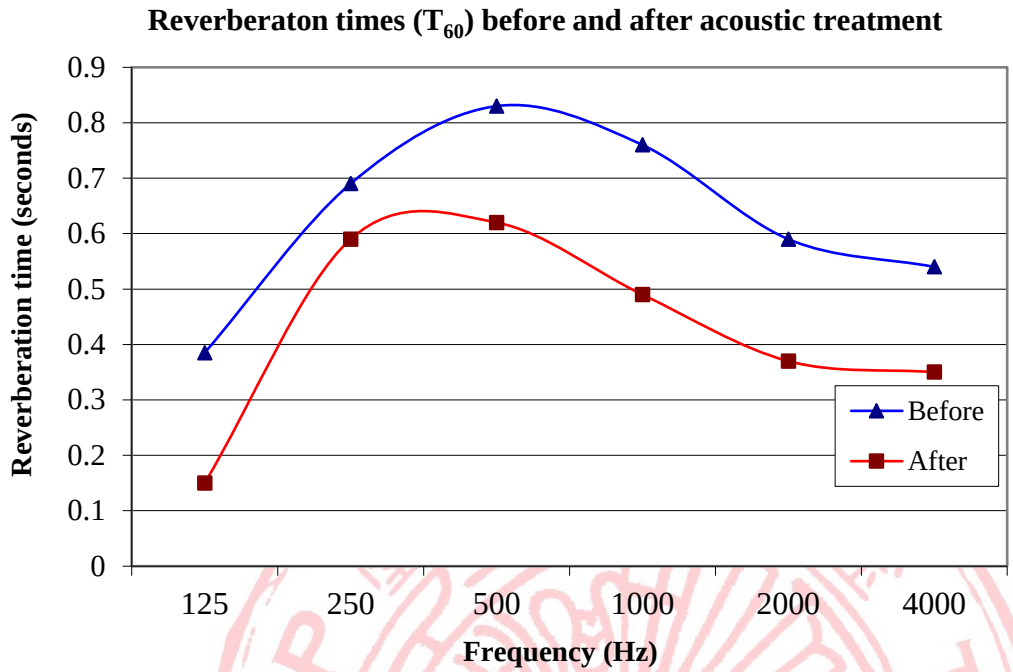


Figure 7b Diagram of Reverberation times T 60 before and after acoustical treatment.



Floor surface

Carpeting of the floor will also result in improved acoustics. This is unlikely to be adopted in Taiwan. Carpets also harbour dust mites which cause allergies and breathing problems in some individuals. Floor coverings in Taiwan are impervious to water and cleaned regularly by mopping rather than vacuum cleaning. However, one kindergarten had installed a floor underlay under the linoleum surface which was soft and comfortable under foot and yet able to be cleaned by mopping in the usual way. This was done to minimise injury from children tripping on the stairs and landing leading to the upper floor level. However, such treatment would also substantially improve the acoustic quality of any learning space if used in a classroom. In Taiwan it would be a worthwhile option for consideration if floor surfaces were to be replaced. The soft nature will also provide a comfortable surface for children to sleep on during their daily rest periods as well as improving the acoustics of the room.

Useful acoustic design guidelines for classrooms

A variety of freely available acoustic guidelines have been developed by a number of jurisdictions and are available online. These can be adapted to suit the Taiwan learning environments and education system. Some examples are:

- *Designing quality learning spaces: Acoustics* (New Zealand) [39]

[39] Designing quality learning spaces: Acoustics Version 2.0, (2016). New Zealand Ministry of Education. In https://www.education.govt.nz/assets/Documents/Primary-Secondary/Property/Design/Flexible-learning-spaces/DQLS-AcousticsV2.0.pdf

- *Acoustics of schools: A design guide* (UK) [40]
- *Noise in educational institutions (Germany)* [41]

Useful acoustic assessment tools

The Australian National Acoustics Laboratory has designed a number of free to download application tools for education institutions. There are a range of other applications freely available as well.

The application '*SoundOut Rooms Acoustics Analyser'*, assesses reverberation time and ambient noise levels. This will allow ready assessment of the acoustic quality in classrooms and learning spaces without having to acquire expensive specialist equipment.[42] A technical paper by Mealings[43] has validated this app with certified instruments (as used in this study) and found it to be an accurate tool for educators.

Conclusions

While the study was limited due to the small numbers of participants, a cross section of preschools was represented including private stand-alone kindergartens and public facilities attached to elementary schools, institutional facilities (e.g. universities/hospitals), an open plan complex and special character preschools such as those subscribing to the philosophies of Maria Montessori and Rudolf Steiner.

The study demonstrated a clear link between acoustical quality and resultant noise levels with the preschool with poor acoustics recording the highest levels in the study. Furthermore, the extensive use of potable PA systems worn by teaching staff suggested that these were being used to try and overcome the reverberant conditions and degraded speech quality. The portable devices also amplified the teacher's voice and because these units were worn on the hip, they contributed to the occupational noise exposure of the teacher.

Overall, the noise levels were comparable with reported studies done elsewhere. Although no facilities had formal noise policies in place over noise management some staff were observed mangling noise as part of their teaching practice and in these cases recorded lower overall noise levels. It would be a good strategy to include such initiatives in a noise management plan or policy.

Noise intrusion from outside the premises was identified as an issue for teaching with widespread dissatisfaction of the noise and interference to the teaching and learning of children from amplified messages and music of mobile shops and promotional vehicles turning up nearby.

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[40] Acoustics of Schools: A design guide. (2015). Institute of Acoustics (UK) and Acoustics and Noise Consultants (UK). (In https://www.ioa.org.uk)

[41] Tiesler, G, Oberdörster, M. (2008). Noise in Educational Institutes. Federal Institute for Occupational Safety and Health, D-44149 Dortmund, Germany. In http://www.inqa.de

[42] National Acoustics Laboratory (Australia) 2020, In (https://www.nal.gov.au/products/downloadable-software)

[43] Mealings, K. (2019). Validation of the SoundOut Room Acoustics Analyzer App for classrooms: A new method for self-assessment of noise levels and reverberation time in schools. Acoustics Australia 47 pp277–28.

An open plan classroom cluster raised a high level of dissatisfaction from the teaching staff in the questionnaires citing inter-classroom noise and disruption. This affected how lessons had to be conducted due to noise transition and disturbance to the other classrooms to the other classrooms.

This study demonstrated the need to attend to acoustics treatment from the beginning and include this in the building plan. The incorporation of acoustic treatment at the start is the most effective and cost-effective solution to providing enhanced acoustical quality. In other words, it is paramount to "get it right first time rather than undertaking a clean-up further down the track" which is often the more expensive and less effective solution.

Further studies could include other related indices such as speech transmission index (STI), signal to noise ratio (SNR) and levels of speech intelligibility in Taiwan. These could not be carried out in this study due to language difficulties in a non-English speaking environment.

Recommendations

Taiwan education regulatory authorities adopt the following recommendations into standard practice guidelines.

1. All reasonable steps be taken to manage noise levels in teaching sessions and activities so that that noise dose not unduly effect speech or communication between children and their teachers
2. Nosie levels should not cause any child attending distress or harm
3. Develop resources to implement noise awareness sessions and protection of hearing health in preschools both for the children and the aural health of teachers.
4. Preschools develop and implement noise management plans into their teaching policies and practice.
5. Develop an acoustical standard and design guide for the establishment of new preschools or major refurbishment (There are a number of resources freely available on line which could be easily adapted to the Taiwan education system).
6. Ensure that noise producing equipment such as air conditioning units are correctly mounted to prevent the transmission of noise from these units into the building structure.
7. Teachers and staff examine ways that beneficial activities which product a high level of sound are conducted in a way that retains the obviously benefits but mitigates the level of hearing damage. Special attention could be given to the practice sessions with the use of drumsticks for example which will not produce the sharp impact sound.
8. All rooms where special education is given such as one on one speech language therapy should have acoustic treatment to meet the optimum acoustic standard (mid-frequency reverberation time of 0.3-0.4s and be free from noise interference from the outside).

Environmental Noise

1. The regulatory authorities examine ways in which unnecessary disturbing nuisance noise generated outside preschools (and other sensitive activities) can be curtailed. Of particular note are the mobile shops and promotional vehicles which use amplified messages and music in an unreasonable manner close to preschools. This could include special zones around such sensitive activities as preschools.
2. Examine ways the noise from essential operations such as construction works can be mitigated if noise from these activities will unduly interfere with the learning of especially young children. Ideally approvals/permits to conduct such activities should include reasonable conditions to control and mitigate noise.

Appendices

高雄醫學大學附設中和紀念醫院
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人體研究新案同意證明書

計畫中文名稱：台灣幼兒園的環境噪音和迴音對孩童和教師的潛在影響
計畫主持人：吳明蒼
共同及協同主持人：吳佳芳
機構名稱：高雄醫學大學附設中和紀念醫院 **經費來源：科技部**
IRB 編號：KMUHIRB-SV(I)-20190023
核准日期(審查通過日)：2019 年 4 月 19 日
計畫執行期間：自 2019 年 4 月 19 日至 2020 年 7 月 31 日止
計畫書：第二版，2019 年 3 月 27 日
受試者同意書：第二版，2019 年 3 月 27 日
受試者同意書-注音版第一版，2019 年 3 月 27 日
問卷-受訪者、訪問者：第一版，2019 年 3 月 11 日

未預期事件或藥品嚴重不良反應通報、後續定期追蹤之程序及應注意事項，請參閱背面。

高雄醫學大學附設中和紀念醫院
第一人體試驗審查委員會
主任委員：顏學偉

西元 2019 年 4 月 19 日

Approval of Clinical Trial/Research

Protocol Title: Noise and acoustics in early childhood education in Taiwan and potential impacts on the children and their teachers.
Principal Investigator(s): Ming-Tsang Wu
Co_Investigator(s): Chia-Fang Wu
Institution: Kaohsiung Medical University Chung-Ho Memorial Hospital
Source of Funding: Ministry Of Science and Technology
IRB Number:KMUHIRB-SV(I)-20190023
Approval dated: 2019/4/19 ***Duration of Approval: from 2019/4/19 to 2020/7/31***
Protocol：Version 2,2019/3/27
Informed Consent Form：Version 2,2019/3/27
Informed Consent Form- Phonetic：1,2019/3/27
Questionnair-受訪者、訪問者：Version 1, 2019/3/11

See the back of this page for the procedures for reporting unanticipated problems, or drug serious adverse reactions, or interim, and other important notes.

Hsueh-Wei Yen

Hsueh-Wei Yen, MD
Chairman
Institutional Review Board- I
Kaohsiung Medical University
Chung-Ho Memorial Hospital

Kaohsiung Medical University Institutional Review Board Chung-Ho Memorial Hospital

幼兒園環境噪音問卷調查表

受訪者代號:
受訪日期: 西元_____年_____月_____日
中心(或幼兒園)代號:
職員代號:

受訪者版本:

一、 教學空間滿意度調查

1. 請您依序排列，對您而言”最重要的教學空間”。1 代表最重要，5 代表最不重要。
   - ☐ 燈光
   - ☐ 空氣流通(通風設備，非冷氣)
   - ☐ 活動空間
   - ☐ 園區內設備
   - ☐ 音響效果 (上課時)

2. 您目前所處環境製造出的聲音讓您有什麼感覺?
   - ☐ 舒服
   - ☐ 困擾
   - ☐ 刺耳
   - ☐ 迴音
   - ☐ 煩燥
   - ☐ 清晰
   - ☐ 放鬆
   - ☐ 其他 (請描述)

3. 您對目前的教學環境有何評價? 若您分別在不同教室工作，請分別選填。

教室 1	教室 2	教室 3
☐ 非常好	☐ 非常好	☐ 非常好
☐ 良好	☐ 良好	☐ 良好
☐ 差	☐ 差	☐ 差
☐ 非常差	☐ 非常差	☐ 非常差

4. 對於給予”差”及”非常差”評價的教室，您認為最大的問題在於:
   - ☐ 開放式空間
   - ☐ 迴音太大
   - ☐ 教室外噪音過大
   - ☐ 學生太吵/製造噪音
   - ☐ 其他因素

二、 教室內噪音來源調查

1. 您對教室內的噪音(包括學生製造的)有感到任何困擾(問題或意見)嗎?
   □ 有 □ 無
   請解釋您的選擇:

2. 在教室內有哪部份噪音是學生製造的?
   □ 無 □ 一些 □ 大部份 □ 全部

3. 您是否有注意到一天當中某些時段或特別課程中，學生會比較吵鬧?

4. 在一天工作中，您認為有多少時間（小時）是噪音最嚴重的時候? (請用百分比表示，或工作時數表示)。例如: 一天工作八小時，大約 4 小時很嚴重，4/8hr =50%

   _____

5. 是否有任何情況(例如:天氣)，影響噪音強度呢?

   _____

6. 請選擇教室內的噪音來源。

   □ 儀器發出的聲音
   □ 開關門產生的聲音
   □ 地板(腳步聲/高跟鞋/打球聲等)
   □ 通風系統產生的聲音
   □ 電風扇產生的聲音
   □ 搬動桌椅或大型儀器產生的聲音
   □ 敲打窗戶產生的聲音
   □ 空調系統產生的聲音
   □ 燈源產生的聲音
   □ 音響設備產生的聲音
   □ 其他 (請說明) _____

三、 教室外噪音來源調查

1. 對於教室外的噪音，您是否覺得困擾?
   □ 有 □ 無

2. 請選擇哪些噪音是來自於教室外，但是仍屬於幼兒園範圍內。
   □ 走廊
   □ 其他教室或特殊活動
   □ 各式的走路聲音
   □ 儀器製造的噪音 (如: 盪鞦韆/開關門/搬動桌椅)
   □ 其他 (請說明) _____

3. 請選擇哪些噪音是來自於幼兒園外面。
   - ☐ 交通車輛
   - ☐ 飛機
   - ☐ 火車
   - ☐ 宣傳車或宣傳活動
   - ☐ 道路工程
   - ☐ 除草機
   - ☐ 其他商業活動
   - ☐ 狗叫聲
   - ☐ 吵鬧的音樂聲
   - ☐ 其他 (請說明) _____
4. 上述何種噪音是您覺得最吵雜的?

   _____

   為什麼?

   _____

四、 噪音對學童的影響

1. 您對於教室內的噪音程度有什麼看法?

   _____

2. 您覺得教室內的噪音對學童有什麼影響?

   _____

3. 您覺得噪音程度太高了嗎?
4. 您認為噪音對學童有傷害嗎?
5. 您認為噪音對老師有傷害嗎?

五、 噪音對殘障學童的影響

1. 您是否曾經教過特殊學生呢? 請註明。

2. 對於殘障學童，噪音對他們的影響為何? 請依照不同症狀分別描述。
(例: 症狀名稱 / 學生反應……)

_____
_____
_____

3. 殘障學童是否會對於某些聲音感到特別痛苦或難過嗎?

_____

4. 您覺得噪音對他們有哪些影響呢?

_____

5. 依照您的教學經驗，是否可以請您分享您使用哪些方法及策略來協助這群特別的學童呢?

_____

6. 您是否認為噪音對殘障學童比其他學童的影響更嚴重?

☐ 是 ☐ 否

請提出您的看法:

_____

六、 噪音對教職員的影響

1. 您覺得噪音對您或同事有什麼影響呢?

_____

2. 是否有其他意見想要補充呢?

七、 政策，規劃及未來發展

1. 請問您的工作場所是否有針對噪音制定相關政策或規劃程序(具體的工作程序指引，例如:製造必要噪音前應先請學童離開並關門）嗎?
☐ 是 ☐ 否

如果有的話，是否可以請您提供相關文件，讓我們參考?

2. 請問您會使用什麼樣的方式來降低幼兒園的噪音強度呢?
   - ☐ 規定安靜時間
   - ☐ 規定學童的睡眠/休息時間
   - ☐ 編排教職員輪替處理教學與非教學職務
   - ☐ 禁止過度吵鬧的活動及音樂
   - ☐ 其他(請說明) _____

3. 您認為有哪些方法可以有效的降低噪音，並且只需花費低成本。

   _____

4. 針對降低或控制噪音的方法，您覺得有哪方面需要更加的深入調查研究及改善呢? **(請提出建議)**

   _____

5. 您希望我們進行其他項目的研究嗎? 請說明。

   _____

6. 還有什麼是我們研究人員可以協助/幫助您和幼兒園學童的地方嗎?

   _____

7. 在問卷調查中並未提到，但您仍有其他意見或建議，請留言。

   _____

   _____

   _____

   _____

   _____

   _____

Participant questionnaire (English version)

Teaching spaces

— ONE

1. What do you consider the aspects of your teaching spaces to be the most important? Please rank those given with 1 being the most important to 5 the least important

    ☐ Lighting ~
    ☐ Ventilation
    ☐ Acoustics (listening environment)
    ☐ Equipment
    ☐ Adequate space

2. How do you experience the listening environment in the rooms you teach in? Please indicate

    ☐ Comfortable
    ☐ Confusing
    ☐ Echo (reverberation)
    ☐ Harsh
    ☐ Clear
    ☐ Irritating
    ☐ Relaxing
    ☐ Other (Please describe)

2. How would you rate your room(s) teaching environment? If you teach in more than one room please indicate for each room you teach in.

Room 1	Room 2	Room 3
☐ Just right	☐ Just right	☐ Just right
☐ Good	☐ Good	☐ Good
☐ Poor	☐ Poor	☐ Poor
☐ Very poor	☐ Very poor	☐ Very poor

4. For rooms rated poor or very poor what do you consider are the most problems in the room? Please indicate

    ☐ Open plan style room
    ☐ Too much echo (reverberation
    ☐ Too much noise outside the room
    ☐ Noise produced by the children too high
    ☐ Other (please indicate)

二 TWO

Noise sources generated inside the teaching rooms

1 Do you have any problems with noise created inside the rooms (including noise made by children)?

2 What amount of nose generated in the teaching spaces is made by the children?

☐ None: ☐ Some: ☐ Most : ☐ All

3 What times of the day or special events do you perceive noise to be the most excessive?

4 How much of the time during the working day (in percentage for example do you consider noise to be too high? 4/8= 50%

5 Are there any conditions (weather etc) which affect noise levels?

6 Please identify all other sources generated inside the rooms!

1 Equipment	2 Moving equipment around the room (furniture scape
3 Doors	4 Rattling windows
5 Floor Foot pounding	6 Ventilation
7 Air Con	8 Lights
9 Fans	10 Hi fi
11 Others (indicate)	

+++++++++

三 THREE

Noise Sources Outside

1 Do you have problems with outside noise or noise from activities not associated with the centre? (Please include noise form other businesses etc if you share a building complex with other tenants or occupants.
Yes ☐ No ☐

2 Identify the sources of noise outside teaching rooms but inside Centre
- ☐ Noise from corridors (if applicable)
- ☐ Noise from other rooms or activities within centre
- ☐ Foot pounding/foot traffic
- ☐ Noise from equipment (Squeaky swings, gates, doors etc)
- ☐ Others Please explain

3 Identify the sources of noise generated outside the Centre
- ☐ Road Traffic

- ☐ Aircraft
- ☐ Rail
- ☐ Recreational vehicles and activates
- ☐ Road or earth works
- ☐ Lawn mowing
- ☐ Noise from other businesses or activities
- ☐ Dogs
- ☐ Loud music
- ☐ Other

Please explain

4 What kind of noise do you find the most intrusive and annoying?

Why?

四 FOUR

Effects of Noise on Children

1 How do you feel about the level of noise in the room?

2 How do you feel the levels of noise affects children generally?

3 Do you feel the noise is too high?

4 Do you think it may be harmful to the children?

5 Do you think it may be harmful to the teachers?

五 FIVE

Effects of noise on Special needs children experiencing te following conditions.

1 Are there any students you are aware of either now or in the past few years who you have cared for who experience any one of the following disabilities? Please indicate:

- ☐ Partially sighted ☐Hearing loss ☐ Down syndrome
- ☐ Autistic Spectrum Disorder ☐ Asperger syndrome
- ☐ Pervasive developmental disorder ☐ ADHD disorder
- ☐ Giftedness (recently added)
- ☐ Other conditions resulting in delay in development, speech and communication. Please indicate

2 For each of the above disabilities you have indicated could you indicate how noise affects these children you have cared for? (i) Special need

3 Are there any sounds the child finds particularly distressing?

4 What effects of noise have you observed in these children?

5 Are there any strategies you can suggest from your practice and experience, which can be implemented to help these children?

6 In your opinion are children experiencing disability, generally more adversely affected by noise than other children?

Yes No

Comments

+++++++

六 SIX Effects of noise on teaching staff

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1 How do you feel noise affects teaching staff? This can be your own personal experience or that related to you by colleagues.

2 Any other comments you would like to make?

+++++

七 SEVEN Policies, procedures and further work

1 Does your centre have any formal policies and procedures in place regarding noise?

Yes ☐ No ☐

If yes would you mind submitting these for consideration and dissemination as part of our study? (There are likely to be excellent individual policies, the contents of which if disseminated in a generic way could be very beneficial.)

2 What strategies do you use to minimise noise levels in your centre?

- ☐ Quiet times,
- ☐ Compulsory sleep/rest times,
- ☐ Rostering of staff between contact and non-contact duties
- ☐ Ban on loud music or activates generating excessive noise.
- ☐ Other

3 What low cost or cost effective strategies do you think could be implemented?

4 Is this an area, which needs more investigation and work?

Yes ☐ No☐

5 Is there any particular work would you like to see undertaken?

6 What other ways can we assist teaching staff and the children?

7 Please free to make any other comments or suggestions not covered in the questionnaire