

**TAPAS**

Tackling air pollution at school

# Final Report

## Tackling Air Pollution At School (TAPAS) Network

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25 July 2024

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## Introduction

This report gives an overview of the ‘Tackling Air Pollution At School’ (TAPAS) network activities over the course of the project. The project officially started in September 2020 amidst a global pandemic which forced all meetings online and relinquished any in-person networking. While this was not an ideal situation, network activities seamlessly switched to online and progressed accordingly. The project was granted a no-cost extension, extending the project end date from August 2023 to August 2024.

School children were chosen as the focus of this network as they are among the vulnerable groups in society. School pupils will experience the impact of poor air quality for the longest period into the future. Due to the immaturity of their immune system they are physiologically less able to regulate their temperature and are more susceptible to exposure to air pollution than adults<sup>1</sup>. Their organs are still developing making them more susceptible to damage<sup>2,3</sup>.

A vision of the TAPAS network was for schools to be empowered to reduce their own exposure to pollution. By bringing together air pollution experts, healthcare professionals, engineers, campaigners, policy makers, teachers, parents and most importantly children, the network hoped to pave the way for a healthier, cleaner future and inspire the next generation of young minds. Expert knowledge and tools made available to staff, students and parents through the TAPAS network will enable schools to tackle their air pollution, inside and out.

## Background of the network

TAPAS was set up as a network designed to bring experts together to understand air quality in and around schools. Funded as part of the [UKRI Strategic Priorities Fund Clean Air Programme](#), the network brought together stakeholders across academia, education, public policy, civil society and business and has worked towards engaging better with schools to improve public understanding of the effects of air pollution. The overarching aim of the Tackling Air Pollution at School (TAPAS) network is ‘to bring together interdisciplinary expertise to develop the research base to design and operate healthy schools in the environment of the future’. This was achieved by funding research projects, holding seminars with a variety of experts, and regularly meeting with our stakeholders and members to further our knowledge base and disseminate information. The network was split into 4 focus areas each led by 2 Co-Investigators as detailed below.

### **Focus Area 1: Understanding the problem in school**

This group focused on the levels of pollution and their impact on overall indoor environmental quality (IEQ) – the extent of the problem; how the outdoor pollution impacts IEQ; the health impacts; the broader impacts on learning; and schools in the context of the wider city, how air pollution problems link into wider sustainability issues in cities.

### **Focus Area 2: Understanding the potential solutions**

Focus Area 2 was set up to look at interventions that could improve air quality around schools. There were 5 original members of the group, but this grew over time as more people asked to join the meetings. At the time of our last meeting, around 40 people were on the mailing list. Towards the end of 2021, we started to ask new members who wanted to join the group to give a presentation at their first meeting. This allowed us to understand the new technologies (mostly air cleaning or air monitoring) that these new members were using, as well as their applications. The format was an open presentation where we were free to ask questions about the technologies at the end. Speakers included

representatives from Immaterial, Earthsense, IS Clean Air, Euroac Research, AirLabs, Cp Catapult, Air Gradient, Hoare Lea, SLS Airtech, Cundell, Rensair, Smart Airfilters, South Coast Science, Quant AQ, Clean Air Stars, Medicaire, Airly and Camfil. Many of these members continued to attend meetings until the end of the project.

### **Focus Area 3: Prioritising the solutions/taking an integrated approach**

Focus area 3 concentrated on the prioritisation of various measures that can reduce schools' exposure to air pollution. The focus was on actions that can bring the most benefit to staff and pupils with the available funding. A systems approach was developed using brainstorming, agent-based and economic modelling including quantification of health-related effects of tackling air pollution. A framework for prioritising interventions was developed and findings were published in a peer-reviewed journal (['Prioritising Actions for Improving Classroom Air Quality Based on the Analytic Hierarchy Process'](#)).

### **Focus Area 4: Dissemination and participation**

Focus Area 4 worked closely with Global Action Plan in field studies involving schools and making links to other sustainability agendas. We developed support for schools with evidence-based solutions and to help them take action. We set up wide dissemination activities through sector bodies including air quality campaigners and via the CO-SCHOOLS website [www.coschools.org.uk](http://www.coschools.org.uk).

## **TAPAS Key Performance Indicators (KPI)**

The points below detail the networks' Key Performance Indicator's (KPI) set out at the start of the project that have been well supported by TAPAS' ongoing project activities.

### **KPI 1: Influential interdisciplinary academic and research community**

The TAPAS network has worked directly with local and national government representatives, academic, engineering, health professional and economic stakeholders. Events such as the UK Indoor Air Quality Observatory workshops and the Clean Air Networks Conference are good examples of how our network has enabled knowledge sharing across different professional communities and expanded our knowledge to identify wider co-benefits of tackling air pollution at school as part of the prioritisation process. Our Collaboration Workshop for small grant funding also encouraged researchers from social science backgrounds to take part and make links with those working in scientific disciplines.

### **KPI 2: Knowledge generation**

Our three TAPAS funded grants included projects that look to identify and test interventions in the built environment to reduce indoor and outdoor air pollution, including influencing behavioural changes in the classroom and implementing engineering mitigations. Working with our partners at Global Action Plan, we are also seeking additional funding to develop a national clean air strategy for schools which will expand our knowledge generation into schools nationwide. Many TAPAS members have contributed to knowledge generation through position papers, media articles and peer-reviewed [publications](#).

### **KPI 3: Knowledge exchange with stakeholders including academics, businesses, local and national government, health sector, policy makers, public, charities**

The TAPAS network has engaged with stakeholders across the UK and internationally over a range of disciplines to facilitate inter-disciplinary knowledge exchange, as demonstrated through our extensive programme of conference events, stakeholder engagement workshops, full network meetings, and recurring lunchtime seminars.

### **KPI 4: Innovation**

We have engaged with innovators throughout the project, but our remit was not to support the development of specific technologies. Our stakeholder engagement events have facilitated linking school leaders, researchers and policy makers to innovators and business leaders in the clean air space which may help to develop sustainable products and services and stimulate policy and regulatory innovation.

## **TAPAS Work Packages**

Over the course of the project, the TAPAS Network has organised a range of activities that have contributed to the five work packages set out in the original proposal.

### **Work Package 1: Identify and engage stakeholders**

We've had a wide range of institutions involved right from the beginning and have expanded the network through monthly newsletters, online lunchtime seminars, and annual full network meetings. These activities have all worked to increase the network engagement to 467 newsletter subscribers and more than 1000 twitter/X followers. TAPAS co-investigators and other working members have also contributed to position papers, media articles and co-design solutions which has helped to increase our profile and engage a wider audience.

At the start of the project, we held a collaboration building workshop which resulted in three successful research teams made up of a range of academics, educational representatives (parents and governors), entrepreneurs and consultants. In addition, our four focus areas met at regular intervals attracting a broad range of stakeholders and encouraged cross-disciplinary discussions.

### **Work Package 2: Encourage interdisciplinary and Early Career Research (ECR) participation**

Through our range of network activities, we have encouraged interdisciplinary working with ECR's and undergraduate/postgraduate students. Our ECR research visit grant scheme has supported two ECR's on research visits relevant to TAPAS.

### **Work Package 3: Facilitate interdisciplinary understanding of air pollution and health impacts**

Our website hosts various resources for teachers and pupils such as educational videos explaining air pollution, the meaning of CO<sub>2</sub> data and ventilation, plus recordings of our lunchtime seminars and network meetings over the past 3 years. We jointly organised and participated in the Clean Air Networks Conference (5-6th July 2023) which facilitated cross-disciplinary networking on various cross-cutting themes. We have held yearly full network meetings with invited health professionals who presented on their work and the impacts of air pollution on childrens' health.

**Work Package 4: Identify future air quality challenges:**

To identify future air quality challenges we have hosted several workshops, including working closely with the [Breathing City - Future Urban Ventilation Network](#) to jointly host a series of meetings to discuss setting up an indoor air quality observatory in the UK, and attended various conferences both in the UK and internationally. Our Collaboration Building Workshop was based around identifying air quality challenges for schools, and the winning projects are focused on addressing those. Our full network meetings have invited discussions from our network members around air quality challenges for schools.

**Work Package 5: Coordinate aligned research areas**

To coordinate aligned research areas we have collaborated with other research projects, in particular the other Clean Air Networks funded by NERC, and funded 3 small research studies.

## Network activities

The following sections detail TAPAS Network activities which have built upon our project aims and objectives and worked towards fulfilling our project KPI's.

### Full network meetings

Over the course of the project, we have held 5 full network meetings attended by TAPAS Co-I's, TAPAS members, TAPAS industry partners and invited guests from other academic institutions, industry, charity groups and government. The purpose of these meetings was to share the work of TAPAS members and discuss relevant topics to further develop the impact of the TAPAS network. These meetings have encouraged networking between different disciplines and inspired new project ideas and partnerships to materialise, fulfilling our project objective to improve multi-disciplinary working and networking. All recordings can be viewed on the [TAPAS website](#).

#### Full Network Meeting 1: TAPAS kick off meeting, 23 October 2020

The first TAPAS full network meeting aimed to introduce the network to invited stakeholders and gather their perspectives on project objectives, engaging with partners, and any ideas for working together effectively. A diverse range of speakers were invited to attend from industry, local councils, charities, and government groups.

#### Full Network Meeting 2: Understanding transmission of COVID-19, 23 April 2021

This meeting focused on the impacts of COVID-19 with respect to air quality and discussed the transmission in classrooms, effective mitigation strategies, health impacts and reflections from the pandemic so far. Again, a diverse range of speakers attended and contributed to group discussions including health professionals, government representatives and leading academics.

#### Full Network Meeting 3: 'Should air cleaners be used in schools?', 7 March 2022

This meeting focused on the topic 'Should air cleaners be used in schools?' and included a range of speakers on this topic. The meeting agenda including speaker names can be viewed [here](#). Breakout sessions asked delegates to discuss the question 'How should air cleaners be deployed in schools?' and 'Do CO<sub>2</sub> monitors provide a measure of air pollution?'

#### Full Network Meeting 4: Engaging with schools, 19 October 2022

Our fourth in person full network meeting was titled 'Engaging with Schools' and was our first in-person meeting following the lifting of COVID-19 restrictions. The event brought together a range of people from industry, healthcare, academia, government and campaign charities. It was a very successful event that encouraged knowledge and idea sharing. At the end of the day we broke out into groups to discuss '**3 top tips for engaging with schools**'. A summary of captured thoughts and top tips are displayed in Figure 1.

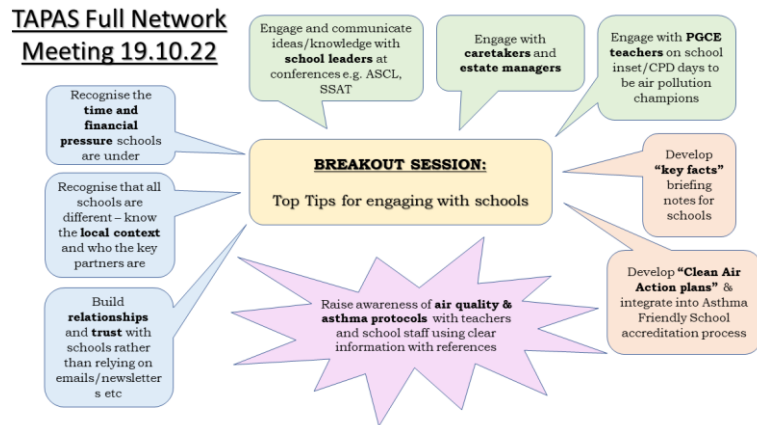


Figure 1: Output summary '3 top tips for engaging with schools'

Full Network Meeting 5: Engaging with Industry, 9 March 2023

On 9 March 2023 we held our fifth TAPAS full network meeting in-person. Several TAPAS researchers were invited to talk on a range of topics, including computer modelling which can help us to better understand the indoor environment, tips and interventions for improving air quality in and around schools, and how we can effectively communicate this research to schools. We also heard an inspirational talk from Tracy Enger who heads up the Indoor Air Quality programme in schools for the U.S. Environmental Protection Agency. Tracy talked on how her team in the U.S. have been working hard over the past 30 years to improve indoor air quality in schools to better health and academic outcomes for all students. A central part of the day involved our breakout sessions where we asked all attendees to firstly, discuss the future of the TAPAS network, and secondly, how TAPAS can better engage with industry. This created a wide range of interesting responses that will help focus our investigations for the remainder of TAPAS. A summary of these collected responses are shown in Figure 2.

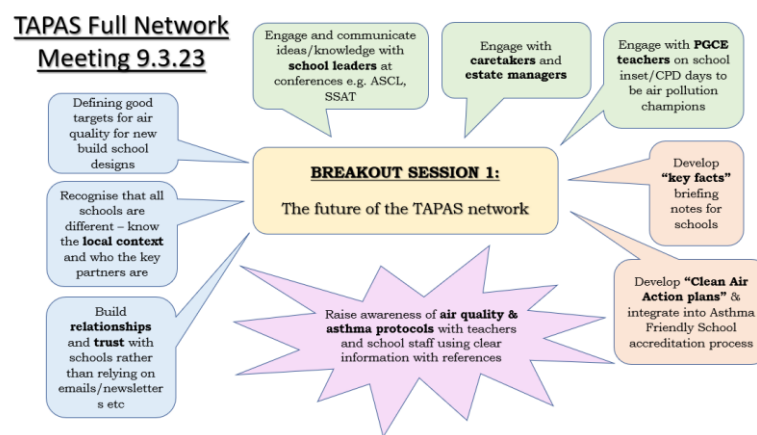


Figure 2: Summary output 'The future of the TAPAS network'



## Blog posts, media articles and media events

There have been several articles written by TAPAS members over the course of the project highlighting the importance of their research. These are listed below in date order.

Blog: [To clean, or not to clean? That is the question!](#) 10 May 2022

Professor Nicola Carslaw talks on why air cleaning devices have become so popular since the pandemic began.

Article: [Attendance focus shows why good ventilation in schools still matters](#), 25 May 2022

Professor Cath Noakes (Breathing City lead) and Dr Henry Burrige (Imperial College London) discuss why ventilation and air cleaning still matter in classrooms.

Blog: [What is the impact of air quality on lung health](#), 9 Oct 2022

Kat Roberts (TAPAS Network Manager) talks on the important work TAPAS is doing to tackle the problem of air pollution at school for the #AskAboutAsthma campaign.

Media event: [Inaugural World Ventilation Day](#), 8 Nov 2022

TAPAS proudly supported the inaugural 2022 World Ventilation Day which aims to raise awareness of the importance of ventilation as a crucial part of enabling health and wellbeing of people. It also seeks to recognise and celebrate the ventilation and indoor air quality community. The day was a huge success and TAPAS celebrated with researchers at the University of Cambridge who engaged students and staff in various ventilation activities.

Interview: [Why should we be concerned with ventilation?](#) 8 Nov 2022

Dr Henry Burrige (Imperial College London) talks to the Clean Air team about WorldVentil8 Day and why we should all be concerned.

Position paper: [Should air cleaners be deployed in schools?](#) 8 Dec 2022

This position paper highlights some of the major areas that Professor Nicola Carslaw and other TAPAS members think should become a focus for policy development around the use of air cleaning devices in schools.

Magazine article: [The need for a national clean air strategy for schools](#), 12 May 2023

While a range of solutions to reducing air pollution in and around schools exist, there is little guidance to help schools implement them. That's why leading experts from TAPAS are calling for a clean air strategy for schools.

## Short Research Visits (SRV's)

The TAPAS network supported 2 SRV's for Early Career Researchers (ECR's) which enabled them to work in another organisation for a short period to gain interdisciplinary knowledge and experience outside their own field of expertise. These SRV's included visits to the Centre Scientifique et Technique du Batiment (CSTB) based in Paris, which consequently led to an international meeting of air quality experts (detailed below), and the Technical University of Denmark (DTU Sustain).

## Other Networking Events

### UK Indoor Air Quality Observatory

In April 2022, members of the [TAPAS](#) network, the [FUVN](#) network, the [CSTB](#) and the [OQAI](#) met to discuss national indoor air quality strategies in France and the UK. The meeting of these four initiatives, together with invited experts from academia, industry and government science organisations, happened over two days in Paris and involved a series of presentations and workshops. A key focus of the meeting was on “observing indoor air” – how we can develop coordinated approaches to capturing data on indoor air quality at scale and over long periods of time and how this can be used to understand health effects and support policy and practice. The knowledge sharing and informative discussions will shape both the French and UK networks’ future indoor air quality studies and campaigns.

In September 2022, Breathing City (FUVN), TAPAS and ICP-ERG jointly hosted an in-person event in White City Campus, Imperial College London, which engaged discussions from academia, industry, and public policy around ‘Understanding IAQ for healthy buildings in net zero world’ and focussed on early career researchers and indoor air studies. We heard presentations across a range of IAQ topics including monitoring, characterization methods, ventilation studies, modelling, IAQ health assessments and behavioural studies.

In May 2023, the Future Urban Ventilation Network (FUVN) and the Tackling Air Pollution At School Network (TAPAS) held an online facilitated workshop with key stakeholders to discuss the viability of a UK Indoor Air Quality Observatory. Key stakeholders were invited from across public policy, academia, funding bodies, and professional institutions.

The vision to establish a UK Indoor Air Quality Observatory has been presented at the Clean Air Networks Conference (July 2023), at a cross-Government Indoor Air Quality Working Group meeting chaired by the Department of Health and Social Care (DHSC) (July 2023), at the UKIEG conference (September 2023) and the UKHSA annual conference (Nov 2023).

Stakeholder engagement has thus far been successful in gaining strong support from the academic community, numerous Governmental departments’ scientific teams, and key senior air-quality and health figures. To strengthen the vision, we are now ready to engage with wider stakeholder groups such as industry, health charities, senior civil servants, MPs, and policy makers, and funders.

### Environmental Audit Committee, June/July 2023

The Environmental Audit Committee held an inquiry to establish the adequacy of current measures to promote and improve indoor and outdoor air quality and assess whether air quality targets are sufficient for protecting public health and the environment. Many of our TAPAS researchers, as well as our partner clean air networks and stakeholders, submitted written evidence to the inquiry and some were also involved in giving oral evidence.

Multiple experts giving evidence highlighted the need for longitudinal monitoring studies in buildings to better understand what pollutants are present, particularly secondary pollutants, and how they affect health. Professor Nic Carslaw highlighted that a sensible place to start would be in schools given that children are particularly vulnerable to the effects of air pollution.

Raising awareness of the dangers of poor indoor air quality, particularly from solid fuel burning in our homes, and highlighting the importance of ventilation in buildings to flush out pollutants, were also highlighted as areas that need addressing.

Tackling air quality in conjunction with the net zero agenda and integrating policies by bringing air quality scientists, health experts and the built environment sector together is a necessary step to really make progress.

You can see the full list of [submitted written evidence here](#).

You can see the [latest list of oral evidence transcripts here](#).

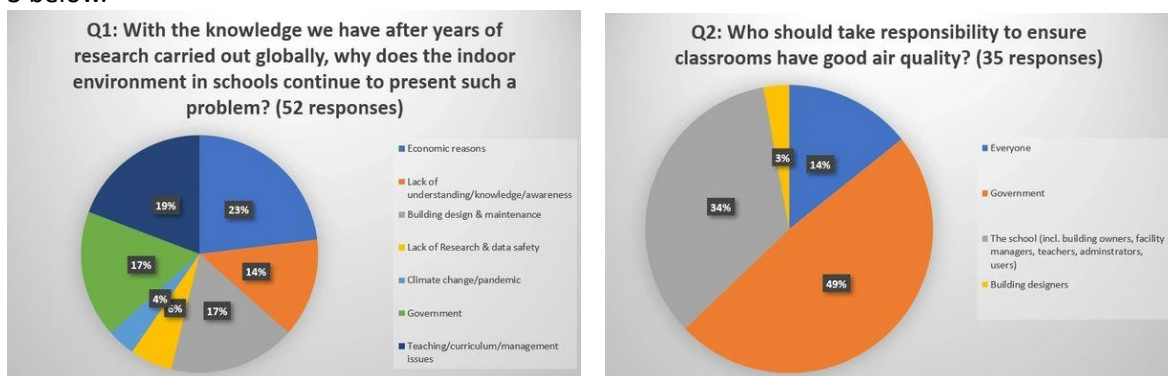
Healthy Buildings Europe Conference, Aachen, Germany, 11-14 June 2023

The TAPAS network hosted a workshop at Healthy Buildings Europe to discuss 'Indoor Environmental Quality in Schools'. Complimenting the conference theme 'Beyond Disciplinary Boundaries' we invited speakers from across the globe to speak on this topic. Our speakers covered a range of indoor environmental quality in schools topics including monitoring, interventions, schools engagement and communications, improving IEQ at low cost and the benefits of investing in these improvements. This workshop was well attended and instigated some interesting discussion.

Our workshop kicked off with presentations from our four international speakers, followed by a panel discussion chaired by Nicola Carslaw (Professor in Indoor Air Chemistry at the University of York), Henry Burrige (Senior Lecturer in Civil and Environmental Engineering at Imperial College London), and Patricia Fabian (Associate Professor of Environmental Health, Boston University School of Public Health). We then used an online collaborative tool to pose the following questions to our audience:

1. With the knowledge we have after years of research carried out globally, why does the indoor environment in schools continue to present such a problem?
2. Who should take responsibility to ensure classrooms have good air quality?
3. What measures and/or solutions should schools prioritise to improve classroom air quality?
4. What are the barriers against improving air quality in schools?

Responses to these questions were collected and a summary in graph format can be viewed in Figure 3 below.



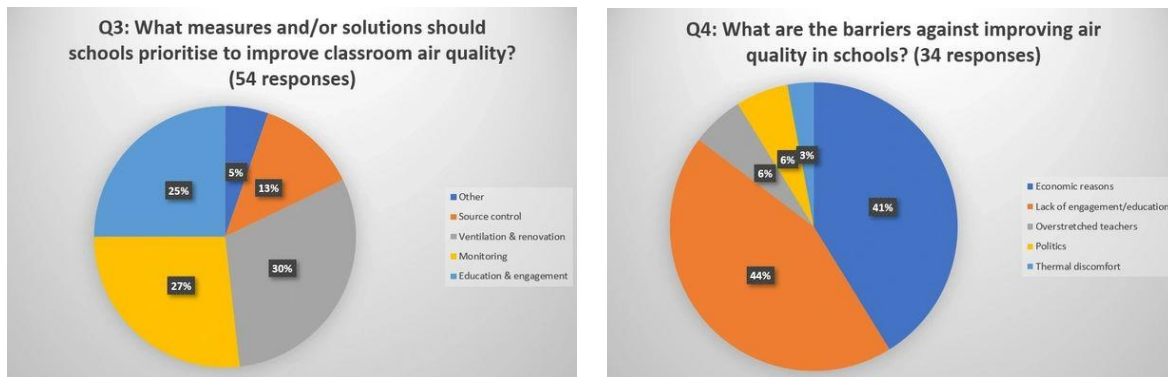


Figure 3: Responses to workshop questions posed to the audience

Clean Air Networks Conference, 5-6th July 2023

On 5-6th July 2023 over 200 air quality researchers, policy makers, industry partners and civic sector groups who work across the atmospheric, health, social and building science disciplines met at the University of Birmingham. The 2023 Clean Air Networks Conference was hosted by seven networks funded under the UK Clean Air Strategic Priority Fund, the Science and Technology Facilities Council (STFC) Air Quality Network and the UKRI Clean Air Champions. Over the two days, delegates exchanged findings from the different networks' wide-ranging activities and cross-cutting themes, and identified the next steps for both indoor and outdoor air quality research and policy. In addition to the talks and guided discussions, there were plenty of opportunities for networking ensuring existing connections were strengthened and new links were formed.



Image 1: Professor Roy Harrison opened the conference on day one with the Martin Williams Memorial Lecture, Clean Air Networks Conference

China-UK Research and Innovation Forum, 8-9<sup>th</sup> January 2024

TAPAS' Network Manager, Kat Roberts, represented TAPAS at a China-UK Research and Innovation Forum on 8-9th Jan 2024 hosted by Chongqing University and the British Consulate General in Chongqing, China. The forum focused on 'Urban Built Environments and Thermal Resilience under Low-Carbon Transition Mode' and UK experts were invited to collectively collaborate with our Chinese colleagues on the future improvement and development of sustainable urban scale thermal resilience. Kat presented on UK strengths including the UK Clean Air Champions and Clean Air Networks and our efforts to date to establish a UK Indoor Air Quality Observatory. She highlighted

the importance of collecting longitudinal indoor air quality data from across multiple building sectors so we can better understand health and climate impacts and can support future policy on urban and building design. It is hoped that researchers from China and the UK continue to collaborate and work towards a more sustainable future for all.



*Image 2: China-UK Research and Innovation Forum delegates, Chongqing University, China*

### TAPAS funded small research grants

TAPAS has funded three small and innovative research projects, each aligned with a research idea that has been identified by the TAPAS network. These projects focus on the overarching question “*How can we deliver timely and effective interventions to improve air quality at school?*” and bring together partners from different disciplines.

#### 1. Act Now!

The Act Now project aims to better understand what measures schools can take themselves to improve their own air quality, pulling together existing research and discussing with others working in the field. The Act Now project team aims to create simple guidance, outlining measures that all schools could take. There is a lot of air pollution evidence already in existence and schools wanting to understand what should be done. The research and communications from this project will help turn this evidence into action. This has the potential to be of use to many schools, teachers, and students nationwide.

#### 2. The Dynamic Classroom

The Dynamic Classroom is an interdisciplinary pilot project that investigates how the school classroom learning environment can be improved by reducing the indoor air pollution exposure of school children and staff using an automated window system to provide fresh air. The project is run by an interdisciplinary team from six Universities and one industry partners, with expertise in air quality, atmospheric science, instrument development, building services management, building information systems, modelling, project management, and social science methods.

Over one-year, with two intensive ‘deep-dive’ phases, the team implemented and monitored one pilot ‘Dynamic Classroom’, in a pre-existing primary school classroom, where ventilation is controlled via an automated window system connected to air quality and weather sensors both inside and outside the classroom.

### 3. The Air We Share

'The Air We Share - Working Towards Sustainable Learning Environments', is an interdisciplinary pilot project that investigates the potential benefits of visual sensors in a classroom on the IAQ, comfort, health and wellbeing of the teachers and children.

This project is an opportunity to investigate a change in the way we think about the shared air we breathe in buildings - moving towards sustainable breathing buildings. A paradigm shift in the way occupants think about air quality is required to promote healthier ways of learning. By providing the tools users need to understand air quality levels, this could enable, empower, respond and re-evaluate how they can operate within the building and influence air quality for healthier, sustainable learning. Outcomes of the research highlighted benefits of the interventions and possible further ventilation enhancement strategies.

Key findings from this study:

- Raising the awareness of the teachers about good ventilation practice for their own classroom improved the air quality as quantified by reduced CO<sub>2</sub> concentrations;
- The visual CO<sub>2</sub> sensors helped the teachers who had them and used them to improve and maintain lower CO<sub>2</sub> concentrations;
- More ventilation reduced the comfort levels of the teachers during the heating season. They found their indoor working environment less comfortable and colder more frequently in winter.

### Summary and lessons learned

The TAPAS Network has been successful in effectively bringing together air quality experts from a vast range of backgrounds, both in the UK and internationally. The main benefits of a network such as TAPAS is that it provides opportunities for members to learn from each other, exchange ideas, work together collaboratively, and ultimately find solutions that will improve air pollution in and around schools. The TAPAS co-investigators have demonstrated this multi-disciplinary working ethic by co-hosting events, seminars, network meetings and research projects. The Clean Air Networks Conference in particular was a hugely successful event providing a space for air quality professionals to interact and grow their connections.

Due to TAPAS being a prominent network led by leading air quality academics and professionals, many renowned air quality experts readily engaged with TAPAS through our online seminar series and full network events. This has allowed us to gather a vast collection of distinguished recorded resource, hosted on the TAPAS website, that is publicly available for playback. Also available on the website are other evidence-based resources, developed by TAPAS members and collaborating professional experts, suitable for teaching and education purposes.

Whilst engagement with air quality professionals has grown distinctly, engagement with schools has proved to be an ongoing challenge. This is largely believed to be due to the excessive time and money constraints many schools are facing, as well as having to deal with other more pressing issues that take priority. There are some school-faced projects with strong links to TAPAS that are looking to overcome this problem including the TAPAS funded 'Act Now!' project and [SAMHE](#) (Schools Air quality Monitoring for Health and Education).

It is hoped that the shared knowledge and new formed partnerships evolved from the TAPAS Network will continue to develop after the project ends and allow for future cross research themed solutions to further improve air quality in and around schools.

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