



School Indoor Air Quality Research Summit

Inspiring the next generation of research and enabling effective partnerships

October 20, 2023



EXECUTIVE SUMMARY



Convening the School IAQ Research Summit

The School IAQ Research Summit was hosted in Washington, DC on October 20, 2023, by the Center for Green Schools and its partners. The summit's central objective was to build a shared understanding between environmental health researchers and school system staff about the research needed to support healthy indoor air for students and teachers.

Throughout the COVID-19 pandemic, the Center focused on understanding the challenges faced by schools, communicating their challenges to policymakers and the public, and educating school staff about the latest evidence for action. We noticed in the midst of this work that the investigations being carried out by trusted researchers in the field were not always matching the on-the-ground needs of school stakeholders, and the summit was created to address this misalignment.

Creating the next generation of research questions

Summit attendees began the day by reflecting on their own confidence in the evidence to support the implementation of various indoor air quality (IAQ) strategies in schools. Building on this group reflection exercise, attendees were then invited to discuss the disparate perceptions of school system staff and the research community. The discussions generated new perspectives on the research that is needed to support healthy IAQ in schools.

The most common area of research called for within the small group discussions was the need to define what "good" or "better" indoor air quality is in schools. The groups considered the lack of clear definition a major stumbling block for schools in identifying and prioritizing actions they should take in their buildings.

Facilitating collaboration

The afternoon session of the summit focused on uncovering the lessons learned in navigating the complex partnerships that form the foundation of school IAQ research. After hearing presentations about the challenges and successes of researchers and school systems who have worked together on research, discussion groups crafted recommendations for school districts and researchers to make future partnerships run smoothly.

> Many discussion groups noted that a central challenge in conducting school IAQ research is school district anxiety around the public communications and legal liability surrounding a research team's data collected from schools. Successful research teams have set clear expectations and taken time to build trust at the beginning of a project.



TABLE OF CONTENTS

Background and Overview

Recognizing the need for dialogue	1
Facilitating a summit between the research community and school systems	2

Summit Proceedings

Unearthing the varied perceptions of researchers and school system staff Brainstorming the next generation of research questions Understanding school IAQ research from different perspectives Recommendations for research teams	3 4 6 8
Recommendations for school systems Concluding reflections Acknowledgements	9 9 9
Appendix A: Confidence Heatmaps	10
Appendix B: Summit Attendees	14
Appendix C: Summit Agenda	16

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BACKGROUND AND OVERVIEW



Recognizing the need for dialogue

Each day, school administrators, teachers, staff, students, families, and communities wrestle with how to balance risks associated with poor air quality in schools with the importance of in-person learning for student success. Chronic underinvestment in public school buildings exacerbates existing indoor air quality (IAQ) problems, and the conditions worsen as school buildings age. In 2012, the <u>average age</u> of the nation's public school buildings was 44 years; without major investment in upkeep and system replacements, the aging infrastructure is nearing the end of its useful life. In 2020, the <u>U.S. Government Accountability Office</u> (GAO) found that 41 percent of districts required HVAC systems upgrades or replacements in at least half of their schools. In addition, 20 to 35 percent of all school districts had serious deficiencies in at least half of their roofing, lighting, or safety and security systems.

During the COVID-19 pandemic, the balancing act between managing risks associated with poor IAQ and the importance of keeping students in school became more apparent to communities than ever, and effectively reducing transmission risk in schools became paramount. However, the nature of the COVID-19 pandemic and responses to it continued to evolve rapidly, sometimes daily; and decision-makers encountered varied, if not conflicting, guidance on control strategies. Given the aging state of many school buildings, school system leaders and staff were left to make many difficult choices without access to—or sometimes the existence of—the necessary information to do so.

The Center for Green Schools was focused during the pandemic on <u>understanding the challenges</u> <u>faced by schools</u>, communicating their challenges to policymakers and the public, and educating school staff about the latest evidence for action. We noticed in the midst of this work that the investigations being carried out by trusted researchers in the field were not always matching the on-the-ground needs of school stakeholders. Given the urgency of this interdisciplinary conversation, the Center began working toward a summit to facilitate conversation between school district stakeholders and the top researchers on school IAQ.





Facilitating a summit between the research community and school systems

In the spring of 2023, the Center for Green Schools invited a diverse group of partners to the table to build trust with the participants who would be valuable to the summit's objectives. With the Department of Energy's Building Technologies Office, DOE's Efficient and Healthy Schools Program, ASHRAE, AASA (The Superintendent's Association), the Collaborative for High Performance Schools (CHPS), and the International Society for Indoor Air Quality and Climate, we set three objectives for the event:

- Assess both the research community's and school practitioners' confidence in the evidence around various indoor air quality practices.
- Identify key gaps in current school indoor air quality research from the perspective of those implementing indoor air quality measures in schools.
- Using case studies from the field, articulate strategies for effective partnerships between research teams and school systems.

We collectively built an invitation list that included researchers that had published school IAQ research in the past several years, as well as the Center for Green Schools' considerable network of school system staff. Our target was to host a group that was evenly split between school system staff and researchers and to ensure that partner organizations and government agency representatives could observe the conversation, as well.

We hosted the full-day summit at <u>Benjamin Banneker Academic High School</u>—a beautiful new LEED platinum certified school that is targeting net zero energy—on October 20, 2023. In all, around 65 people attended the event, including around 1/3 researchers, 1/3 school system staff, and around 1/3 observers. The list of attendees is included as Appendix B.

SUMMIT PROCEEDINGS



Unearthing the varied perceptions of researchers and school system staff

The morning of the summit was dedicated to unearthing differences in the perceptions of school system staff and the research community to spark a dialogue about research needs. Participants began with an exercise that asked them to reflect on their own confidence in the existing evidence to implement various IAQ strategies. As they reflected, they placed green, yellow, or red dots on large paper charts that began to visually represent the school system staff's confidence and—separately—the researchers' confidence. The resulting visuals in both their original, dot format and an averaged format are included as Appendix A.

Participant observations

After the dot exercise, participants convened to listen to a facilitated conversation about the resulting visuals between professionals that represented the disciplines in the room. In the facilitated panel discussion and the subsequent attendee small group conversations, panelists and participants noted several takeaways from the dot charts.

Related to capital strategies:

- Both researchers and school systems indicated a lack of confidence in the evidence that in-duct germicidal UV would be effective in the school setting as well as lack of confidence in whether such systems are being properly installed.
- While school system staff indicated high levels of confidence in installing IAQ sensors and implementing classroom-level air cleaning, researchers' confidence was not as high.
- On the other hand, researchers were more confident in the evidence around the effectiveness of HVAC filter changes than school system staff were.
- Across the board, school system staff had more confidence in their ability to evaluate the effectiveness of various strategies than researchers had.



Related to operations and maintenance strategies, the differences between the confidence levels of school system staff and researchers were stark.

- School system staff indicated high confidence in their ability to implement almost all stages of the strategies indicated. Notable exceptions included the planning stages of HVAC repair to improve air change rates as well as understanding the needed frequency of retrocommissioning.
- By contrast, researchers indicated a lack of confidence in the evidence around implementing almost all aspects of operations and maintenance for improving IAQ. They were particularly lacking confidence in the evidence to support effectively implementing retrocommissioning and, more generally, the evidence around evaluating the effectiveness of various strategies.

Brainstorming the next generation of research questions

Nine discussion group leaders from the indoor air quality research community, noted in the attendee list in Appendix B, led small group conversations to reflect on the morning's exercise and brainstorm possible research questions. The objective of the conversation groups was to craft ideas that reflected the needs of school districts as they work to improve IAQ on the ground.

Given what attendees saw in comparing the researchers' confidence heatmap with the school districts' confidence heatmap, they arrived at a wide variety of research ideas.

Most common research question proposed: What is "good" or "better" indoor air quality in schools?

• Seven discussion groups asserted that an essential research question for the field revolves around defining "good" or "better" IAQ in schools. The groups considered the lack of clear definition a major stumbling block for schools in identifying and prioritizing actions they should take in their buildings.

THEME: Evidence to aide in implementation

- How should school districts evaluate their inventory and prioritize the needs from an air quality perspective?
- What are the highest priority uses of the multitude of IAQ data that schools might be collecting via IAQ sensors?
- How could research inform the steps school districts should take when investigating and acting on a sub-optimal IAQ sensor reading, particularly regarding volatile organic compounds (VOCs)?
- What is the evidence for how often should HVAC filters be replaced?
- What does a school district need to know about placement and best uses of germicidal UV products? What is supported by the evidence?
- How should a school district use existing research to evaluate and select germicidal UV products for use?
- How should a school district use existing research to evaluate and select low-emitting materials for installation in schools?

THEME: Learning from the process of implementation

- What are the organizational and social barriers and facilitators of effective HVAC maintenance at schools?
- What are the energy and environmental quality impacts of air quality actions in schools (for example, noise from filtration units)?
- What are the options and implications of filter upgrades in HVAC systems, particularly ones that were not originally designed to take upgraded filters?

THEME: Factors impacting IAQ in classroom spaces

- How do building-level variables affect IAQ outcomes?
 - o Factors such as building layout, access to windows, building age
 - o System factors such as ventilation approach and heating/cooling type
- How do other environmental, climatic, and human factors affect IAQ outcomes?
 - Areas prone to wildfires or hurricanes/flooding
 - Socioeconomic make-up of the community and students
 - Geography and seasonal weather patterns
- How do actual conditions in a classroom
 (as opposed to idealized or lab-based conditions) affect research outcomes
 related to IAQ conditions in schools?



- Presence of personal care products on IAQ readings
- Actual density of students, as opposed to supposed density based on square footage
- What are the chemical reactions that occur in a classroom space when using electronic air cleaners and/or ozone-producing equipment?

Other suggested research questions

- What is the performance of low-cost IAQ sensors versus research-grade sensors?
- How can the research field better validate sensors for specific VOCs?
- What is the impact of hurricanes on IAQ in schools?
 - What contaminants are released in the destruction and the ensuing demolition, and what should schools prioritize to keep staff and students safe?
 - How should schools manage water damage after flooding events?
- [Related to environmental quality] What is the prevalence of active design strategies in schools, and what impact do the strategies have on student and staff health?
- [Related to environmental quality] What impact does summer break have on water quality in schools? In particular, how common is detection of *Legionella* bacteria in water systems at this time of year, and what can school districts do to monitor and prevent associated effects?

Suggested resources for future development

- Tools and resources for schools that translate IAQ research for specific geographic areas.
- Detailed and well-researched business case for IAQ improvement, reflecting the long-term health and learning impacts.
- Data bank of indoor air quality data from schools that can collect existing data, anonymize it, and make it available to researchers, similar to the EPA Base Study (Building Assessment Survey and Evaluation Study) conducted in the 1990s. The group suggested such data be used to establish clearer standards for school IAQ.
- A standard and consistent platform by which schools and the public could access existing and new testing and evaluation of IAQ technologies, similar to a "consumer reports" model.

Understanding school IAQ research from different perspectives

The afternoon of the summit focused on enabling school and researcher partnerships so that needed research can move forward. Attendees first listened to stories from the field through a series of presentations about school IAQ research projects. Using the information gleaned from these presentations, participants broke into seven small discussion groups to generate recommendations for school district and research stakeholders for making school-based research projects most successful. These small group conversations were facilitated by school district staff, noted in Appendix B.

Challenges

Many challenges exist in moving the research forward to better understand how to support healthy air in schools. Using the expertise and experience of the summit participants, we asked seven school district-based discussion leaders to guide their groups in naming the challenges that they have confronted or witnessed when research groups and school districts attempt to work together on indoor air quality research.

Many groups cited a lack of willingness or buy-in on the part of school districts, and they captured several detailed reasons for this hesitance:

- Five discussion groups cited school district anxiety around the public communications and legal liability surrounding a research team's environmental health data collected from schools.
- Two groups cited the lack of school district staff capacity.
- One group brought forward challenges related to school district labor agreements and the complexities that arise when researchers find themselves caught in workplace labor disputes.



Other challenges discussed by the small groups were more varied:

- Three discussion groups cited privacy and/or security issues in handling student data, including the Institutional Review Board approval process.
- Three discussion groups brought forward the complex differences in culture between researchers and school district staff; for instance, these groups have misaligned incentives, mismatched terminology, and different timelines.
- Two groups noted the difficulties that arise when school districts do not have existing tracking systems or data to build on and/or if the data quality of existing systems is lacking.
- Two groups cited the lack of reference guidance and standards for "good" school indoor air quality as contributing to the challenges.
- Two discussion groups noted that entities who fund research are sometimes not as interested in real-world, applied research that serves the needs of a school district.
- One group cited the high cost of conducting research and accessing appropriate equipment.

Successful strategies

School district staff discussion leaders were also invited to lead their small groups through a conversation about the successful tactics that the attendees had employed or witnessed in conducting school IAQ research. To aid in the discussion, immediately before the small group discussions, several recent research project exemplars were presented to spark ideas.

- All discussion groups noted that successful teams have set clear expectations and taken time to build trust at the beginning of a project, including:
 - Starting with a pilot
 - Using contractors that are known in the community
 - o Identifying and building relationships with relevant stakeholders and key leaders
 - Establishing methods and timelines for consistent communication and follow-up
- Three discussion groups highlighted the importance of connecting to a current challenge for the school district so that the research serves their needs.
- Three discussion groups observed that successful research teams have helped the school district with messaging post-research by articulating clear action steps they could take and by co-creating an action plan that could be communicated to the community.
- Two discussion groups focused on the importance of selecting the right school district to work with, including choosing a district that has some historic data available as well as some funding lined up for building improvements (such as a district that recently passed a bond and will be addressing building conditions over the next few years).
- Two discussion groups observed that research teams could improve the quality of research design by selecting multidisciplinary partners and utilizing university-level students for as much of the field work as possible to lower the overall research costs.

Recommendations for research teams

After discussing typical challenges and successes within school district and researcher partnerships, discussion groups offered recommendations for research teams that want to work with school systems on IAQ research.

Initializing the project

- Have an initial conversation with the school district to identify their needs and consider a research plan that could meet their goals.
- Set clear expectations at the beginning of the project to increase trust between the research team and the school district. Include expectations about:
 - the timeline of data collection, analysis, and final results (two discussion groups)
 - the ownership and use of the collected data (two discussion groups)
 - o how the research will help improve school environments
- Identify the champions within the school district who can help the research team navigate departmental dynamics and help the school district communicate with its community. If present, connect early with the research department at the school system.
- Build flexibility into the research plan to reflect that school hours and school calendars might get in the way of progress.
- Ensure that the research design is specific to school district geographic location and socioeconomic context.
- Start with a research pilot to build trust with the school system.

During the project

- Offer opportunities for curriculum integration to involve teachers.
- Offer resources and Q&A documents that can be shared with the community about IAQ and the research project.
- Ensure that the research is utilizing accurate information about actual, on-the-ground set-up and conditions in the spaces where IAQ measurements are taken.

Communicating research results

- Maintain constant communication with the school district, including clear and concise followup about research results.
- When presenting results, combine the data with possible solutions to IAQ problems.
- Offer communication tools for accurately sharing the research results with the community.

Recommendations for school systems

After discussing typical challenges and successes within school district and researcher partnerships, discussion groups offered recommendations for school systems that want to work research teams on IAQ research.

Recruiting assistance with needed research

- Articulate and create a written description of the problems and knowledge gaps that the school system has that may be addressed in working with researchers.
- Reach out to local universities, research centers, and public health agencies to find research partners who might address needs.
- Identify the best points of contact for researchers interested in working with the school district and ensure that these contacts are posted clearly.

Effectively working with researchers

- Define parameters for data sharing that can be communicated to potential research partners, including the use of the data type and continuity of existing IAQ data.
- Communicate with research partners specific expectations and processes around community communications to set expectations up front.
- Take advantage of opportunities to integrate the research project with student learning.

Concluding reflections

The perceptions of school district staff and researchers are, in many ways, quite far apart regarding which facets of school IAQ need to be further investigated by the research field. Given that change in physical school environments will only happen with the action of school facilities staff, it is critical that the perspectives of these staff are incorporated early in the design of research on school IAQ.

The School IAQ Research Summit was an important first step in understanding the perspectives of researchers and school staff and how effective dialogue can be fostered between them. Our hope is that the research questions that were generated at the summit can be prioritized and refined in future discussions to form the backbone of a new research agenda for school IAQ. To execute on that agenda, both the school community and the research community will need to consider how to work with the other—building from the recommendations that were generated in the summit—to support the objective of healthier school environments for all students.

Acknowledgements

We would like to thank the summit participants for contributing their time and expertise to this valuable discussion. Thanks also to event partners, speakers, discussion leaders, and sponsors for enriching the day's programming. We would like to thank the staff and leadership at Benjamin Banneker Academic High School for welcoming our group to the school.

APPENDIX A: ATTENDEE REFLECTION EXERCISE

Figure 1. Confidence levels expressed by attendees related to capital projects strategies. School district staff were asked, "How confident are you that you have or could easily find the information to effectively take these steps?". Researchers were asked, "How confident are you that sufficient evidence exists for schools to effectively take these steps?". Red indicates a lack of confidence, yellow indicates moderate confidence, and green indicates high confidence. Dots were placed by participants in-person during the summit.

1A. School district staff answers.

CAPITAL PROJECTS	What is your confidence that this strategy, when properly implemented, would benefit IAQ in schools?	Planning and design	How confic Selecting a product & specifying details	lent are you that you have o	Fr could easily find the in How to operate (When? How often? In what conditions?)	nformation to effective	ely take these steps? Evaluating effectiveness	Communicating the value
HVAC systems to address temp. and humidity	· · · · · · · · · · · · · · · · · · ·		000	:::::			•	• • • • • • •
HVAC equipment filter upgrades	:22: •	2	• • • •	8			•	• • • • • • •
HVAC equipment to achieve ASHRAE recommended ACH rates	•••••			•				•••••
IAQ sensors (CO2, VOC, and PM)	0000000		•	0 0000				• • • • •
Classroom level air cleaning		•••••	•	• • • • • • •	••••		• • • • •	
In-duct UV-C/UVGI	2: 2		6 000 0 0 0 0	8		0000		• • • • • • •
Purchasing low-emitting materials (construction)		•	****	8		00 00 0		••••••
Isolating/exhausting high- emitting and/or polluting equipment			· · · · · · ·		•			

CAPITAL PROJECTS	What is your confidence that this strategy, when properly implemented, would benefit IAQ in schools?	Planning and design	How conf Selecting a product & specifying details	ident are you that sufficie	How to operate (When? How otten? In what conditions?)	How to maintain	ke these steps? Evaluating effectiveness	Communicating the value
HVAC systems to address temp. and humidity	0000 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0				••••••		• • • • • •	
HVAC equipment filter upgrades			000 0 0		****	Sec. 1		
HVAC equipment to achieve ASHRAE recommended ACH rates								
IAQ sensors (CO2, VOC, and PM)	••••			° •••••				
Classroom level air cleaning						:		
In-duct UV-C/UVGI				· • • • • •				
Purchasing low-emitting materials (construction)					•••		•••••	
Isolating/exhausting high- emitting and/or polluting equipment	****	°	00 0 0 0 0		••••		** **	•

Figure 2: Averaged and color-coded attendee responses related to capital projects strategies. School district staff were asked, "How confident are you that you have or could easily find the information to effectively take these steps?". Researchers were asked, "How confident are you that sufficient evidence exists for schools to effectively take these steps?". Participant dots (presented in Figure 1) were counted and given a weighted score, the score was averaged for the number of dots present in each cell, and the averaged number was assigned a color to indicate average level of confidence.

2A. School district staff answers.

CADITAL	What is your confidence that		How confident are you that you have or could easily find the information to effectively take these steps?					
PROJECTS	implemented, would benefit IAQ in schools?	Planning and design	Selecting a product & specifying details	Installing (such as placement)	How to operate (When? How often? In what conditions?)	How to maintain	Evaluating effectiveness	Communicating the value
HVAC systems to address temp. and humidity								
HVAC equipment filter upgrades								
HVAC equipment to achieve ASHRAE recommended ACH rates								
IAQ sensors (CO2, VOC, and PM)								
Classroom level air cleaning								
In-duct UV-C/UVGI								
Purchasing low-emitting materials (construction)								
Isolating/exhausting high- emitting and/or polluting equipment								

CADITAL	What is your confidence that	How confident are you that sufficient evidence exists for schools to effectively take these steps?						
PROJECTS	implemented, would benefit IAQ in schools?	Planning and design	Selecting a product & specifying details	Installing (such as placement)	How to operate (When? How often? In what conditions?)	How to maintain	Evaluating effectiveness	Communicating the value
HVAC systems to address temp. and humidity								
HVAC equipment filter upgrades								
HVAC equipment to achieve ASHRAE recommended ACH rates								
IAQ sensors (CO2, VOC, and PM)	8- 							
Classroom level air cleaning								
In-duct UV-C/UVGI								
Purchasing low-emitting materials (construction)								
Isolating/exhausting high- emitting and/or polluting equipment								

Figure 3: Confidence levels expressed by attendees related to operations and maintenance strategies. School district staff were asked, "How confident are you that you have or could easily find the information to effectively take these steps?". Researchers were asked, "How confident are you that sufficient evidence exists for schools to effectively take these steps?". Red indicates a lack of confidence, yellow indicates moderate confidence, and green indicates high confidence. Dots were placed by participants in-person during the summit.

3A. School district staff answers.

OPERATIONS & MAINTENANCE	What is your confidence that this strategy, when properly implemented, would benefit IAQ in schools?	Planning and design	How confider Selecting a provider/partner	nt are you that you have of Creating SOPs (processes)	Contracting for needed services	formation to effectively t Assessing needed trequency	ake these steps?	Communicating the value
Optimizing HVAC to achieve recommended air change rates				• • • • • •	••••••	•••••	000 0000 0	
Retrocommissioning	••••••			• • • •				
Effective and healthy cleaning	••••••	••••• 8	*****	•••••• • •	••••••	• • • • • • • • •		0000 00 0 0
HVAC maintenance: filter changes and coil cleaning				*****	••••••	••••		
Air quality testing (one time)	••••••		•••••	••••	••••	••••••		**
Analyzing sensor data and establishing thresholds for action	*********		••••••	\$	•••			••••••
Making changes based on IAQ data	••••••	••••••	••••••	°•••••••	****	• • • •		•••••
Staff training on their role to ensure good IAQ		···· · · ·	•••••	••••••	•••••	••••		****

OPERATIONS & MAINTENANCE	What is your confidence that this strategy, when properly implemented, would benefit IAQ in schools?	Planning and design	How col Selecting a providen/partner	nfident are you that suffi Creating SOPs (processes)	cient evidence exists for Contracting for needed services	schools to effectively tak Assessing needed trequency	e these steps? Evaluating effectiveness	Communicating the value
Optimizing HVAC to achieve recommended air change rates		••••••				• • • •	•	••••
Retrocommissioning		0030	••••					
Effective and healthy cleaning	• • • • • • • • • • • • • • • • • • •		**	••••	:		••••	•••••
HVAC maintenance: filter changes and coil cleaning			•	••••	÷•••		•••••	••••
Air quality testing (one time)								••••
Analyzing sensor data and establishing thresholds for action	0000000			·*****			••••	••••
Making changes based on IAQ data			••••		••••	••••••	**:***	
Staff training on their role to ensure good IAQ	••••			••••		•••••	0 <mark>000 - 0</mark> 0	•••••••••

Figure 4: Averaged and color-coded attendee responses related to operations and maintenance strategies. School district staff were asked, "How confident are you that you have or could easily find the information to effectively take these steps?". Researchers were asked, "How confident are you that sufficient evidence exists for schools to effectively take these steps?". Participant dots (presented in Figure 3) were counted and given a weighted score, the score was averaged for the number of dots present in each cell, and the averaged number was assigned a color to indicate average level of confidence.

4A. School district staff answers.

OPERATIONS &	What is your confidence that this strategy, when properly implemented, would benefit IAQ in schools?	How confident are you that you have or could easily find the information to effectively take these steps?							
MAINTENANCE		Planning and design	Selecting a provider/partner	Creating SOPs (processes)	Contracting for needed services	Assessing needed trequency	Evaluating effectiveness	Communicating the value	
Optimizing HVAC to achieve recommended air change rates									
Retrocommissioning									
Effective and healthy cleaning						l l			
HVAC maintenance: filter changes and coil cleaning									
Air quality testing (one time)									
Analyzing sensor data and establishing thresholds for action									
Making changes based on IAQ data									
Staff training on their role to ensure good IAQ									

OPERATIONS &	What is your confidence that	How confident are you that sufficient evidence exists for schools to effectively take these steps?							
MAINTENANCE	implemented, would benefit IAQ in schools?	Planning and design	Selecting a provider/partner	Creating SOPs (processes)	Contracting for needed services	Assessing needed trequency	Evaluating effectiveness	Communicating the value	
Optimizing HVAC to achieve recommended air change rates									
Retrocommissioning									
Effective and healthy cleaning									
HVAC maintenance: filter changes and coil cleaning									
Air quality testing (one time)									
Analyzing sensor data and establishing thresholds for action									
Making changes based on IAQ data									
Staff training on their role to ensure good IAQ									

APPENDIX B: SCHOOL IAQ RESEARCH SUMMIT ATTENDEES

First Name	Last Name	Company	Job title	Summit Role, If Applicable
Serene	Almomen	Attune (formerly Senseware)	CEO	
Sydney	Applegate	DOE BTO	ORISE STP Fellow	
Parham	Azimi	Harvard University	Research Associate	Researcher Table Host
Sadie	Baker	Baltimore City Public Schools	Policy Specialist	
Andrew	Barberi	ASHRAE	Office Operations Manager	
Liam	Bates	Kaiterra	CEO	Panelist
Carys	Behnke	DOE Building Technologies Office	DOE Fellow	
Cristi	Bell-Huff	Chemical Insights Research Institute of UL Research Institutes	Research Manager	
Seema	Bhangar	USGBC	Principal, Healthy Buildings & Communities	Event Organizer and Host
Sharicca	Boldon	Baltimore City Public Schools	Director of Strategy and Compliance- Operations	
Lauren	Bolton	Boston Public Schools	Environmental Technician	
Patrick	Carr	U.S. Department of Education	Director of Rural, Insular, and Native Achievement	
Latanya	Carter	Baltimore City Public Schools	Senior Manager of Environmental Compliance	School District Table Host
Hannah	Carter	USGBC	Project Manager	Event Organizer and Host
Rengie	Chan	Lawrence Berkeley National Laboratory	Staff Scientist	Panelist
Louie	Cheng	PureLiving Environmental	CEO	
Ginger	Chew	CDC	Epidemiologist	Researcher Table Host
Brian	Croyle	Montgomery County Public Schools	Environmental Specialist	School District Table Host
Sandra	Dedesko	Harvard Univeristy	PhD Candidate	
Brian	Fox	Green Schools National Network	Director of Development & Strategic Partnerships	
Elliott	Gall	Portland State University	Associate Professor	
Brian	Gilligan	U.S. General Services Administration	Deputy Director, Office of Federal High-Performance Green Buildings	Panelist
Whitney	Gray	International WELL Building Institute	SVP, Head of Research	
Ulla	Haverinen-Shaughnessy	The University of Oulu, Finland	Professor	Researcher Table Host
Jill	Heins-Nesvold	American Lung Association	National Senior Director, Indoor Air Quality	
Anisa	Heming	USGBC	Director, Center for Green Schools	Event Organizer and Host
Mark	Hernandez	University of Colorado	Professor	Presenter
Christopher	Hubler	Delos Living LLC	VP of Revenue Operations	
Heather	Jauregui	Perkins Eastman	Director of Sustainability	School Tour Host
Vik	Kafley	School District of Palm Beach County	Environmental Manager	School District Table Host
Zahra	Keshavarz	Harvard University	Research Assistant	
Peggy	Lai	Harvard Medical School/Massachusetts General Hospital	Associate Professor of Medicine	Researcher Table Host
Josephine	Lau	University of Nebraska - Lincoln	Associate Professor	Researcher Table Host
Andrew David	Lewis	UCLA	Director	
Hongwan	Li	University of Oklahoma Health Sciences Center	Assistant Professor	Researcher Table Host
Dusan	Licina	EPFL, Switzerland	Assistant Professor	
David	Lunderberg	AAAS / DOE BTO	AAAS Policy Fellow	
Sheryl	Magzamen	Colorado State University	Associate Professor	Panelist and Presenter
Debarati "Mimi"	Majumdar Narayan	The Pew Charitable Trusts	Officer	
Jacqueline	Maley	USGBC	Associate	Event Organizer and Host
Erik	Malmstrom	SafeTraces	CEO	
Kelley	McDonald	Airthings	Regional Account Manager	
Ron	McMahan	SGS	Director of Innovation	
William	McQuade, P.E., Fellow ASH	ASHRAE	ASHRAE Society Treasurer	
VIncent	Newman	McArthur High School	Teacher	
Lisa	Ng	National Institute of Standards and Technology	Mechanical Engineer	Researcher Table Host
Sean	ODonnell	Perkins Eastman	Principal, K12 Practice area Leader	School Tour Host
Lori	Olson	Clark County School District	Director, Environmental Services	School District Table Host
Andrew	Persily	National Institute of Standards and Technolgy	Mechanical Engineer	Researcher Table Host

Samuel	Petty	US Department of Energy	Technology Manager	
Joni	Rix	Denver Public Schools	Environmental Program Manager	Presenter and School District Table Host
Lindsay	Rogers	Vancouver Public Schools	Environmental Safety Coordinator	
Julia	Roth	SGS	Air Services Director	
Julie	Schafer	Flu Lab	Chief Technology Officer	
Craig	Schiller	Collaborative for High Performance Schools	Executive Director	
Raj	Setty	Setty and Associates, Intl.	President	Panelist
Melanie	Share	Chemical Insights Research Institute of UL Research Institutes	Education Development	
Derek	Shendell	Rutgers School of Public Health	Prof./Conc. Lead (EHS); Dir., NJ Safe Schools Prog	Researcher Table Host
Jeffrey	Siegel	University of Toronto Civll & Mineral Engineering	Professor	
Brenden	Tong	Boston Public Schools - Facilities Management	Senior Environmental Supervisor	
Laney	Umland	U.S. Department of Education	Program Officer	
Katherine	Walsh	Boston Public Schools	Sustainability, Energy, & Environment Program Dir.	Panelist and Presenter
Pawel	Wargocki	Technical University of Denmark	Professor	
Will	Wenzloff	Hillsboro School District	Environmental Health and Safety Supervisor	School District Table Host
Jason	Wilcox	US EPA	Analyst	
Alison	Witoshynsky	School Board of Broward Co	Director EHS	School District Table Host

Appendix C. School IAQ Research Summit Agenda

Date and time: Friday, October 20 · 9:00am – 4:00pm EDT (with optional events from 4:00-5:00pm) Location: Benjamin Banneker High School; 1600 9th St NW Washington, DC 20001

Agenda

9:00 AM - 9:30 AM:	Networking and light breakfast
9:30 AM - 10:15 AM:	Opening presentation and exercise Together, attendees use a unique visual "heat map" method to assess the group's perception of gaps in IAQ research for schools.
10:15 AM - 11:15 AM:	Facilitated panel discussion Experts from research and the field react to attendees' perceptions and prioritize results. Please see the following page for information and background on our panelists.
11:15 AM - 11:30 AM:	Wellness break
11:30 AM - 12:30 PM:	Facilitated small group discussions: Brainstorming the next generation of research questions Indoor air quality experts host small group table discussions, reflecting on the morning content and using it to draft and prioritize research questions that are of most importance to ensuring healthy IAQ for students in schools.
12:30 PM - 1:30 PM:	Networking and lunch
1:30 PM - 2:30 PM:	Best practice presentations on school research partnerships School district staff and researchers who have created partnerships explain their approach to working together. Please see the following page for information and background on our presenters.
2:30 PM - 2:45 PM:	Wellness break
2:45 PM - 3:30 PM:	Facilitated small group discussions: Best practices for partnership School district leaders host small group table discussions, reflecting on the presentations and using the group's insights to craft recommendations for school- researcher partnerships.
3:30 PM - 4:00 PM:	Next steps and concluding remarks

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4:15 PM - 5:00 PM: (Optional) Facilitated round robin for IAQ researchers IAQ researchers are invited to informally share with each other their current and upcoming research activities, successes, and challenges to identify areas of possible collaboration.

4:15 PM - 5:00 PM: (Optional) Tour of Benjamin Banneker High School Perkins Eastman, the architects for Benjamin Banneker High School, will offer a tour of the school, which is LEED Platinum certified and targeting net zero energy. Find out more about the school building: https://perkinseastman.com/projects/benjamin-banneker-academic-high-school/

Additional Information about the Sessions

MORNING FACILITATED PANEL DISCUSSION PANELISTS

Sheryl Magzamen, PhD Associate Professor and Associate Department Head for Graduate Education Department of Environmental and Radiological Health Sciences Colorado State University

Sheryl's research focus is the intersection of social factors and environmental exposures on chronic disease. Her school health research includes implementation of asthma control programs, understanding the relation between lead exposure and standardized testing, and the role of indoor air quality on student and teacher health.

Wanyu Rengie Chan, Ph.D. Staff Scientist, Indoor Environment Lawrence Berkeley National Laboratory

Dr. Rengie Chan is a Staff Scientist leading the Indoor Environment Group at Berkeley Lab. She studies building ventilation and indoor air quality, and is co-leading the <u>Efficient and Healthy Schools Program</u> for the U.S. Department of Energy. Rengie earned her Ph.D. in Environmental Engineering from University of California, Berkeley.

Katherine H. Walsh *Sustainability, Energy, and Environment Program Director* Boston Public Schools

Katherine leads districtwide initiatives to transform the sustainability measures and environmental health of 132 Boston Public Schools buildings. Serving on the Facilities Management leadership team, Katherine manages the Sustainability, EH&S, and Utilities Divisions, prioritizing critical, equitable improvements in drinking water access, IAQ, outdoor teaching and learning, energy efficiency, and zero waste.

Raj Setty, PE, CxA, LEED AP ASHRAE IAQ Leadership member

Mr. Setty is President of a mechanical, electrical and plumbing consulting engineering firm headquartered in Washington DC, with 9 offices. He is on the ASHRAE epidemic task force for schools and TC 9.7. He worked overseas for US Space Command and ZAP e-scooters. He taught as a Peace Corps volunteer in Namibia.

Brian Gilligan, PE, SCPM Deputy Director, Office of Federal High Performance Buildings U.S. General Services Administration

Brian has 20 years of experience in facilities, construction, and energy management and a passion for sustainability in the built environment. He is currently focused on GSA's Health in Buildings research which seeks to develop tools and methods to enhance health in buildings and make every project at GSA a learning experience.

Liam Bates *Co-founder & CEO* Kaiterra

Liam Bates is the co-founder and CEO of Kaiterra, a global leader in indoor air quality solutions. Expert in IAQ, sensor tech, and healthy buildings, Liam leads Kaiterra's research and development and serves as an IWBI advisor and WELL Faculty.

Seema Bhangar, Ph.D. [Moderator] *Principal, Health Buildings & Communities* U.S. Green Building Council

Seema Bhangar serves as Principal, Healthy Buildings and Communities, for Innovation and Research at the U.S. Green Building Council. She is on the board of the nonprofit Indoor Air Institute. She holds a Ph.D. in Environmental Engineering and an M.S. in Public Health from UC Berkeley.

AFTERNOON SCHOOL / RESEARCHER PARNTERSHIP PRESENTATIONS PRESENTERS

Mark Hernandez, Ph.D.

S J Archuleta Professor of Civil and Environmental Engineering Director, Environmental Engineering Microbiology and Disinfection Lab University of Colorado

Mark Hernandez is a professor and accredited professional civil engineer who directs <u>the aerobiology</u> <u>laboratory at the University of Colorado</u>. This group develops and applies modern forensic techniques to assess building engineering interventions that are relevant to environmental health. He has extensive experience translating modern building science developments to benefit educational settings.

Joni Rix Environmental Services Manager

Denver Public Schools

Joni leads environmental services across Denver Public Schools, serving 207 schools and over 90,000 students. With extensive experience in environmental health and indoor air, she strives to put students first and to create great learning environments. Over the years, this has brought collaborations with EPA, the City and County of Denver, National Jewish Hospital and recently with University of Colorado.

Sheryl Magzamen, Ph.D. [See biography above]

Katherine H. Walsh [See biography above]