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AIR: PROBLEMS OF HEAT AND POLLUTION

A Vygotskian Theoretical Learning Approach to Urban Environmental Consciousness

Fanhe, China. 10 day interval contrast (photography by Tomskyhaha)

PREFACE

TEACHING, LEARNING AND DEVELOPMENT

Vygotsky provided one of the best paths to understand development and learning. He rejected the main assertions by didactic methods (e.g., the idea that development must lead learning) and those of constructivist methods (e.g., the idea that learning is development). He asserted that learning could *lead* development – a radical idea even today. In the *Understandings of the Material World* Series approach to urban environmental consciousness, we are using Vygotskian approaches to teaching and learning science. According to Yuriy Karpov (2014, p.186-187) Vygotskian approaches have the following in common:

1. *Promoting students' learning motivation in relation to the given topic by creating a problem situation.* Problem situations are curious, surprising, delightful, puzzling, and/or engrossing phenomena that hook students on learning by peeking interest in learning more about solving subject domain problems.

2. *Providing the students with the subject domain concepts related to the topic to be learned*. These concepts are presented to the students in the form of written definitions, diagrams, posters, and other media formats so that the students do not need to memorize these concepts: they are always available for reference.

3. *Providing the students with a general procedure for solving subject domain problems*. The procedure is presented to the students in the form of a chart: a symbolic and graphic model that represents the canonical steps that one could undertake to solve a given subject domain problem. As an alternative, sometimes this procedure is not provided to the students already made, but rather the teacher and the students work together using the subject domain concepts to develop the problem-solving procedure that will be used for learning. In other words, the procedure is not the focus of learning. Instead, the focus of learning is on *how to solve problems through the adept use of mind tools* (concepts and procedures) that have been developed over time.

4. *Providing the students with the subject domain problems*. The students solve these problems using the procedures and concepts provided. Initially, the students verbalize each step in their problem solving, and the teacher closely monitors their problem solving to make sure that they use mind tools correctly. Then the students become engaged in cooperative learning in small groups. All the students within a learning group take turns performing each of the roles. As the students use the subject domain knowledge for problem solving, they master and internalize this knowledge, which reveals itself in their not looking anymore at the charts and written definitions while working

on new problems. At this point, these external tools can be gradually removed.

Stated another way by Galina Zuckerman and her colleagues,

> "A Vygotskian approach to the development of students' **ability to engage in persistent and systematic inquiry** is exemplified by a science curriculum for elementary school children. Three factors are singled out as crucial for evoking and amplifying this ability:
>
> a) Instruction starts by introducing ideas that are central and general to the discipline features in learning investigations;
> b) students invent and adapt cultural (mind) tools for thinking about these ideas (models, schemes, and symbols designed by students under the teacher's guidance); and
> c) problems are solved in cooperation with peers, helping students to present explicitly their own naive theories of growth and development and to see the phenomena being studied from the other's point of view." (Zuckerman, Chudinova, Khavkin, 1998, p. 201)

Karpov (2014) described one approach to teaching consistent with Vygotsky's theoretical ideas and empirical works as the **Vygotskian Theoretical Learning Approach (VTLA).** Other authors have described similar approaches to instruction: Developmental Teaching (Davydov 1988, 1990, 2008), Developmental Teaching (Giest & Lompscher 2003), Theoretical Learning (Aidarova 1982), El'konin-Davydov System (Zuckerman, Chudinova & Khavkin 1998), and Davydov Curriculum in Mathematics (Schmittau 2011).

The workshop structure shown on the following pages of this guide is a combination of Karpov, Aidarova and Zuckerman's approaches (and inspired by Bruner 1966, n.d.); it also includes sections required in the lessons planning templates used by many schools. Whatever science lesson planning approach you choose in the future, it ought to reflect a theory of learning that empowers students and teachers as learners, observers, and investigators of the world.

AUDIENCE

The *Material World Series* of VTLA teaching and learning guides were developed to be used by new teachers (before and after certification) in the Young Investigators Workshop (YIW). Young Investigators is an after-school science workshop for children ages 9-11 (students in grades 4-5). However, the activities are appropriate for both non-formal and formal educational settings.

This version of *Air: Problems of Heat and Pollution (i.e., AIR)* is comprised of three workshops. They illustrate how particular concepts might be taught using a Vygotskian Theoretical Learning Approach (VTLA). That said, this version is also an incomplete draft version so that readers (e.g., YIW Lead Teams) can revise and co-author their own complete VTLA guide with background materials (a) before their workshop sessions begin (e.g., YIW) and (b) before they share it with colleagues (e.g., Collective Planning). Note that "Lead Teams" ought to involve students whenever possible especially in formal educational environments.

FORMATTING

Guidelines and information are provided throughout this teaching and learning guide in blue text boxes. For example,

Section 1.3 **Overarching Performance Objectives** **Guidelines & Information**
To work on an object with learners (e.g., "understanding the plants perspective"), teachers outline outcomes and **performances** they will look for as students are learning. Once they establish this, then they co-create **tools for thinking** w/students (e.g., **mind tools described by Bodrova and Leong**) through theory-practice episodes (e.g., activities).

If a complete text is presented beneath a blue section, then *any revisions should improve the section, but not change the content significantly.* For example, if the performance objectives were listed below the blue box shown here, then they should be used "as is" or modified gently. Significant revision to the performance objectives provided would mean that all other related sections of the guide will need revising, which may disrupt the VTLA.

If the Lead Team needs to complete or finalize any aspect of the guide, then this is indicated with an orange text box (example below). The box provides some minimal information for the task and states what the Team Leaders need to complete. If any text is provided beneath an orange box, then this is considered a draft version and ought to be used by the team leaders to complete the section. For example, if a list of mind tools is provided in or below the orange box without complete descriptions, then descriptions and connections ought to be provided by the team. If no text is provided, then the team leaders ought to design and finalize the section, integrating their work into the featured workshop topic based the VTLA guidelines of Zuckerman et al. (1998) and Karpov (2014).

Section 2.8
Learning Roles
Guidelines & Information

Team Leaders: Outline the roles you expect students to take during small group work. For example, students might rotate roles: first student solves the problem with the procedural model, second student monitors the correct use of the model, third student evaluates the correctness of the solution based on the model (Karpov 2014, p. 187 and examples therein).

Connection to readings. This is related to Wiggins and McTighe's WHERETO Strategy: Provide opportunities to rethink and revise their understandings and work. Allow students to evaluate their work and its implications. Be tailored to the different needs, interests, and abilities of learners.

If one were to complete the content outlined in the orange text boxes and then remove all the text boxes (blue and orange) from the document what would result is a complete guide one could use for teaching three (or more) workshop sessions on the topic of *Air: Problems of Heat and Pollution* in urban environments. By designing this way, we can lead ourselves (teacher candidates, teachers, and teacher educators) through the process of learning how to plan workshops in the spirit of a Vygotskian approach. This format is meant to be a tool for teachers (new and practicing) to use, and further develop, as they work on the problem of designing VTLA workshops for learners.

GENERAL ORGANIZATION OF TEACHING GUIDES

The Teaching Guides for the *Material World* are divided into sections and subsections as follows:

Parts

1. Themes
2. Workshop #1 Plan
3. Workshop #2 Plan
4. Workshop #3 Plan
5. Team Expectations, Comments, Concerns & Possible Solutions
6. Analysis of Learning for Workshop #1
7. Analysis of Learning for Workshop #2
8. Analysis of Learning for Workshop #3

Sections

1. Topic
2. Alignment to Science Learning Standards
3. Teaching-Learning Objectives
4. Problem Situation
5. Target Concept(s)
6. Problem Solving Model(s)
7. Problem Presented
8. Learning Roles
9. Assessment(s)
10. Session Timing
11. Person Flow
12. Support Staff Roles
13. References
14. Resources

All guides contain the eight parts listed here. All workshops (Parts 2-4) must include Sections 8-14 otherwise the number and content of the sections will vary depending on the teaching-learning objective(s) and the problem being presented. It is expected that Part 1 will contain enough relevant science background to inform all three workshops as well as the three learning analyses that follow in Parts 6-8.

Table of Contents

FIGURES

IMAGE CREDITS (IN ORDER OF APPEARANCE)

Fanhe 10 day interval contrast (2019). Tomskyhaha Photographer. https://commons.wikimedia.org/wiki/File:Fanhe_Town_10_day_interval_contrast.png

Set of infrared images paired with visible light versions and captions (2013). Nickolay Lamm Photographer. https://nickolaylamm.com/art-for-clients/why-are-cities-hotter-than-suburbs/

NASA LADSAT surface temperature map of upper Manhattan with Central Park in the center (2015). New York City Panel on Climate Change (NPCC) https://nyaspubs.onlinelibrary.wiley.com/doi/epdf/10.1111/nyas.12670 (Figure F.2, p.145)

Images from the NASA/USGS satellite Landsat show the cooling effects of plants on New York City's heat (2002). Maps by NASA/Robert Simmon, using data from the Landsat Program. https://commons.wikimedia.org/wiki/File:Newyork_heat_island.jpg

Young Investigator Workshop (mixed years). Susan Kirch, Pooneh Sabouri, and Molly Zhang Photographers.

Young Investigator Workshop Materials & Set-up (mixed years). Susan Kirch, Pooneh Sabouri, and Molly Zhang Photographers.

Young woman suffering from heat stroke symptoms. She became dizzy and sweaty in the hot summer climate (n.d.). Image by Orapun. Adobe Stock, File 442742610.

PART 1: THEMES

(1) OVERARCHING TOPIC

Section 1.1
Overarching Topic
Guidelines & Information

Team Leaders: Complete the STEM content background pertinent to the three workshops. Be sure to make connections to relevant readings and unpack stories of NYC air (and air in areas of interest) featured in the news as they educate the reader about this topic. See other available teaching guides for examples of content introductions (e.g., *Great Explorations in Math and Science* guides).]

See these stories of relevant local news as an example (note, teams should find current websites):

- https://www.adaptny.org/2016/05/23/faq-harlem-and-the-urban-heat-island-effect/
- https://www1.nyc.gov/office-of-the-mayor/news/411-17/mayor-program-help-curb-effects-extreme-summer-heat
- https://www.nytimes.com/2011/07/22/nyregion/newark-is-hotter-than-its-neighbors.html
- https://dash.harvard.edu/bitstream/handle/1/12361745/NYC_SSBx_UHI_Mit_Can_Improve_NYC_Enviro%5B1%5D.pdf?sequence=1
- https://www.epa.gov/arc-x/new-york-city-adapts-deal-projected-increase-heat-waves
- https://www.nytimes.com/interactive/2019/08/09/climate/city-heat-islands.html
- https://www.zmescience.com/other/pieces/european-cities-heat-30072019/

Examples of NYC Air in the Regional News

- https://www.thirteen.org/metrofocus/2018/06/august-2-2017-heat-island-effect/

Examples of Urban Air in the National News

- https://nypost.com/2018/07/26/urban-heat-island-effect-tests-large-cities-across-the-country/
- http://news.mit.edu/2018/urban-heat-island-effects-depend-city-layout-0222

Problems of urban heat & pollution (a draft to be completed by lead team)

The first two workshops of this guide introduce the phenomenon of the Urban Heat Island Effect, which affects cities all over the world including the Greater New York City Metropolitan area. An urban heat island ***(UHI) refers to.....[Lead Team includes descriptions and citations].*** There are many reasons to care about the UHI effect, but the big two are (1) health effects, including death from UHIs and (2) UHI contribution to global climate change. ***[Lead Team ought to summarize science news reports and scientific evidence for those two claims].***

Why else should we care about the UHI effect? [***Lead Team ought to summarize science news reports and scientific evidence for those additional claims; be sure to include the plant experience of UHIs as well].***

What are the main factors in the formation of an UHI? ***[Lead Team ought to review science content helpful for a teacher of this guide; touch upon the content in the workshops herein; connect to plants and the workshops.]***

Can we stop UHIs from forming and how? ***[Lead Team ought to discuss possible solutions; touch upon the content in the VTLA workshops]***

Conclusion. In the first two workshops of *Air: Problems of Heat and Pollution* students will learn about UHI, what contributes to heating the air and how, how to change our urban environments to "cool down". In the third workshop (described in Section 4) students learn what is air pollution and whether our air in NYC is polluted, by what, and how much.

(2) CONTENT ALIGNMENT TO STEM STANDARDS (NYC AND NGSS)

Section 1.2
Content Alignment to STEM Standards
Guidelines & Information

Team Leaders: Find relevant local, state, and national STEM learning standards online, e.g., NYC Learning Standards and the Next Generation Science Standards (NGSS). Read through the entire draft of the *AIR* guide and then decide which STEM standards are most relevant.

Include a list of the standards most relevant to the workshops that you will address. Your list should not include standards that are not covered directly by your workshops.

> **Connection to Course Readings.** In their "Backward Design" planning template, Wiggins and McTighe refer to standards as the "Established Goals" and "Understandings". Bruner doesn't really address standards at all, but if he did maybe he would say that they should be used to promote participation in solving problems and that they ought to stimulate interest. Teaching to the standards is not an option for Bruner. Karpov' (2014) doesn't really address standards. He is concerned with identifying target concepts and problem-solving models. If the relevant standards are well written, then a teacher's target concepts might overlap with the standards. For Karpov, it is not an option to teach to standards that are not clearly aligned to content that helps students think theoretically about a problem space.

Section 1.2
Content Alignment to STEM Standards
Guidelines & Information

(3) OVERARCHING TEACHING-LEARNING OBJECTIVES

Section 1.3
Overarching Teaching-Learning Objective(s)
Guidelines & Information

When developing **teaching-learning objectives** we can begin by asking the question "What do we want students to have learned at the end of their studies?"

The overarching learning objective(s) ought to encompass the big idea(s) you want students to learn at the end of all three workshops. This objective(s) can be parsed at the workshop-level, but this section is meant to provide a broader context for teaching-learning.

Learning Objective. To learn about the role of the normal process of heat transfer in generating an Urban Heat Island (UHI). This is a topic that ought to concern urban citizens because it creates an unhealthy environment for living and is unsafe (e.g., pollution from ozone production, death, heat-related illness, and blackouts from high A/C usage). There are simple solutions to this problem, but urban citizens must insist on these solutions. One solution is in the form of green architecture and a reduction in air pollution from all sources.

Section 1.3
Overarching Performance Objective(s)
Guidelines & Information

To work on an object with learners (e.g., "understanding the plants perspective"), teachers outline outcomes and **performances** they will look for as students are learning. Once they establish this, then they co-create **tools for thinking** w/students (e.g., **mind tools described by Bodrova and Leong**) through theory-practice episodes (e.g., activities).

Performance Objectives. At the end of *the AIR* workshops, we would like students to: have a greater understanding of:

1. Heat transfer in various systems.
2. Urban Heat Island (UHI) and how it is created through normal heat transfer processes.
3. How we define the problems of the urban heat island effect (in our case, what causes it and how can we reduce it).
4. The mind tools (and physical tools) humans have made in the process of solving problems like the UHI and how these tools can be useful for others.

Students ought to learn how to:

5. Reduce the UHI effect (there are many ways to solve the problems of the urban heat island effect i.e., there is no one right answer).
6. Consider models of real-life scenarios, and how to consider the differences and similarities between models and real-life structures.
7. Use mind tools (i.e., conceptual tools) and prior knowledge to develop various investigations and create models of how to reduce the UHI effect.

PART 2: WORKSHOP #1 – URBAN HEAT ISLAND, A LOTTA HOT AIR

PART 2

The activities provided in this section are meant to reflect a Vygotskian theoretical learning approach (VTLA) described by Karpov (2014) combined with the Wiggins and McTighe WHERETO strategy to guide planning.

Team Leaders: Conduct **Sections 4 thru 7** as written with revisions or additions as indicated. Gently revise these sections if clarification is needed, otherwise it ought to be taught as written.

In this workshop, various tools for measuring heat are used to explore the temperature of various materials. First, students explore infrared images of familiar objects in NYC produced by infrared sensors. This is followed by using infrared sensors in the lab to study various construction materials. At the heart of this workshop, however, is learning more about heat and how to track its movements. Prepared instructors can use the heat transfer activities to make many subtle observations with students. Students can develop "spin-off" questions and investigations from the problem situation as well as the model production activity presented here. Investigations and questions which can be pursued at home or in future workshops (in school or afterschool).

(4A) PROBLEM SITUATION – WHAT'S HOT AND WHAT'S NOT: MATERIALS IN THE CITY

Section 2.4A
Problem Situation
Guidelines & Information

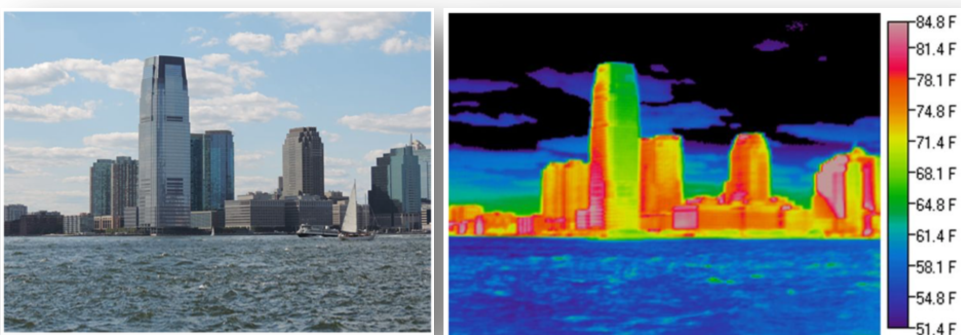
The **problem situation** is designed to promote students' learning motivation in relation to the given topic (see Karpov, 2014 p. 186 and examples therein). Does this problem situation achieve that goal when it is used for teaching-learning?

The problem situation is somewhat related to Wiggins and McTighe's WHERETO Strategy, but still distinct: Help the students know where the unit is going and what is expected. Help the teacher know where the students are coming from. Hook all students and hold their interest. Be tailored to the different needs, interests, and abilities of learners. Does this problem situation achieve these goals when it is used?

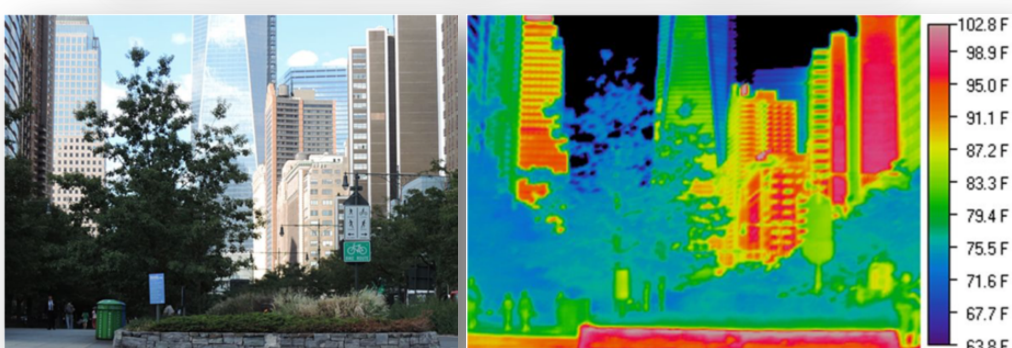
Discrepant Events: What's hot and what's not?

In the case of the problem of the UHI, the numerous and varied surface structures that are the hallmark of a city lead to higher temperatures compared to those in nearby suburban and rural areas. Without changing its identity, what can be done for the city and its residents? Tensions include intersectionality of multiple variables, stability of engineered structures, and human's inertia among others. In any VTLA, the problem situation must be worthy of learner's attention and promote learning motivation in relation to the given topic (Karpov, p. 186 and examples therein).

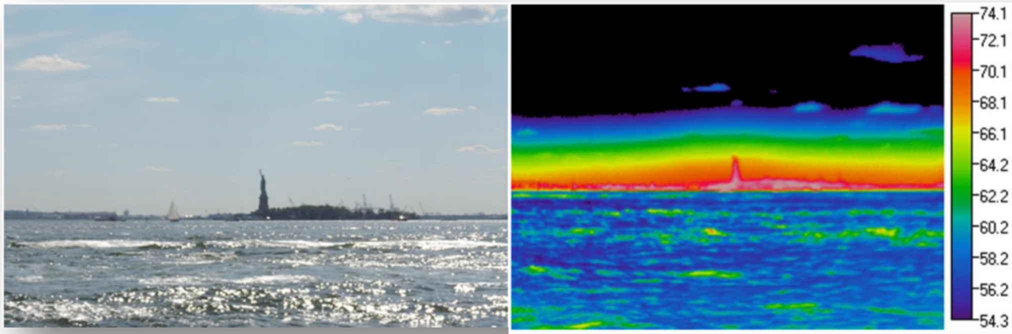
As the session begins, students ought to be shown a series of infrared images of structures and locations around the city (photography by Nickolay Lamm, 2013). Each of these is paired with the visible light image. As a group, students are asked to indicate what surfaces are relatively hot (higher temperature) and what surfaces are relatively cool (lower temperatures). The goal is to make as many observations as possible about all of the surfaces in the images. The images are shown next.



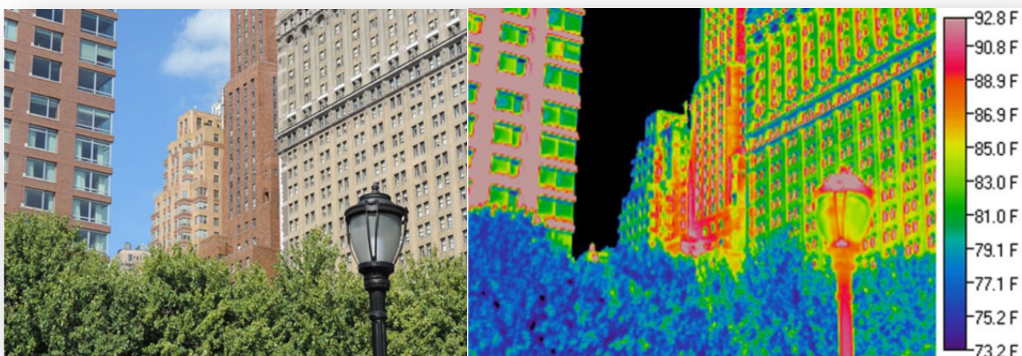
Jersey City Skyline from Manhattan
(left, unaided eye and right, thermal imaging camera)



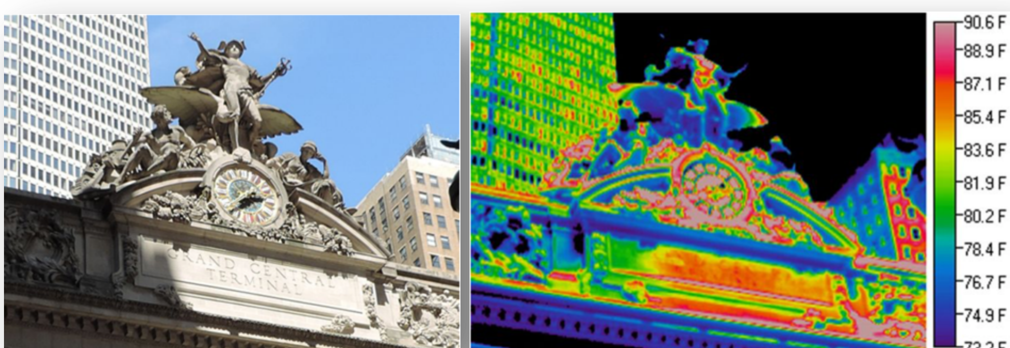
Borough Hall Park
(left, unaided eye and right, thermal imaging camera)



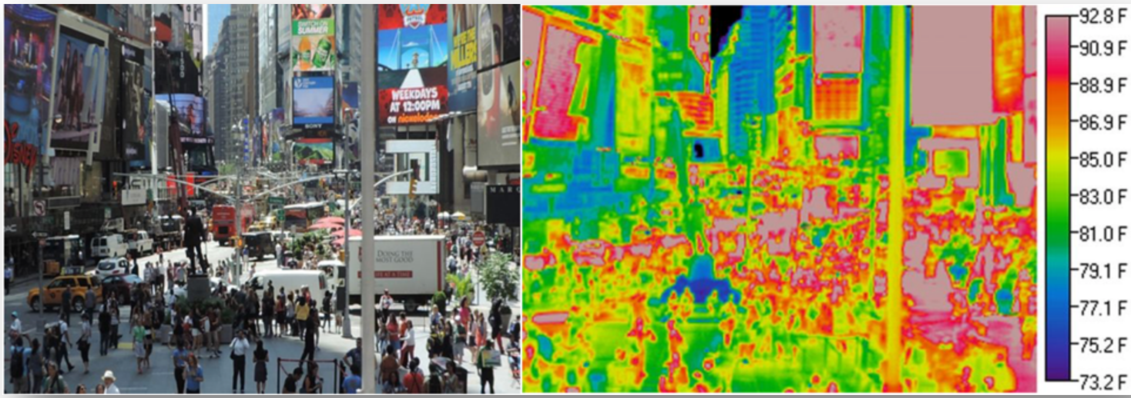
Statue of Liberty
(left, unaided eye and right, thermal imaging camera)



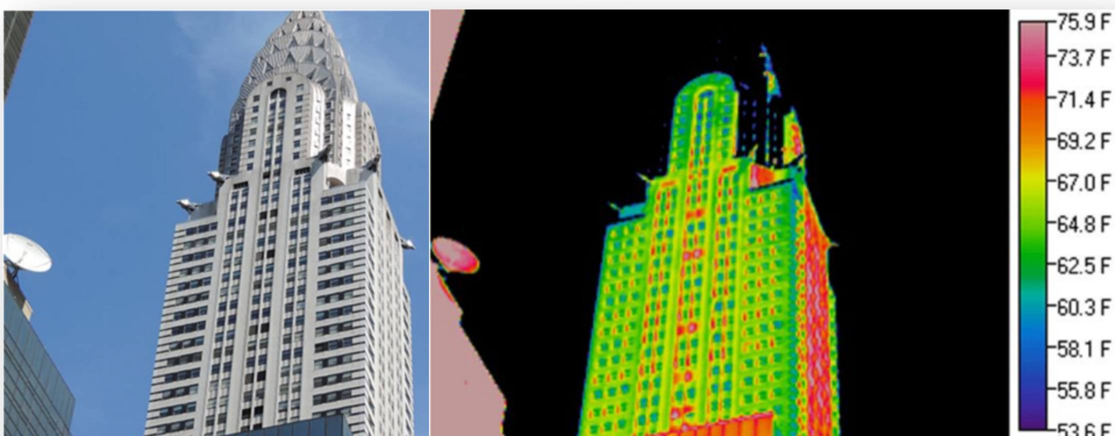
(left, unaided eye and right, thermal imaging camera)



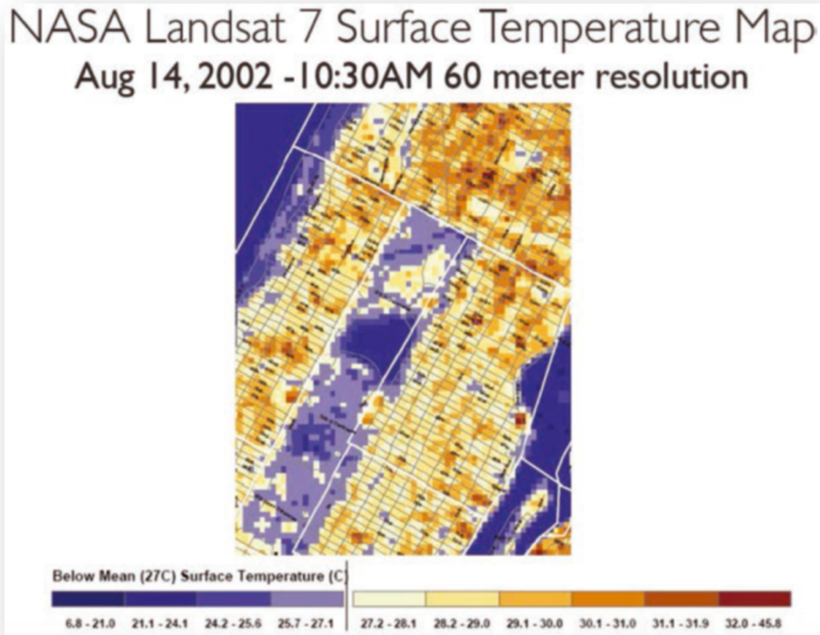
Grand Central Terminal
(left, unaided eye and right, thermal imaging camera)



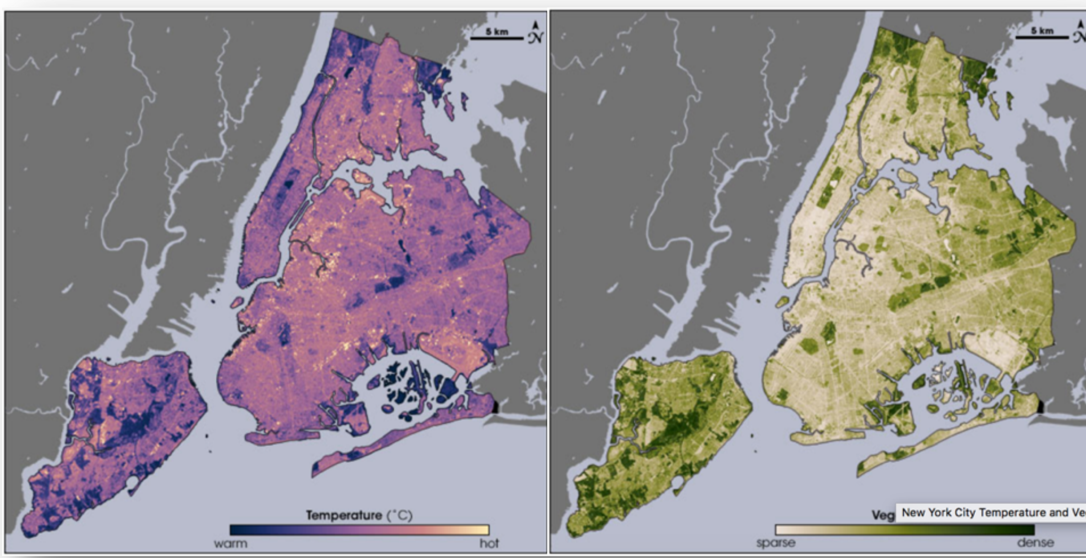
Times Square, Manhattan
(left, unaided eye and right, thermal imaging camera)



Chrysler Building
(left, unaided eye and right, thermal imaging camera)



NASA LADSAT surface temperature map of upper Manhattan with Central Park in the center (photography by NPCC, 2015)



https://earthobservatory.nasa.gov/IOTD/view.php?id=6800

These images from the NASA/USGS satellite Landsat show the cooling effects of plants on New York City's heat. On the left, areas of the map that are dark green have dense vegetation. Notice how these regions match up with the dark purple regions—those with the coolest temperatures—on the right. These photos were taken on one of the hottest days in NYC's 2002 summer (photography by NASA/Robert Simmon 2002).

Section 2.4A
Problem Situation - Observations
Guidelines & Information

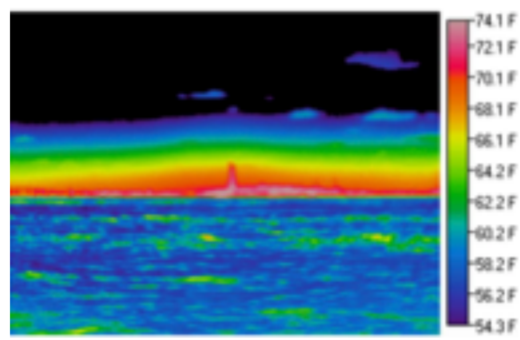
Team Leaders: Provide detailed observations of all 10 infrared images and the 2 LANDSAT images for teachers' reference. An example of some of the observations we could make about the thermal image of the Statue of Liberty are shown below as an illustration.

Figure 1 and its transcript illustrate the types of observations made by students who had observed the following images in the past.

Observations made of the infrared image of the Statue of Liberty (an example)

The water is roughly 68°F with some variation at the surface between 60-66°F.

The land and base of the statue are nearing pink/white and approximately 74°F.



The air immediately above the land surface is 70-71°F. It is just a little cooler than the land. When the temperature of the air is measured in this snapshot, the air near the land is in the 70°s, but it is cooler the further away it is from the land and the higher it is in the air column (70°s – red to orange, 60°s orange to light blue, 50°s dark blue to purple).

The black color at the top of the image indicates that the temperature of the object is off the low end of the temperature-color scale provided. We can say air furthest from the ground in this picture is below 54.3°F. Similarly white indicates that the temperature of the object is off the higher end of the temperature-color scale provided. If something is white (maybe parts of the ground in the photo) then the temperature is above 74°F.

Below, Figure 1 features examples of students' responses to the question, "Which surfaces in the photos taken around NYC were relatively hot and which were relatively cool?" (Figure 1 and transcript)

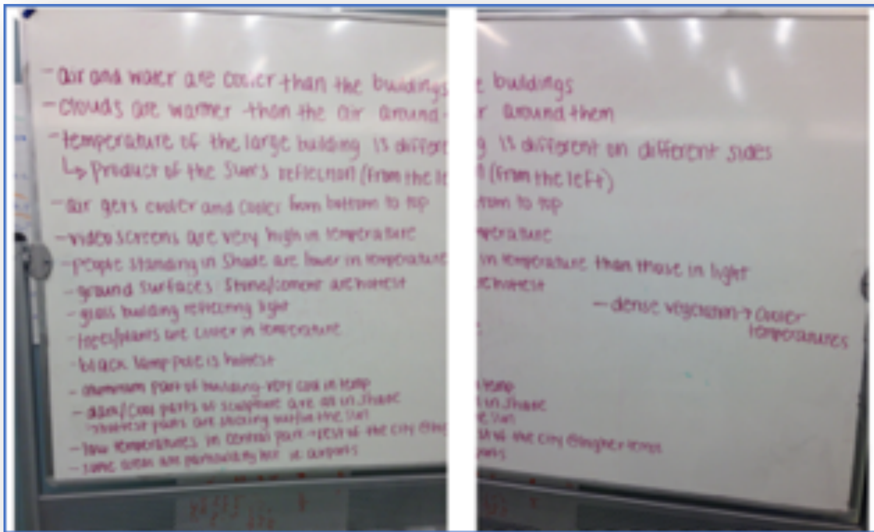


Figure 1. Recorded student responses during infrared image slide viewing

Transcript of Figure 1

Building material (glass vs. metal vs. stone/cement/brick)

- Temperature of the large building is different on different sides
  ↳ a product of the sun's reflection (from the left)
- Ground surfaces (stone/cement) are hottest
- Glass surfaces reflect light (inference)
- Aluminum part of [Chrysler] building very cool in temp
- Light colored surfaces vs. darker colored surfaces
- Black lamp post is hottest [compared to white/ glass lamp housing]

Shade/shadow from buildings vs. plants

- People standing in shade are lower in temperature than those in light
- Coolest parts of sculpture are in the shade (Grand Central); Hottest part of sculpture in sun (cement?)

People, pets, cars, air conditioners, everything inside buildings, etc.

- Video screens [at Times Square] are very high temp
- Some areas particularly hot (e.g., airports)

Natural environment

- Air and water are cooler than buildings
- Clouds are warmer than air around
- Air is cooler from bottom to top with bottom coolest and top warmest (Statue of Liberty)

- Trees/plants are lower in temperature
- Low temperatures in Central Park [compared to] rest of the city with higher temps

(4B) PROBLEM SITUATION CONT'D – HOW IS HEAT TRANSFERRED?

Recording student responses to questions about materials

The next question posed to the students for small-group (or pairs) discussion is:

> *What are some ways each of these materials or living things that we identified in problem situation 4A might work to make the surrounding air hotter or cooler and create blanket atmospheric urban heat island effects (i.e., to transfer heat to, or from, the air)?*

Listen to students as they share their ideas and record their responses next to each type of material. How do you understand student responses? Are there other interpretations of student meaning-making? How will you use these responses to track student learning about heat and UHI over-time? What do you notice about student contribution and participation? How might you change inequitable patterns that are sidelining students? What questions do you have about students talking science?

Section 2.4B **Problem Situation cont'd** **Guidelines & Information**
Team Leaders: Provide a list of all the possible materials shown in the images that could be discussed in response to the questions posed to students.

The materials shown in the infrared and LANDSAT images include but are not limited to:

- Cement
- Glass
- Water
- Trees (living tissue)
-

(5) TARGET CONCEPT(S) – URBAN HEAT ISLAND

Section 2.5
Target Concepts
Guidelines & Information

When a learner approaches any new problem situation, they will reconstruct tools they have learned in the past for use in understanding and developing solutions. If the problem situation is worthy of their time and is to teach them something, then they must learn new tools. If the problem situation can be solved with tools the learner can wield without much effort, then the situation is not worthy of their time because they will not gain any new insights, skills, etc. A teacher ought to consider what learners can do with ease and what they cannot, and the learner should know this about themselves as well.

Target concepts under investigation refer to the tools that learners will construct through the workshops, readings, and discussions. In our case, we provide the subject domain concepts that students will need to understand and develop solutions for the problem situation but may not necessarily be familiar with. In this section, the written definitions or other reference resources necessary for student's work, are listed and ought to be provided to the students in the form of handouts, classroom posters, table tents, etc.) (see Karpov, p. 186 and examples therein).

The idea of providing the target concepts of learning is related to Wiggins and McTighe's WHERETO Strategy: Equip students, help them experience the key ideas and explore the issues. They should be tailored to the different needs, interests, and abilities of learners**.**

Mind tools for working on the problem of the Urban Heat Island

In this session, the major idea is heat (what is it) and how it moves from one object to another (heat transfer). In the UHI effect, the heat in the air is caused by transfer of heat from the objects all around us to the molecules that comprise the air. Following heat transfer in any system can begin by asking these questions (answers to be completed by the team):

- What is heating up?
- What is cooling down?
- What are all the parts of the system in the example and where are all the points of temperature difference in the system?
- Is heat transferred by contact?

Additional mind tools that are related and necessary for understanding the UHI effect include (to be defined by the team):

- What is heat?
- How does air warm up and cool down?

Students are faced with the problem of explaining what was observed in the infrared images through a variety of investigations of their own design, demonstrations of specific concepts, data analysis (i.e., how do normal processes of heat transfer contribute to UHI in the urban context), and decision-making (e.g., how to reduce heat absorption and emission). Other mind tools that may come up, but are not directly necessary for the problem at hand (to be defined by the team):

- Infrared radiation (a.k.a. infrared light)
- Visible radiation
- Infrared Sensor
- Thermometer

As usual, we want to promote the production of new, useful mind tools for the urban heat island problem and related problems:

- new tools created by students in process of problem-solving (to be predicted by the lead team)

Physical experience to clarify mind tools

We can create (find) in our workshop space a temperature differential of 15-25°F so students can walk between these two spaces and be reminded how extreme this is and that it represents the difference between urban and adjacent green suburban or rural environments (e.g., inside/outside our building; hands in/out of the freezer compartment; stepping inside/outside a stairwell, etc.).

Notes about heat
We chose not to focus on the concepts of conduction, convection, and radiation as the main mind tools for students to learn at this time. The vocabulary detracts from what we are really interested in, which is defining the system (recall the variables scans in *The Plant Experience*), exploring the location of heat in the system, and showing the temperature differentials. Once students know how to track heat, they can later (maybe after these workshops) be introduced to the idea that heat is kinetic energy contained in the system, and moves between objects by conduction, convection, and radiation. Heat can also be absorbed or released by chemical or physical changes. Evaporation of water absorbs heat energy, and condensation releases it (remember transpiration and evaporative cooling). Only radiation works in space through a vacuum (what does this have to do with the sun?). A well-insulated object will stay at the same temperature because none of these transfers will happen (maybe very slowly). In the infrared images, which of these effects are important? (Actually, all are happening at the same time, but various types of heat transfer are prominent). As we see in the thermal images, the air carries heat. Air is made up of multiple gases (and all kinds of particulates), each of which has different properties. Carbon dioxide is a better blanket than oxygen and nitrogen gases. It is very good at absorbing infrared radiation and changing it to vibrational kinetic energy. This is how sunlight gets trapped in a form that can't radiate away again and why

Notes about heat
it is key to the existence of both the stable form of global warming that is necessary for humans to survive on Earth and the unstable form of global warming from the rapid and exponential rise of carbon in the atmosphere due to human activity.

(6) PROBLEM SOLVING MODEL – BUILD MODELS TO STUDY HEAT TRANSFER

Section 2.6 **Problem Solving Model** **Guidelines & Information**
A **problem-solving model is a model or concept** that students have already learned, and which is necessary for problem solving in a session. If necessary, provide the symbolic or graphic model and make it clearly available to students. If teachers and students are expected to work together using the subject domain concept or model to develop a problem-solving approach, then provide possible approach and explain that variation is expected (Karpov 2014, p. 186-187 and examples therein). This is related to Wiggins and McTighe's WHERETO Strategy: Equip students, help them experience the key ideas and explore the issues. Be tailored to the different needs, interests, and abilities of learners.

Students will need models of the UHI effect to understand the problem(s) and to devise possible solutions. The major problem they will face is how to build the "coolest" building based on their models and understanding of the problems related to atmospheric and surface UHIs.

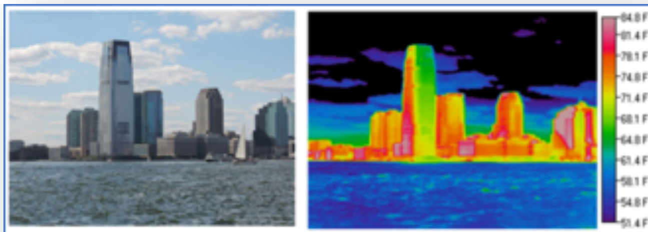
The models provided and developed with students included:

- Thermal infrared **photographs** (ground and satellite) as well as related **graphics**.
- **Definitions** (surface UHI and atmospheric UHI; temperature; heat; flow/movement; heat transfer)

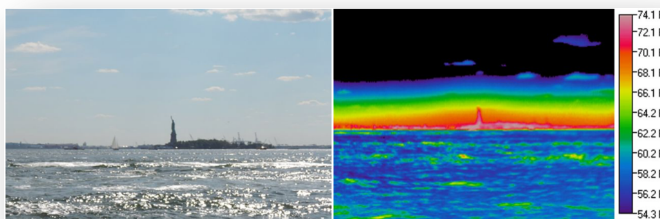
Ideally, all models are used with students as **mind tools to mediate the phenomenon** under study (heat transfer and UHI). **Demonstrations** of heat transfer within and between various materials are outlined on the following pages.

Introducing the model

How could we study the problem of UHI in NYC and create solutions to mitigate the problem?



Jersey City Skyline from Manhattan
(left, unaided eye and right, thermal imaging camera)



Statue of Liberty
(left, unaided eye and right, thermal imaging camera)

Thermal imaging (right panel of the photos above) shows temperatures of various objects including air, water, buildings among others (see list in Section 2.4).

In the VTLA, it is essential to ensure that students understand the problem (see Section 1) so that teachers can build with them a model for studying the problem and solving the problem in various ways.

To build a model for studying the UHI and solving UHI problems, students and teachers must ask and answer several questions.

1. Based on our experiences, what do we know about heat? What questions do we have about heat?
2. What is heat? (e.g., Is it an object, if so, what? Is it a process, if so, what? Is it an interaction, if so, what is interacting? Is it an idea, if so what?).
3. What do we know about how heat moves from one object to another? (e.g., heat from the hot water in a bathtub or shower to the cooler air in a bathroom).
4. Based on our experiences, what do we know about temperature?
5. What is temperature? (e.g., Is it an object, if so, what? Is it an idea, if so what?)
6. What other questions might we need to answer to understand the UHI effect?

7. [LATER] What other questions might we need to answer to create solutions to our NYC UHI problem?

In this workshop, students and teacher perform a series of demonstrations designed to illustrate heat and heat on the move and help students build a conceptual model of heat transfer. These mind tools will help them create “cool” buildings in future sessions.

Questions, photos, and materials for Heat Transfer demonstrations (#1-4) are shown next.

Modeling Heat: Building a model to study heat transfer

The same four or five questions were asked at every heat transfer demonstration station:

1. What is heating up?
2. What is cooling down?

   When we look at what is heating up and what is cooling down this helps us think about radiation phenomena like absorption and emission (e.g., how long it takes for an object to heat up and how long it takes for that same object to cool down; heat transfer without contact). But it also allows us to think about all the objects interacting in a heat transfer system. For instance, at the boiling water station the hot plate is heating up, the metal pot or glass beaker is heating up, the water at the bottom is heating up, is anything cooling down? The bottom of the pot/beaker is cooling down because the water above is cooling it off even as the hot plate is trying to heat it up more than the temperature of the water! These objects are conductive components in the system (hot plate, pot, beaker).

3. Where are the points of temperature differences?

   When we identify all the points of a temperature differential (where there is a higher temp object next to a lower temperature object) that helps us looks closer at conductive and radiation components. For example, in the temp differential station (conduction) there is a differential between the surface of the water and the air (hot water and cooler air), between the surface of the water and the main tub of water just below (hot water and cooler water), between the ice cube and the surrounding water (~0C and warmer water). As the ice melts and the water cools (equalizing to) what happens? Water starts to move, and that movement is caused by heat transfer.

4. Where do we see flow or movement?

   Where we see flow or movement in the air or water demos, this shows us that there is or was a temperature differential that created the movement. The movement reflects the universal trend of temp differentials to "even out" and become the same temperature. The differential could have been created by either conduction or radiation components.

5. Is the heat transfer through contact or not?

   There are two main types of transfer. Transfer with contact between objects is referred to as *conduction* and transfer without contact between objects is called *radiation*. The physics of each type of transfer are entirely different (contact is through sharing vibrations whereas without contact is through photons of light-energy).

What is our model for studying the UHI effect in NYC?

The key question under study is: How do the normal processes of heat transfer contribute to UHI effects?

As teachers and students work through the Heat Transfer demonstrations, teachers ought to be building a graphic model for studying the UHI effect with students. Constructed together, this model should reflect the ways that scientists study environments and build models of urban areas. For example, how do we:

1. Determine a method for taking temperature measurements (e.g., IR thermometers, surface thermometers, air temperature thermometers)
2. Determine what to measure and for what purpose (https://www.epa.gov/heat-islands/measuring-heat-islands)
3. Determine a method for displaying the temperature measurements (e.g., thermal images such as those shown in Part 2, isotherm map, temperature graphs)

Heat Transfer Station #1: Observing and comparing the surface temperatures various types or colors of paper

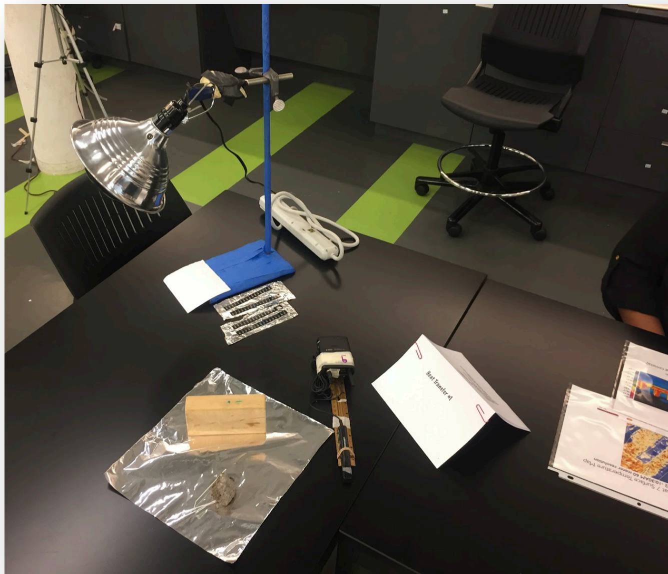


Figure 2. Heat transfer station #1, materials set-up

1. What is heating up? (increasing in temperature)

   We assume the paper is heating up because the temperature of the strip thermometer increases. It looks like the _____ paper does not heat up as much at the black color paper.

2. What is cooling down? (decreasing in temperature)

   It's not obvious that anything is cooling down, but it is! Even as the paper is heating up from the heat lamp (absorbing the radiation/light from the lamp) it is continually emitting some radiation, which is heating the air around it. When the temp of the paper does not rise very much it's not absorbing light from the lamp, it is reflecting that same light (no heat was produced in the interaction).

3. Is the heat transfer through contact or not?

   Since none of the paper is touching the lamp, it would seem that the light (the IR light not the visible light) from the lamp is heating the paper through radiation (IR light traveling through the air to the paper).

Questions to connect observations in Heat Model to problem situation (heat transfers to the air in NYC).

- How can your observations and inferences from this demonstration help to explain some of the IR patterns we see in some of the infrared images from the problem situation? (e.g., discuss Chrysler building image; discuss NYC's white roof project).

- How does this discussion help us put together a method for studying UHI effect in NYC? (record student ideas).

<u>Materials for Heat Transfer Station #1</u>

- black paper (5-10 sheets)
- white photocopy paper (5-10 sheets)
- 3-4 colors of photocopy paper (5-10 sheets of each)
- 1 heat lamp set up on ring stand and secured with tape (and connected to extension cord)
- thermometers: surface (strip), air temperature, IR with lasers taped to prevent their use in the classroom (2)
- 1 plastic tablecloth (white)
- color printout of the IR slide of __________ (e.g., Chrysler Building, Times Square, etc.)
- table tents with inquiry questions:
    1. What is heating up? (increasing in temperature)
    2. What is cooling down? (decreasing in temperature)
    3. Is the heat transfer through contact or not?
    4. Based on what we've observed and inferred here how could this help us understand how heat transfers from objects to the air here in New York City?

Heat Transfer Station #2: Observing and comparing the surface temperatures of various building materials

Figure 3. Heat transfer station #2, materials set-up

Remember to work in such a way that temperatures can be compared across groups.

1. What is heating up and how much? (increasing in temperature)

   We assume the paper is heating up because the temp of the strip thermometer increases.

2. What is cooling down and how much? (decreasing in temperature)

   It's not obvious that anything is cooling down, but it is! Even as the roofing material is heating up from the heat lamp (absorbing the radiation/light from the lamp) it is continually emitting some radiation, which is heating the air around it. When the temp of the material does not rise very much it's not absorbing light from the lamp, it is reflecting that same light (no heat was produced in the interaction).

3. Is the heat transfer through contact or not?

   Since none of the materials are touching the lamp, it would seem that the light (the IR light not the visible light) from the lamp is heating the material through radiation (IR light traveling through the air to the paper).

The materials here are a mixture of various degrees of reflectivity (the fraction of radiation arriving at a surface and reflected by it) and emissivity (the surface's tendency to emit radiation (IR light) to other bodies after absorbing radiation (or heat transfer via conduction).

There is also the question of once the surface is hit by radiation and absorbs that radiation then it conducts the heat produced at the surface into the object. An object that is a good heat conductor will heat throughout, but an object that does not conduct heat well may only warm the first few centimeters or inches into the object (the brick may heat on the surface, but not to the core or throughout if it is not a good conductor).

Questions to connect observations in Heat Model to problem situation (heat transfer to the air in NYC).

- How can your observations and inferences from this demonstration help to explain some of the IR patterns we see in some of the infrared images from the problem situation?

- How does this discussion help us put together a method for studying UHI in NYC? (record the ideas with the study method notes).

<u>Materials for Heat Transfer Station #2</u>

- box of building materials as well as the brick, cement block, 2 wood blocks
- heat lamp set up on ring stand and secured with tape (and connected to extension cord)
- strip thermometers in three ranges
- thermometers: surface (strip), air temperature, IR with lasers taped to prevent their use in the classroom (2)
- 1 plastic tablecloth (white)
- color printout of the IR slide of Chrysler Building
- table tents with inquiry questions
  1. What is heating up? (increasing in temperature)
  2. What is cooling down? (decreasing in temperature)
  3. Is the heat transfer through contact or not?
  4. Based on what we've observed and inferred here how could this help us understand how heat transfers from objects to the air here in New York City?

Names: ______________________________

BULIDING MATERIALS AND UHI:
A DATA COLLECTION MODEL

Gather data: you can decide which materials you would like to measure with the infrared thermometer. Record the surface temperature for each material with the infrared sensor. You may record different temperatures but remember our work on fair tests!

Material	Temperature	Temperature	Temperature
Black Roof Tile			
White Styrofoam			
Silver bubble paper			
Aluminum foil			
Glass			
Grey ceramic tile			
Pink ceramic tile			
Wood block			
Plant			
Soil			
Cement brick			
Paper, White			
Paper, Black			
Paper, ___________			
Paper, ___________			
Other ____________			
Other ____________			
Other ____________			

Figure 4. Urban Heat Island Effect: Data collection model.

Heat Transfer Station #3: Observing and comparing ice and a hot plate

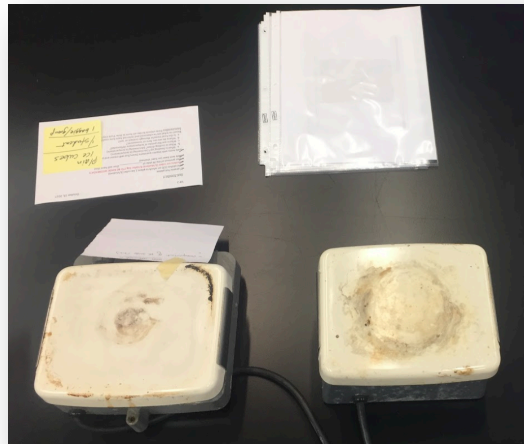


Figure 5. Heat transfer station #4. Student-teacher interaction (left), materials set-up (right)

1. What is heating up? (increasing in temperature)

   The ice cube seems to be heating up from our hands and the warmer air. Our hands seem to be heating up from the hot plate.

2. What is cooling down? (decreasing in temperature)

   With the hot plate our hand is cooling down by sweating and moving through the cooler air creating convection and conduction conditions between our hand and the air. Our bodies want to stay around 98.6°F and have several ways to manage that. With the ice cube melting from the heat of our hand (and the air) the air is cooling off and so is our hand because heat transfers from our hand (and air and table top, etc.) to the ice.

3. Where are the points of temperature differential?

   Possible points are between the surface of the ice cube and the air, the surface of our hand and the ice cube, the surface of our hand and the air, the surface of the ice cube and the dish, the surface of the dish and the table. For the hot plate it might be the surface of the plate the air touching it, the surface of the plate and the surface of our hand, the surface of the plate and the surface of anything else around.

4. Where do we see flow or movement?

It is difficult to see anything moving or flowing, but wherever there is a differential (two different temperatures) movement will be created as heat transfer occurs from the hotter area to the cooler area. In this case the air is probably flowing (hot air created from the hot plate is floating up because it's less dense and the cooler air is sinking, that cooler air is warmed by contact with the hotplate and rises pushing more cooler air down, etc.)

5. Is the heat transfer through contact or not?

   Since we are not touching the ice cube or the hot plate, heat transfer is not through contact. This is an example of radiation. But the air is touching the hot plate and ice therefore, heat transfer is through contact. So, this is an example of conduction and convection if we consider the air.

Questions to connect observations in Heat Model to problem situation (heat transfer to the air in NYC).

- How can your observations and inferences from this demonstration help to explain some of the IR patterns we see in some of the infrared images from the Problem Situation (Part 2)?

- How does this discussion help us put together a method for studying UHI in NYC? (record the ideas with the study method notes).

<u>Materials for Heat Transfer Station #3</u>

- 2 ceramic hot plates
- petri dishes (12) on which to place 1 ice cube (1/student)
- colorless ice cubes (1/student) in small zip-close bags
- color printout of the IR slide of ______________ (e.g., Chrysler Building, Times Square)
- table tents with inquiry questions
  1. What Is heating up? (increasing in temperature)
  2. What is cooling down? (decreasing in temperature)
  3. Where are the points of temperature differential?
  4. Where do we see flow or movement?
  5. Is the heat transfer through contact or not?
  6. Based on what we've observed and inferred here how could this help us understand *how <u>heat transfers</u>* from objects to the air here in New York City?

Heat Transfer Station #4: Observe what happens when water of various temperatures is next to each other (and the air)

Figure 6. Heat transfer station #4. Students watching phenomena (left), materials set-up (right)

1. What is heating up? (increasing in temperature)

   The water is heating up in the teapot, the ice is heating up in the water. Technically the air is heating up from the teapot heat and the hot water. Others?

2. What is cooling down? (decreasing in temperature)

   The tub of water is cooling down, the teapot water is cooling down as soon as it is poured. The tabletop is cooling ever so slightly as the bottom of the tub of water is cooled. Others?

3. Where are the points of temperature differential?

   Between the air and the layer of hot water, between the layer of hot water and the RT tub, between the ice and the RT tub of water, between the ice and the air, between the tub and the tabletop. Others? Technically between our bodies and the tub. The tub of water starts at room temperature so there is no heat transfer possible there.

4. Where do we see flow or movement?

   We see movement start immediately when the hot water and the ice cube are added to the bin. The cold water from ice cube sinks and swirls are created in the bin. As the hot water touches the ice it cools and sinks in purple-blue-red streams. As we watch the hot water layer we see “stalactites” begin to form a mixing occurs between the RT water and the hot water layer. There may be more observations here as we pay attention to motion (not motion caused by hitting or moving the table, but by the heat differentials in the liquid)

5. Is the heat transfer through contact or not?

   All the heat transfer in this system seems to be through contact, but there is heat transfer from our bodies and breath, from the IR spectrum of the lights in the room, etc. that are also causing heat transfer to the demonstration system (i.e., the tub of water w/temp diff.) via radiation.

Questions to connect observations in Heat Model to problem situation (heat transfer to the air in NYC).

- How can your observations and inferences from this demonstration help to explain some of the IR patterns we see in some of the infrared images from the Problem Situation (Part 2)?

- How does this discussion help us put together a method for studying UHI in NYC? (record the ideas with the study method notes).

<u>Materials for Heat Transfer Station #4</u>

- clear plastic tub or small fish tank for room temp water (in prep room on countertop)
- at least 6-8 gallons of room temp water (or large flasks/beaker) ready for water changes the clear plastic tub in prep room will need to be refilled at six times with room temp equilibrated water throughout the session
- blue ice cubes (batches of 5 in zip lock bags)
- boiling water in electric kettle (the lab kettle) plugged in at the station
- plastic 15 mL blue capped tubes filled with water+ Red food coloring (10-12 filled tubes) in test
- tube rack (fill the rack)
- color printout of the IR slide of the Statue of Liberty
- table tents with inquiry questions
  1. What is heating up? (increasing in temperature)
  2. What is cooling down? (decreasing in temperature)
  3. Where are the points of temperature differential?
  4. Where do we see flow or movement?
  5. Is the heat transfer through contact or not?
  6. Based on what we’ve observed and inferred here how could this help us understand how heat transfers from objects to the air here in New York City?

(8) LEARNING ROLES (TO BE COMPLETED BY THE TEAM)

Section 2.8 **Learning Roles** **Guidelines & Information**
The **roles** available to participants are specified by institutional culture and its division of labor (e.g., in education typical roles include student, teacher, poor performer, troublemaker, smart, talented, difficult, disadvantaged, average, etc.). Assembling images of new **learning roles** depend on actions of role making, role taking, and role verifying. For example, if we want to help students develop a new learning role like: "constructive and gentle critic" then teachers need to model (and discuss) what this learning role might look and sound like through our gestures and speech and students need to practice. This is related to Wiggins and McTighe's WHERETO Strategy: Provide opportunities to rethink and revise their understandings and work. Allow students to evaluate their work and its implications. Be tailored to the different needs, interests, and abilities of learners. **Team Leaders:** Outline the learning roles you expect students to take during small group work. For example, students might rotate roles: first student solves the problem with the procedural model, second student monitors the correct use of the model, third student evaluates the correctness of the solution based on the model (Karpov 2014, p. 187 and examples therein).

(9) ASSESSMENT (TO BE COMPLETED BY THE TEAM)

Section 2.9 **Assessment** **Guidelines & Information**
According to Karpov (2014), it is important to assess not only what the child can do independently, but his or her zone of proximal development as well. This idea is the foundation of **dynamic assessment**, which is aimed at "the evaluation of children's ability to benefit from adult assistance, that is, their learning ability" (p. 23). For examples, see chapters in Dynamic assessment: Prevailing models and applications (Lidz & Elliott 2000) especially Chapter 1 by Carol Lidz and Julian Elliott (2000) and Chapter 5 by Yuriy Karpov & Boris Gindis (2000). Throughout these workshops it is possible to develop dynamic assessments for and as teaching. **Team Leaders:** Include a description of a small-scale dynamic assessment used to monitor student learning ability as well as a range of possible answers to all assessments and questions. Note: it may be necessary to use time prior to the official start of the YIW session for the DA.

(10) SESSION TIMING (TO BE COMPLETED BY THE TEAM)

Section 2.10
Event Timing
Guidelines & Information

Event timing refers to how long each learning task or other activity (e.g., problem situation, model construction, problem solving) will take during the workshop. This is related to Wiggins and McTighe's WHERETO Strategy: Be organized to maximize initial and sustained engagement as well as effective learning.

Team Leaders: Estimate how long each learning task or other activity will take and how you will pace the workshop accordingly.

(11) PERSON FLOW (TO BE COMPLETED BY THE TEAM)

Section 2.11
Person Flow
Guidelines & Information

Person Flow refers to where students and teachers will work and how they will be asked to move through the physical space during the workshop. This is related to Wiggins and McTighe's WHERETO Strategy: Be organized to maximize initial and sustained engagement as well as effective learning.

Team Leaders: Include maps and diagrams of the workshop for each distinct activity. This includes locations of materials and actions as well as planned movement if necessary. For example, if you plan to ask students and/or teachers to move from one location to another every 10-15 minutes be sure to have a plan for how to orchestrate that move.

(12) SUPPORT STAFF ROLES (TO BE COMPLETED BY THE TEAM)

Section 2.12
Support Staff Job Descriptions
Guidelines & Information

Every teacher in the workshop who is not a Team Leader is considered a support staff. These colleagues ought to be given **job descriptions** and expectations for the session. They are there to support the Lead Team and should be dispatched to key duties related to understanding students as learners.

Team Leaders: Include a description of support staff duties and expectations (e.g., will you ask your colleagues to teach in small groups, will you ask them to make observations of student engagement and learning with a checklist or heuristic, will you ask them to manage materials, will you ask them to manage and position cameras, etc.?)

(13) REFERENCES (TO BE COMPLETED BY THE TEAM)

Section 2.13 **References** **Guidelines & Information**
Team Leaders: Include the list of references used in the writing of the Teaching Guide (APA, MLA, Chicago or another sanctioned format).

(14) RESOURCES (TO BE COMPLETED BY THE TEAM)

Section 2.14 **Resources** **Guidelines & Information**
Team Leaders: Include… • A bibliography of useful resources, which are targeted to people of all ages such as textbooks, books, articles, websites, and movies. • Resources for teachers to consult prior to teaching. • Resources for curious families

PART 3: WORKSHOP #2 – SOLUTIONS TO THE URBAN HEAT ISLAND EFFECT

(6) PROBLEM-SOLVING CONCEPTS OR MODELS – BUILD A MODEL OF THE UHI EFFECT AFTER EXPLORING HEAT TRANSFER

Section 3.6
Problem Solving Concepts or Models
Guidelines & Information

A **problem-solving model is a model or concept** that students have already learned, and which is necessary for problem solving in a session. If necessary, provide the symbolic or graphic model and make it clearly available to students. If teachers and students are expected to work together using the subject domain concept or model to develop a problem-solving approach, then provide possible approach and explain that variation is expected (Karpov 2014, p. 186-187 and examples therein).

This is related to Wiggins and McTighe's WHERETO Strategy: Equip students, help them experience the key ideas and explore the issues. Be tailored to the different needs, interests, and abilities of learners.

Team Leaders: Continue working with the overarching question for the AIR guide, "What effects to the problems of urban heat and pollution create for residents?" Finalize the problem situation below in which students and teachers construct mind tools for data analysis in this workshop. Develop descriptions and approaches (models) for the following concepts need to be developed (refer to *The Plant Experience* guide as you expand these ideas further): observation, inference, interpretation, generalization, fair test, methods for data analysis.

Provide questions for data analysis, sure to build on the questions from *The Plant Experience* and use questions from the readings by Harlen (some examples are provided below).

Mind tools for data analysis

Overarching question: Based on the demonstrations of heat transfer, what is a model for UHI and how could we study the UHI effect in NYC?

During the second workshop, students analyze their data from the heat transfer demonstrations (Figure 4). Usually, a great deal of data is available from the class. This is collected and groups analyze it before they can begin building structures (e.g., schools, malls, apartment buildings, office buildings, etc.). They use their analyses and interpretations of the data to choose building materials that heat a structure over a wide range of temperatures. Before this can be done mind tools need to be described, co-constructed based on the work conducted in the YIW to date and highlighted for study and development.

Central mind tools include:

- Observation described as….
- Inference…
- Interpretation….
- Generalization…
- Fair test…
- Methods for data analysis…

Questions for data analysis

- How did each group gather their data? What data is it fair to include in a class average?
- How do we decide what the data means? For example, how do we make this type of statement "Under these conditions ______, this happens ________"
- Can we make any generalizations? For example, could we say, "All light-colored surfaces will behave this _____________way or all dark colored surfaces will behave this ______ way?"
- How does heating up concrete buildings and black pavement contribute to the Urban Heat Island?
- Others…

(7) PROBLEMS PRESENTED – CHALLENGING SCENARIOS

Section 3.7 **Problems Presented** **Guidelines & Instructions**
The **problem presented** to the students for learning is the main object on which students will work and perform learning. Students solve problem(s) presented using the mind tools (e.g., subject domain concepts and models related to the topic to be learned). Students work towards solving an observed problem in science using the conceptual knowledge and procedural knowledge (the psychological/mind tools). Students master the provided knowledge through practice. Mastery is obtained when student no longer use the provided resources and they have internalized the knowledge (see Karpov 2014).

After data analysis of all their investigations students make construction decisions based on the models of heat transfer, they made in Workshop 1 and will make at the beginning of this workshop. The Urban Heat Island Construction Planners (Figure 7a and 7b) are designed to help them consolidate data analysis, make interpretations, and build according to the data gathered scientifically.

Based on what we have learned about heat transfer so far, each team will work through these three engineering challenges to reduce the amount of heat contributing to the UHI in NYC. Structures include school, mall, skyscraper, apartment building, stadium, etc.

Challenge/Scenario #1

*Create the **hottest structure(s**) from scratch (i.e., structures that maximally heat the air around them)*

> After students' investigations to learn more about heat transfer in our environment are complete, their task is to create a structure from scratch so **that the heat contributing to the UHI effect is increased as much as possible**. The point of this is to see how our common building materials easily achieve this. Students should also ask what can be done differently to "build cool". (Planner 7a)

Challenge/Scenario #2

Once you've built a structure in Challenge #2, improve it with the modifications allowed (per scenario instructions).

> After students' investigations to learn more about heat transfer in our environment are complete, their task is to **modify an existing structure so that the heat contributing to the UHI effect is reduced**. (Planner 7a)

Challenge/Scenario #3

*Create the **coolest structure(s**) from scratch (i.e., structures that minimally heat the air around them)*

> After students' investigations to learn more about heat transfer in our environment are complete, their task is to build a structure from **scratch that reduces the heat contributing to the UHI as much as possible.** (Planner 7b)

By the end of this workshop, students ought to be able to explain their decisions and justify their LEED scores based on the data that they gathered and their understandings of heat transfer and related processes.

Urban Heat Island Construction Planner (Hot Construction)

Mission: Increase the heat island effect using the findings from your materials study when planning and re/building.

Goal: To avoid LEED certification, teams must try to avoid as many points as possible in your land quadrant.

Materials: Teams can use any material from the Building Supply. Supplies of some items are limited due to seasonal shortages (e.g., plants) and national shortages (e.g., ceramic tile).

Procedure: Teams must include **ALL** the features that will increase the Urban Heat Island effect in your quadrant. Avoiding sustainability features will help you increase the heat your quadrant produces.

Tools: Use your Building Materials and UHI collection and interpretation model (Figure 4). The building inspector will use the class data model and the LEED scorecard to evaluate.

Figure 7a. Urban Heat Island Construction Planner (hot construction)

Urban Heat Island Construction Planner (Cool Construction)

Mission: Reduce the heat island effect and use sustainable materials when planning.

Goal: To receive LEED certification, teams must try to acquire as many points as possible in your land quadrant.

Materials: Teams can use any material from the Building Supply. Supplies of some items are limited due to seasonal shortages (e.g., plants) and national shortages (e.g., ceramic tile).

Procedure: Teams must include **ALL** the features that will reduce the Urban Heat Island effect in your quadrant. Sustainability features will help you earn more points for LEED certification!

Tools: Use the Scorecard (Figure 8) to help you plan your structure. The building inspector will use this scorecard for the LEED certification process.

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Figure 7b. Urban Heat Island Construction Planner (cool construction)

The Urban Heat Island Construction Planner is designed to help students consolidate data analysis, make interpretations, and build according to the data gathered scientifically. In the three challenges/scenarios, students expand experiments at the Heat Transfer Stations (Workshop 1) to ask new questions, test new ideas, explore new evidence (etc.) if it helps them complete their challenges/scenarios.

With the help of the UHI Scorecard (Figure 8), students ought to be able to explain their decisions and justify their self-assigned LEED scores based on the data that they gathered and their understandings of heat transfer and related processes. LEED Certification Rankings include Silver (10-15 points), Gold (15-20 points), and Platinum (20+ points). This system is similar to what is used by U.S. Green Building Council.

✓	Feature	Possible Points	✓	Feature	Possible Points
	Plants	1		Green roofs	2
	Reflective surfaces	1		Solar panels	3
	Insulation (structure – walls/roof)	1		Insulation	3
	Insulated windows	1		Reusable materials	5
	Cool Roof	1		Rain gardens or native plants	2
	Green Roof	1		Permeable pavement	2
	Cool pavement	1		Wildlife corridors	3
	Green "pavement"	1		Reflective surfaces	1
	Reduce human-generated heat (cars; A/C; heat, etc.)	1		Energy saving shading	3
	Additional ideas?	1		Biking amenities	1

Figure 8. UHI Scorecard

(8) LEARNING ROLES (TO BE COMPLETED BY THE TEAM)

Section 3.8
Learning Roles
Guidelines & Information

The **roles** available to participants are specified by institutional culture and its division of labor (e.g., in education typical roles include student, teacher, poor performer, troublemaker, smart, talented, difficult, disadvantaged, average, etc.). Assembling images of new **learning roles** depend on actions of role making, role taking, and role verifying. For example, if we want to help students develop a new learning role like: “constructive and gentle critic” then teachers need to model (and discuss) what this learning role might look and sound like through our gestures and speech and students need to practice.

This is related to Wiggins and McTighe’s WHERETO Strategy: Provide opportunities to rethink and revise their understandings and work. Allow students to evaluate their work and its implications. Be tailored to the different needs, interests, and abilities of learners.

Team Leaders: Outline the learning roles you expect students to take during small group work. For example, students might rotate roles: first student solves the problem with the procedural model, second student monitors the correct use of the model, third student evaluates the correctness of the solution based on the model (Karpov 2014, p. 187 and examples therein).

(9) ASSESSMENT (TO BE COMPLETED BY THE TEAM)

Section 3.9
Assessment
Guidelines & Information

According to Karpov (2014), it is important to assess not only what the child can do independently, but his or her zone of proximal development as well. This idea is the foundation of **dynamic assessment**, which is aimed at “the evaluation of children’s ability to benefit from adult assistance, that is, their learning ability” (p. 23). For examples, see chapters in Dynamic assessment: Prevailing models and applications (Lidz & Elliott 2000) especially Chapter 1 by Carol Lidz and Julian Elliott (2000) and Chapter 5 by Yuriy Karpov & Boris Gindis (2000). Throughout these workshops it is possible to develop dynamic assessments for and as teaching.

Team Leaders: Include a description of a small-scale dynamic assessment used to monitor student learning ability as well as a range of possible answers to all assessments and questions. Note: it may be necessary to use time prior to the official start of the YIW session for the DA.

(10) SESSION TIMING (TO BE COMPLETED BY THE TEAM)

Section 3.10
Event Timing
Guidelines & Information

Event timing refers to how long each learning task or other activity (e.g., problem situation, model construction, problem solving) will take during the workshop. This is related to Wiggins and McTighe's WHERETO Strategy: Be organized to maximize initial and sustained engagement as well as effective learning.

Team Leaders: Estimate how long each learning task or other activity will take and how you will pace the workshop accordingly.

(11) PERSON FLOW (TO BE COMPLETED BY THE TEAM)

Section 3.11
Person Flow
Guidelines & Information

Person Flow refers to where students and teachers will work and how they will be asked to move through the physical space during the workshop. This is related to Wiggins and McTighe's WHERETO Strategy: Be organized to maximize initial and sustained engagement as well as effective learning.

Team Leaders: Include maps and diagrams of the workshop for each distinct activity. This includes locations of materials and actions as well as planned movement if necessary. For example, if you plan to ask students and/or teachers to move from one location to another every 10-15 minutes be sure to have a plan for how to orchestrate that move.

(12) SUPPORT STAFF ROLES (TO BE COMPLETED BY THE TEAM)

Section 3.12
Support Staff Job Descriptions
Guidelines & Information

Every teacher in the workshop who is not a Team Leader is considered a support staff. These colleagues ought to be given **job descriptions** and expectations for the session. They are there to support the Lead Team and should be dispatched to key duties related to understanding students as learners.

Team Leaders: Include a description of support staff duties and expectations (e.g., will you ask your colleagues to teach in small groups, will you ask them to make observations of student engagement and learning with a checklist or heuristic, will you ask them to manage materials, will you ask them to manage and position cameras, etc.?)

(13) REFERENCES (TO BE COMPLETED BY THE TEAM)

Section 3.13 **References** **Guidelines & Information**
Team Leaders: Include the list of references used in the writing of the Teaching Guide (APA, MLA, Chicago or another sanctioned format).

(14) RESOURCES (TO BE COMPLETED BY THE TEAM)

Section 3.14 **Resources** **Guidelines & Information**
Team Leaders: Include… • A bibliography of useful resources, which are targeted to people of all ages such as textbooks, books, articles, websites, and movies. • Resources for teachers to consult prior to teaching. • Resources for curious families

PART 4: WORKSHOP #3 – AIR POLLUTION

(1) TOPIC - AIR POLLUTION

Section 4.1 Overarching Topic (Air Pollution) Guidelines & Information
Team Leaders: See Section 1.1 and revise as needed to include content about air pollution if not integrated previously.

(2) CONTENT ALIGNMENT TO STANDARDS (NYC AND NGSS)

Section 4.2 Content Alignment to STEM Standards (Air Pollution Workshop) Guidelines & Information
Team Leaders: See Section 1.2 and update alignment to local, state, and national STEM learning standards as needed.

(3) OVERARCHING TEACHING-LEARNING OBJECTIVES – AIR POLLUTION

Section 4.3 Overarching Teaching-Learning Objectives Overarching Performance Objectives Guidelines & Information
The **learning objective** ought to be clearly stated with details about why the topic ought to concern urban citizens. **Performance objectives** list what you like students to be able to do and discuss. [See Section 1.3 for details] **Team Leaders:** State the learning objective (if not included in Section 1.3) and expand the performance objectives to include ideas related to: • atmosphere, smog, pollution • how humans change their environments • how pollution is created • how we can limit our harmful impact • how pollution is connected to the UHI effect

(4) PROBLEM SITUATION – UNEXPECTED POLLUTION

Section 4.4
Problem Situation
Guidelines & Information

The **problem situation** is designed to promote students' learning motivation in relation to the given topic (see Karpov, 2014 p. 186 and examples therein). Does this problem situation achieve that goal when it is used for teaching-learning? [See Section 2.4. for more details]

Team Leaders: Continue the overarching question for the *AIR* guide, "What effects to the problems of urban heat and pollution create for residents?" Finalize a problem situation in which students explore the idea of air pollution and how the processes by which humans generate pollution harms everything including all people everywhere. Be sure to "hook" students into thinking about how humans create pollution and how it relates to all of us in the workshop (and beyond).

Problem Situation – Unexpected Pollution (a draft to be completed by lead team)

Engage students in thinking about pollution or how it relates to them.

Find compelling video clips coupled with discussion questions for Science Talks can form the basis of a problem situation for air pollution.

- Video clips showing (a) model of how pollution comes to be in the air and how it can affect humans.
- Video clip(s) illustrating different levels of emissions created by polluting processes or objects.

Possible discussion questions to pair with video clips.
(1) Where did you assume there would be the most pollution?
(2) What was surprising about the results?
(3) Do you think pollution is a necessary evil?
(4) Do you think we can stop pollution? What can we do in our everyday lives to reduce the amount of pollution we produce?
(5) What types of human-made machines or objects makes pollution better or worse? What about air pollution, specifically?

(5) TARGET CONCEPT(S) – POLLUTION CONCEPTS

Section 4.5
Target Concepts
Guidelines & Information

Target concepts under investigation refer to the tools that learners will construct through the workshops, readings, and discussions. In our case, we provide the subject domain concepts that students will need to understand and develop solutions for the problem situation but may not necessarily be familiar with. In this section, the written definitions or other reference resources necessary for student's work, are listed and ought to be provided to the students in the form of handouts, classroom posters, table tents, etc.) (see Karpov, p. 186 and examples therein). [See Section 2.5 for more detailed information about Target Concepts.]

Team Leaders: Revise and expand the concepts and ideas throughout this guide to include mind tools for the pollution session. Include concepts such as: atmosphere, smog, pollution, particulates.

(6) PROBLEM SOLVING MODEL – METHOD FOR DETECTING POLLUTION (PARTICULATES)

Section 4.6
Problem Solving Model
Guidelines & Information

A **problem-solving model** is a model or concept that students have already learned, and which is necessary for problem solving in a session. If necessary, provide the symbolic or graphic model and make it clearly available to students. If teachers and students are expected to work together using the subject domain concept or model to develop a problem-solving approach, then provide possible approach and explain that variation is expected (Karpov 2014, p. 186-187 and examples therein).

This is related to Wiggins and McTighe's WHERETO Strategy: Equip students, help them experience the key ideas and explore the issues. Be tailored to the different needs, interests, and abilities of learners.

Note: In this AIR workshop, the problem-solving model was combined with the problem presented and will be re-constructed in collaboration with students. The models include the percentage of pollution key provided as well as the map+stickers (the map of pollution data that participants generated).

There are a variety of methods for detecting particulates in the air as well as other types of air pollution. Airborne particulate matter (PM) is the focus of this workshop because it is a mix of many chemical species including solid dry fragments such as pollen, bacteria, wind-blown dust from construction sites, waste burning and industrial sites. (PM 10µm or less). A sticky tape "sampler" can be used to capture these invisible particles as well as larger particles such as animal/pet dander as well as dust, soot, or smoke particles from various indoor and outdoor sources. Studying visible particles provides a window on the invisible, inhalable particles that might also be present the air and can pose serious problems for terrestrial organisms in the vicinity.

(7) PROBLEM PRESENTED – WHERE IS AIR POLLUTION IN THE PLACES WE FREQUENT? AND HOW CAN WE CLEAN IT UP?

Section 4.7 **Problem Presented** **Guidelines & Information**
The **problem presented** to the students for learning is the main object on which students will work and perform learning. Students solve problem(s) presented using the mind tools (e.g., subject domain concepts and models related to the topic to be learned). Students work towards solving an observed problem in science using the conceptual knowledge and procedural knowledge (the psychological/mind tools). Students master the provided knowledge through practice. Mastery is obtained when student no longer use the provided resources and they have internalized the knowledge (see Karpov 2014). [See Section 3.7 for more detail about Problems. Presented.] **Team Leaders:** Finalize the Problem outlined below.

How can we investigate the air pollution in our neighborhood?

- Students analyze their pollution packs[1], which they have had since the first AIR YIW session OR Students build their own pollution pack based on what they want to observe (lint, dust, smoke, diesel exhaust, etc.).
- Discuss their findings in small groups.
- Students assign a percentage of air pollution level based on a key (provided)
- Based on said key, students will affix a color-coordinated sticker associated with the percentage to a blown-up map of New York City (Figure 9).

[1] These pollution packs should have been distributed in the previous YIW sessions with written instructions on use.

- They will be given the chance to look at pollution under microscopes and assess the level of pollution that they saw with their naked eye vs. under a microscope.
- Explore connections between looking out window/walking down street and what they see (large particles) vs. what is invisible (fine particles and gases).
- Each group will have different data subject to their pollution packs that they are investigating. Later the whole group will have a chance to present data and see it wholistically, but first they will see their own individual pollution levels.

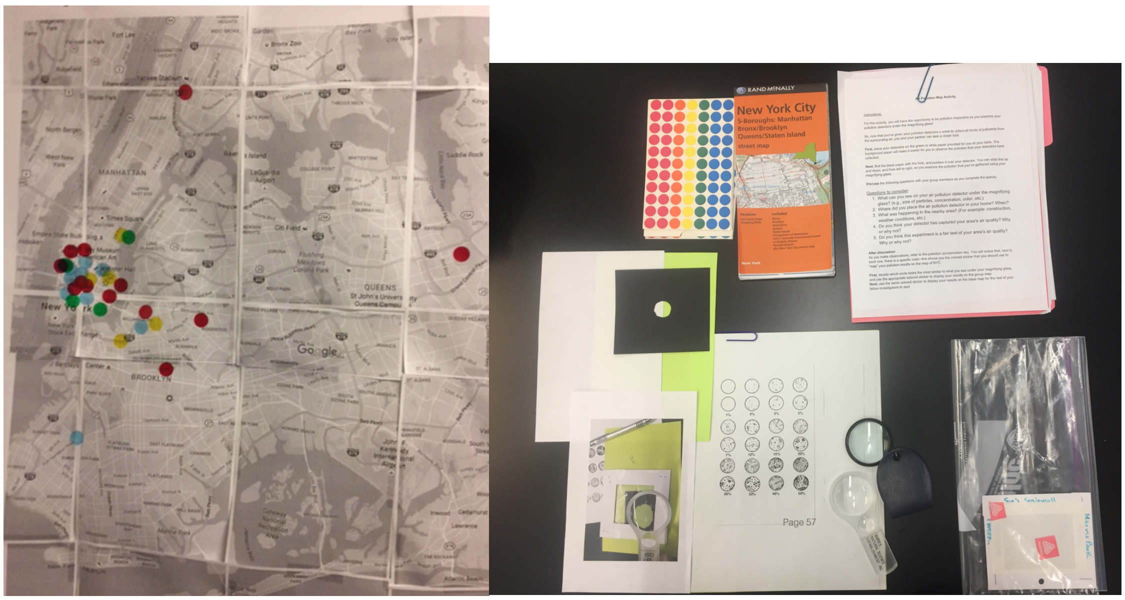

Figure 9. Neighborhood air pollution investigation. Participant's results (left), materials set-up (right)

Creating Air Pollution Cleaners: How can we clean the air in our living spaces?

- Understanding that there are ways to reduce air pollution by not producing it at all, students will also invent air cleaner prototypes that can remove one or more types of pollution.
- While working with one partner, students will be advised that their prototype must operate like a typical air cleaner, with polluted air entering one side of the frame and clean air exiting the other side.
- Students will present their invention when completed, stating the type of pollution the invention cleans, how the polluted air enters the invention, how the clean air exits the invention, and demonstrating how their invention works.

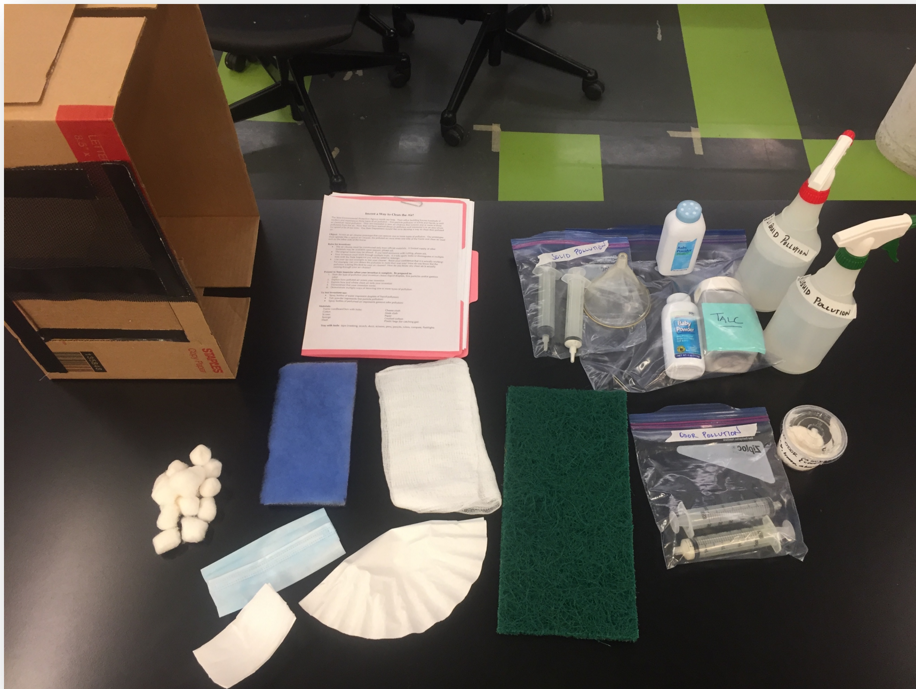

Figure 10. Creating air pollution cleaners, materials set-up

<u>Materials, Supplies, and Technology (Figure 10)</u>

- Spray bottles of water (represent droplets of liquid pollution)
- Talc powder (represents fine particle pollution)
- Spray bottles of perfumed air (represents gaseous odor pollution)
- Material for the air filer
    - Frame (cardboard box with hole)
    - Cotton
    - Screen
    - Sponge
    - Mesh
    - Cheese cloth
    - Mask cloth
    - Paper
    - Crushed carbon
- Plastic bags (a simulations for catching gas)
- Tray with tools: tape (masking, scotch, duct), scissors, pens, pencils, rulers, compass, flashlights
- List of storeroom supplies available for construction & filtering

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PART 5: TEAM EXPECTATIONS, COMMENTS, CONCERNS, POSSIBLE SOLUTIONS

Part 5
Team Expectations, Concerns, Solutions
Guidelines & Information

Team Leaders: In this section, outline the expectations, comments, and concerns that arise during planning and before the YIW session begins. When planning for teaching-learning a variety of expectations, comments and concerns arise. These might be about content, materials, personnel, workshop flow, etc.

Outline possible solutions to your expectations and concerns, discuss these with the support staff during Collective Planning, and implement them during the YIW session.

PART 6: ANALYSIS OF LEARNING FOR WORKSHOP 1

Part 6
Analysis of Learning – Workshop 1
Guidelines & Information

Team Leaders: See the "Collective Reflection Instructions". For each YIW you lead you will generate transcripts and analyses of learning to distribute to the Support Staff during Collective Reflection ("handout").

PART 7: ANALYSIS OF LEARNING FOR WORKSHOP 2

Part 7
Analysis of Learning – Workshop 2
Guidelines & Information

Team Leaders: See the "Collective Reflection Instructions". For each YIW you lead you will generate transcripts and analyses of learning to distribute to the Support Staff during Collective Reflection ("handout").

PART 8: ANALYSIS OF LEARNING FOR WORKSHOP 3

Part 8
Analysis of Learning – Workshop 3
Guidelines & Information

Team Leaders: See the "Collective Reflection Instructions". For each YIW you lead you will generate transcripts and analyses of learning to distribute to the Support Staff during Collective Reflection ("handout").

ACKNOWLEDGEMENTS

Special thanks to Dr. Pooneh Sabouri, Molly Zhang, and all the teacher candidates for their critical feedback on the flow and content of various versions of this teaching and learning guide. Having their feedback on the minutiae of the workshops in real time was invaluable as we all worked on these concepts together with Young Investigators. Dr. Sabouri also contributed to reformatting the guide for clarity – integrating our advice to teachers in the form of dialog boxes and developing the table of contents. Additionally, Pooneh spent a heroic amount of time developing pollution catchers with a focus on simple ways students could monitor air pollution at home. I would also like to thank Christina Tobitsch and Carly Cox for initiating the adaptable and engaging clean building project (Workshop 2). This AIR guide features their green building challenge rules and their LEED certification sheet, with some minor modifications. Also, a big thanks goes to Lily Crouss and her team (Abigail Rollenhagen, Fletcher Bouvier, and Jodi Blass) for suggesting and developing the idea of studying the Urban Heat Island effect. Finally, I am grateful to Dr. Moshe Sadofsky for lively discussions during the initial stages of workshop development. Moshe generously contributed to the design of the problem situations, problems presented, and the nature of their scientific content.

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