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How can a focus on classroom environment contribute to our students' academic success?

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Learning outcomes

- ▶ Explain how design thinking provides an effective approach to improve our students' experiences in the classroom, and gives classroom users agency to make such improvements
- ▶ Recognise how design thinking can help identify and address problems which derive from environmental variables like air quality, partly by building a research phase into the process to help build understanding of the problem
- ▶ Understand how classroom environmental variables, like air quality and temperature, can affect learning and attainment

Design thinking



https://www.youtube.com/watch?v=_r0VX-aU_T8

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What would you change about your classroom and why?

- ▶ We all have things we'd like to change about our classrooms.
- ▶ In pairs, interview each other to find out what they would like to change in their classroom, and why (what would be the positive impact of changing it)
- ▶ You have 2 minutes for each interview



Collating ideas

- ▶ Share and collate your ideas with the rest of your group into a table like the one on the right.
- ▶ Some of the ideas from each pair may overlap. Only include each idea once.

What do you want to change?	Why do you want to change it?

Understand how your students experience the classroom and the challenges they may encounter

Building empathy with your students as users of your classroom



User empathy map

- ▶ Students will also have ideas about what to change in your classroom.
- ▶ This is important - it's their success that we want to maximise.
- ▶ Complete the grid from the perspective of the student. You would usually run this exercise with students.
- ▶ Try to imagine both what your best students would say, but also those who are 'not your best'
- ▶ Draw the grid on a large piece of paper, and complete it together.

<p>Do <i>What do your students need to do in your classroom?</i></p>	<p>Think <i>What do you students think about your classroom?</i></p>
<p>Say <i>What would your students say about your classroom to their friends and parents?</i></p>	<p>Feel <i>What do your students feel when they are in your classroom?</i></p>

Empathy map

<p>Do <i>What do your students need to do in your classroom?</i></p>	<p>Think <i>What do your students think about your classroom?</i></p>
<p>Say <i>What would your students say about your classroom to their friends and parents?</i></p>	<p>Feel <i>What do your students feel when they are in your classroom?</i></p>

Now that we've considered your and your students' views and experiences of your classroom, both from your perspectives and from those of your students, we need to focus in on a single problem.

Define a problem



- ▶ Think about the things you wanted to change, and think about the student empathy map.
- ▶ You should have some good ideas of problems you could address in your classroom(s).
- ▶ It's now time to define a problem statement, which defines where you want to get to, and the challenges in getting there.
- ▶ I want you to choose one problem statement, preferably about the classroom itself.

Defining the problem statement

Define a point of view

Problem statement

“I am a school student, who wants to learn and enjoy their learning in the classroom.”

“I am a school teacher, who wants their students to learn and enjoy their learning in my classroom.”

“I’m struggling because...”

Defining the problem statement

Turn the point of view into a
'How might we?' question

Problem statement

“How might we _____ so that our students can learn and enjoy their learning in the classroom?”

Ideation



Ideation

- ▶ Now you've written your problem statements, you need to think about possible ways in which you can address the problem.

- ▶ There are lots of ways to stimulate creative ideation.

Approaches to ideation

- ▶ Brainstorming – draws on the group
- ▶ Brainwriting – enables individuals' participation
- ▶ Bad ideas – reduces reticence
- ▶ Mind-mapping – problem statement in the centre, idea and consequences leading from the statement
- ▶ Sketchstorm – like brainstorming but visualisation may be beneficial
- ▶ Fishbowling – two rings, one brainstorming, one listening
- ▶ Anti-solution generation
- ▶ Jigsawing / envoying / snowballing – use of any group talk techniques to stimulate ideas
- ▶ Analogies
- ▶ Provocations – building deliberate challenges during the ideation process
- ▶ Storyboarding – storyboarding the problem to help 'see' ideas for addressing the problem
- ▶ Use of AI

Ideation

- ▶ Collate your ideas into a 'If we, then we' table, which lists the action (under 'if we') and the consequence of that action under 'then we'.

If we...	Then we...	Because
<i>Open the windows</i>	<i>Will concentrate better</i>	<i>The air will be fresher</i>



Empathize

Understanding people



Define

Figuring out the problem



Test

Refining the product



Ideate

Generating your ideas



Prototype

Creation and experimentation



<https://www.maqe.com/insight/the-design-thinking-process-how-does-it-work/>

Building understanding to support ideation and prototyping

Understanding the problem to help refine your problem statement, ideation and prototyping



Problem statement

“I am a school student, who wants to learn and enjoy their learning in the classroom. I’m struggling because I can’t concentrate in this classroom.”

“How might we change the classroom so I can concentrate better?”

Problem statement

“I am a school student, who wants to learn and enjoy their learning in the classroom. I’m struggling because I always get a headache in this classroom.”

“How might we change the classroom so I don’t get a headache so much?”

Problem statement

“I am a school student, who wants to learn and enjoy their learning in the classroom. I’m struggling because I can’t read the interactive whiteboard.”

“How might we change the classroom to make it easier to read the interactive whiteboard?”

Problem statement

“I am a school student, who wants to learn and enjoy their learning in the classroom. I’m struggling because the classroom is too noisy.”

“How might we change the classroom so the classroom is less noisy?”

Problem statement

“I am a school student, who wants to learn and enjoy their learning in the classroom. I’m struggling because the classroom is really dark

“How might we change the classroom to make it lighter?”

Problem statement

“I am a school student, who wants to learn and enjoy their learning in the classroom. I’m struggling because I keep feeling sleepy in this classroom.”

“How might we change the classroom so I don’t feel as sleepy during lessons?”

Problem statement

“I am a school student, who wants to learn and enjoy their learning in the classroom. I’m struggling because my lesson is at the end of the day and the classroom is so stuffy.

“How might we change the classroom so the classroom is less stuffy?”

Air quality



“I am a school student, who wants to learn and enjoy their learning in the classroom. I’m struggling because I keep feeling sleepy in this classroom.”



“I am a school student, who wants to learn and enjoy their learning in the classroom. I’m struggling because my lesson is at the end of the day and the classroom is so stuffy.



Air quality




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Monitor CO ₂ Reading	LED colour	Number of LEDs	Description	What this means for you	Actions
0-799 ppm	Green 	1 - 2 lights	Indicative of good ventilation	Ventilation is acting to help maintain a good classroom environment, including reducing the risk that airborne diseases are spread.	If CO ₂ levels are not rising then you can consider having your windows open slightly less wide or temporarily closing them. Do so gradually and in stages.



800-
1499
ppm



3 - 6
lights

Potential for
increasingly
stuffy/stale
air

Consider the potential to improve ventilation in your classroom for better health and learning outcomes - this might include having more windows & doors open, opening them more widely, or getting any mechanical ventilation serviced.

Consider opening windows and/or doors - higher-level openings first and then, if necessary, also lower-level openings. Continue to monitor the CO₂ levels.



1500-
3000
ppm



7 - 8
lights

Indicative of
inadequate
ventilation

There are quite high levels of shared/rebreathed air in your classroom which, if maintained, might lead to poorer learning and health outcomes. Consider the potential to improve ventilation (for example, by having more air flow by opening any windows and doors, or getting any mechanical ventilation serviced).

Keep checking that ventilation provision (e.g. windows and doors) is fully operational/open and continue to monitor the CO₂ levels. If consistent, notify school leadership.



3000+ ppm	Red + Purple 	9 lights	Indicative of inadequate ventilation	There are quite high levels of shared/rebreathed air in your classroom which, if maintained, might lead to poorer learning and health outcomes. Consider the potential to improve ventilation (for example, by having more air flow by opening any windows and doors, or getting any mechanical ventilation serviced).	Keep checking that ventilation provision (e.g. windows and doors) is fully operational/open and continue to monitor the CO ₂ levels. If consistent, notify school leadership.
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Improving air quality



Improving Indoor Air Quality

What can I do to improve my air quality?



TAPAS

Tackling air pollution at school

Particulate Matter

- Use a fan fitted with a HEPA filter.
- Vacuum and dust regularly.
- Cook with the extractor fan on.
- Use candles instead of burning incense.
- Don't open windows next to very busy roads.

Volatile Organic Compounds (VOCs)

- Use solid or liquid cleaning products which are allergy friendly or chemical free rather than sprays.
- Only burn candles in large well-ventilated spaces.
- Consider buying low VOC paints and furnishings.

Gases (CO, CO₂, NO₂)

- Cook with the extractor fan on.
- Keep rooms well aired by opening windows 5-10 minutes a few times a day when you're using them.
- Don't smoke indoors.
- Get more houseplants (these also help reduce VOC's and particulate matter).

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Problem statement

- ▶ I am a school student who wants to learn in a healthy environment where I can concentrate, but I know from research that after 30 minutes, CO₂ levels build up to levels which can affect my concentration and make me feel sleepy”
- ▶ “How might we regulate the CO₂ levels in the classroom so I don’t feel sleepy?”



Ideation

- ▶ Deploy CO₂ monitors in every classroom
- ▶ The teacher should open the windows to ventilate the classroom and keep CO₂ levels below 800ppm



Prototyping and testing

- ▶ Opening windows reduced CO₂ levels below 800ppm and towards 400ppm
- ▶ Some windows were obstructed and couldn't be opened, or teachers said they were too busy to open them
- ▶ Opening windows facing a busy road, led to high NO_x and particulate matter entering the classroom



Implementing

Teachers should monitor CO2 levels using a meter.

School leaders should ensure that windows can be opened, or that they open automatically.

They should open windows to stop CO2 building up beyond 800ppm.

For classrooms on busy roads, only open the windows when the traffic is low to prevent entry of particulate matter and NOx. Opening windows overnight, and then in the middle of the day, may be a good solution.

Other impacts of school design on students' academic success?

Barrett et al. (2015a, b; 2018)



Impact of classroom design



The impact of classroom design on pupils' learning: Final results of a holistic, multi-level analysis

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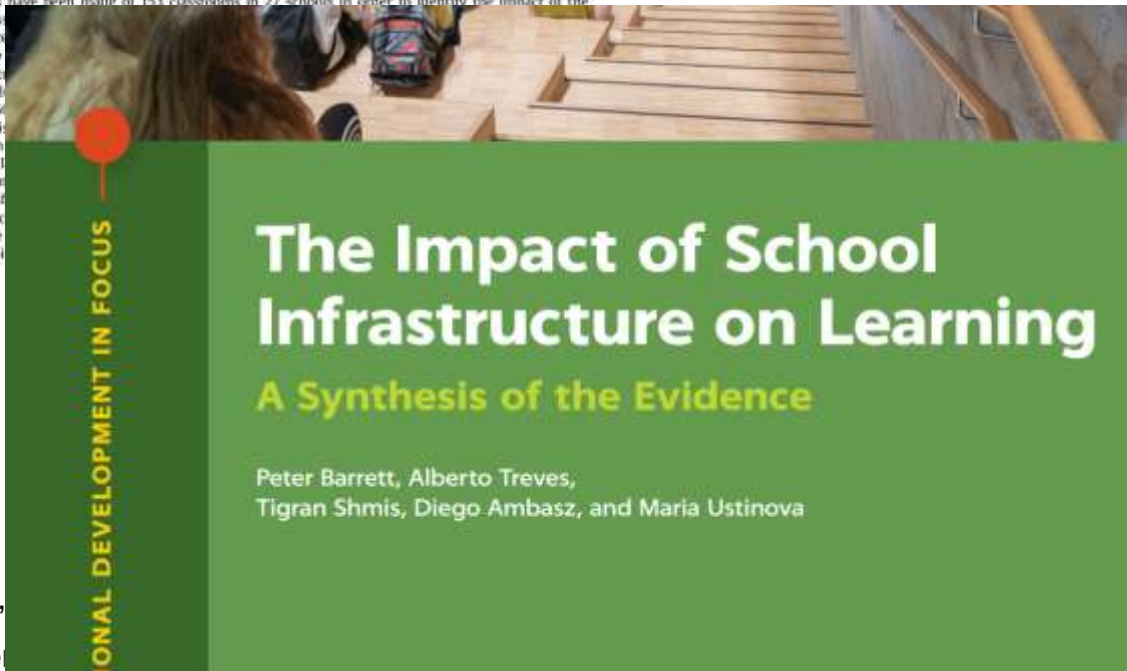
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ABSTRACT

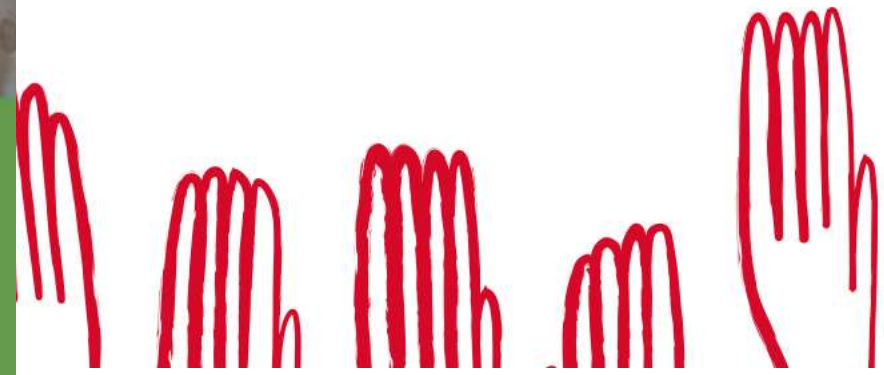
Assessments have been made of 153 classrooms in 27 schools in order to identify the impact of the physical classroom design on learning. This study identifies the impact of specific space design on learning. This study (SIN) concept is based on the idea of an individual learning environment for around 50 pupils. Within this concept, the variation in design provides some flexibility. The identification of the impact of design on learning performance is a key finding for school design.



Clever Classrooms

Summary report of the HEAD Project
(Holistic Evidence and Design)

Professor Peter Barrett
Dr Yufan Zhang
Dr Fay Davies
Dr Lucinda Barrett



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Impact of classroom design

Naturalness

- ▶ Air quality
- ▶ Light
- ▶ Temperature
- ▶ Sound
- ▶ Link to nature

Individualisation

- ▶ Flexibility
- ▶ Ownership
- ▶ Connection

Stimulation

- ▶ Complexity
- ▶ Colour

Lighting



Natural light

The importance of daylighting in classrooms and its effect on primary students' academic performance

10 March 2022

Environmental Design and Engineering MSc student (2020-21) Jean-Baptiste Clochet reviews the importance of daylighting in schools.



A classroom for primary school children should not only be designed for high academic performance, but also for the well-being of children. And what if some parameters, such as daylighting could both have a positive impact on student's academic performance as well as their wellbeing? Indeed, primary school students spend 190 days per year at school and around 5-6 hours a day in classrooms in the UK [1], and their environment can have a decisive impact on their academic performance [2].

Better student progress
(Barret et al. 2015)

Higher attainment in reading and science
(Herschong et al. 2002)

Better concentration
(Slegers et al. 2013)

Better physical and mental health and comfort
(Slegers et al. 2013)

Increased reading vocabulary and science test scores
(Tanner 2009)

Glare and low frequency fluorescent lights



Journal of Environmental Psychology

Volume 29, Issue 1, March 2009, Pages 63-75



Lighting and discomfort in the classroom

Mark Winterbottom^a  , Arnold Wilkins^{b 1} 

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<https://doi.org/10.1016/j.jenvp.2008.11.007>

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Abstract

Aspects of classroom lighting and décor that can promote discomfort and impair task performance through glare, and imperceptible 100Hz flicker from fluorescent lighting, were examined in a sample of UK schools. In 90 classrooms, across eleven secondary schools and six local education authorities variables measured included flicker, illuminance at desks, and luminance of whiteboards. Results showed that 80% of classrooms are lit with 100Hz fluorescent lighting that can cause headaches and impair visual performance. Mean illuminance (from excessive day- and artificial lighting) was in excess of recommended design illuminance in 88% of classrooms, and in 84% exceeded

Glare can cause discomfort and impair task performance (Winterbottom & Wilkins 2008)

Low frequency fluorescent lamps can cause headaches (Wilkins 2003)

Classroom illuminance should be between 300-500 lux at students' desk (CIBSE)

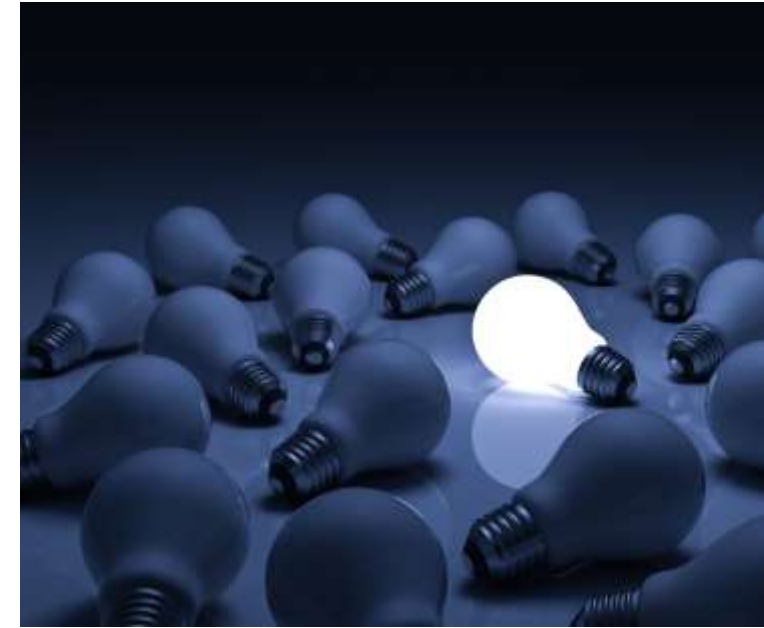
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Actions for you

- ▶ Maximise natural light, but avoid glare, keeping lighting even across the classroom (avoiding glare spots or dark spots)
- ▶ Use artificial light when natural light inadequate
- ▶ Avoid blocking windows with displays and furniture
- ▶ Use blinds to avoid glare, but keep blinds open otherwise
- ▶ Use a high-power projector on a matt surface to reduce need to use blinds to avoid glare on the screen
- ▶ Only project onto a matt surface, rather than a glossy whiteboard, to avoid a glare spot
- ▶ Give teachers control over switching individual luminaires on and off.



Temperature



Temperature

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RESEARCH ARTICLE

Effects of Classroom Ventilation Rate and Temperature on Students' Test Scores

Ulla Haverinen-Shaughnessy , Richard J. Shaughnessy  

Published: August 28, 2015 • <https://doi.org/10.1371/journal.pone.0136165>

Article

Authors

Metrics

Comments

Media Coverage

Abstract

Significance

Introduction

Materials and Methods

Results and Discussion

Acknowledgments

Author Contributions

References

Reader Comments

Figures

Abstract

Using a multilevel approach, we estimated the effects of classroom ventilation rate and temperature on academic achievement. The analysis is based on measurement data from a 70 elementary school district (140 fifth grade classrooms) from Southwestern United States, and student level data (N = 3109) on socioeconomic variables and standardized test scores. There was a statistically significant association between ventilation rates and mathematics scores, and it was stronger when the six classrooms with high ventilation rates that were indicated as outliers were filtered (> 7.1 l/s per person). The association remained significant when prior year test scores were included in the model, resulting in less unexplained variability. Students' mean mathematics scores (average 2286 points) were increased by up to eleven points (0.5%) per each liter per second per person increase in ventilation rate within the range of 0.9–7.1 l/s per person (estimated effect size 74 points). There was an additional increase of 12–13 points per each 1°C decrease in temperature within the observed range of 20–25°C (estimated effect size 67 points). Effects of similar magnitude but higher variability were observed for reading and science scores. In conclusion, maintaining adequate ventilation and thermal comfort in classrooms could significantly improve academic achievement of students.

As temperature increases, discomfort increases (Zeiler and Boxem 2009)

As temperature increases, task-performance and achievement decrease (Mendell and Heath 2005)

As temperature decreases (in range 20-25C), maths, science and reading scores increase (Shaughnessy and Shaughnessy 2015)

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Actions for you

- ▶ If you have a thermostat in your classroom or school, keep the temperature cool comfortable
- ▶ If incident sunlight leads to warming, close blinds and open windows
- ▶ If the classroom regularly overheats, school leaders should fit external shading to stop radiation entering the room



Sound



Sound

Revisiting Speech Interference in Classrooms: Revisando la interferencia en el habla dentro del salón de clases

Michel Picard & John S. Bradley

Pages 221-244 | Received 07 Feb 2001, Accepted 06 Jun 2001, Published online: 07 Jul 2009

Download citation

References Supplemental Citations Metrics Reprints & Permissions [Read this article](#)

Abstract

A review of the effects of ambient noise and reverberation on speech intelligibility in classrooms has been completed because of the longstanding lack of agreement on preferred acoustical criteria for unconstrained speech accessibility and communication in educational facilities. An overwhelming body of evidence has been collected to suggest that noise levels in particular are usually far in excess of any reasonable prescription for optimal conditions for understanding speech in classrooms. Quite surprisingly, poor classroom acoustics seem to be the prevailing condition for both normally-hearing and hearing-impaired students with reported A-weighted ambient noise levels 4-37 dB above values currently agreed upon to provide optimal understanding. Revision of currently proposed room acoustic performance criteria to ensure speech accessibility for all students indicates the need for a guideline weighted for age and one for

Related

People also read

The Effects of Temperature on the Performance of Children (1257) >

Pavel Warshawsky HVAC&R Research Published online: 2012

Effects of Noise and School

Auditory environment sub-optimal (Picard and Bradley 2001)

Effects of noise on children at school (Shield and Dockerell 2003)

Impact of acoustics on attainment for students with SEN (Barrett et al. 2015)

Impact of acoustics on classroom learning (Canning and James 2012)

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Actions for you

- ▶ Planting to shield school buildings from noise
- ▶ Fit sound absorbent surfaces in classrooms
- ▶ Fit rubber feet to movable furniture
- ▶ Use carpet to attenuate noise



Ownership



Ownership

A PLACE OF THEIR OWN: Children and the Physical Environment

Ulrich, Clare
Human Ecology; Oct 2004; 32, 2; Social Science Premium Collection
pg. 11

A PLACE OF THEIR OWN: Children and the Physical Environment



Ownership of the classroom promotes feelings of responsibility (DeVries and Jan 1994)

Display of students' work fosters greater learning engagement (Ulrich 2004)

Personalised spaces help to promote learning (McMillan 1997)

Actions for you

- ▶ Display student work to provide a sense of ownership.
- ▶ Make each classroom recognisable from others by distinctive class-made displays / artwork
- ▶ Let students personalise aspects of the classroom, e.g. named lockers.
- ▶ Classroom infrastructure should be maintained and kept modern, to value students as learners.



Complexity



Complexity

Less visual distraction leads to higher attainment (Godwin and Fisher 2014)

Attainment is higher in sparsely decorated classrooms (Fisher et al. 2014)

High or low levels of visual complexity lead to poor learning outcomes, whereas intermediate level of visual complexity is optimal (Barrett et al. 2015)

Actions for you

- ▶ The displays on the walls should be designed to provide a lively sense to the classroom, but without becoming chaotic in feel.
- ▶ 20-50% of the available wall space should be kept clear.



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Colour



Colour

Colour can affect learning (Jalil et al. 2012)

Large, brightly coloured areas or white walls with few colour elements do not have a positive impact on learning.

Light walls plus a feature wall in a brighter colour was more effective for learning

Additional colour elements in the classroom played a complementary, stimulating role. For example, relatively bright colours on the floor, blinds, desk, chairs add extra highlights and flashes of colour

(Barrett et al. 2015)

Actions for you

- ▶ Adopt light walls with a feature wall highlighted in a brighter colour to achieve an appropriate background level of stimulation.
- ▶ Avoid simple white environments which lead to restlessness, excessive response, and difficulty in concentration.
- ▶ Design displays in a way that is sensitive to the colour in the rest of the room. Increase stimulation if the background is muted. If the background is very bright, adopt muted shades.



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Thank you
Any questions?



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