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THE PLANT EXPERIENCE

A Vygotskian Theoretical Learning Approach to Urban Environmental Consciousness

East side of Manhattan looking west with trees and cars.

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 *The Plant Experience* 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 needs to be completed. 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 *The Plant Experience* 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.

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FIGURES

IMAGE CREDITS (IN ORDER OF APPEARANCE)

East side of Manhattan street looking west with trees and cars (2016). Tomwsulcer Photographer. https://commons.wikimedia.org/wiki/File:East_side_of_Manhattan_street_looking_west_with_trees_and_cars.jpg

Sitting Asian elephant bathing in Tad Lo river, Laos (2019). Basile Morin Photographer. https://commons.wikimedia.org/wiki/File:Sitting_Asian_elephant_(Elephas_maximus)_bathing_in_Tad_Lo_river,_Laos.jpg

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Damage from Hurricane Sandy, tree (2013). Peetlesnumber1 Photographer. https://commons.wikimedia.org/wiki/File:HurricaneSANDYCheltenham.jpg

Tree roots change concrete sidewalk (2015). Philadelphia Magazine. @philavore Photographer. https://www.phillymag.com/citified/2015/04/03/philadelphia-sidewalks-horrible-shape/

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Operator with Jackhammer (2013). Holding graz Photographer. Source: Baufortschritt Theodor-Körner-Straße 21.8.2013 https://commons.wikimedia.org/wiki/File:Baufortschritt_Theodor-Körner-Straße_21.8.2013_(9561351789).jpg

Police Stuck in Traffic in New York City with sirens (2008). Firstac5 Photographer. https://commons.wikimedia.org/wiki/File:Police_in_New_York_City.jpg

A Plane Prepared to Land at LaGuardia Airport (2017). Timothy Fadek Photographer for Bloomberg News. https://www.wsj.com/articles/lawmaker-urges-laguardia-flight-path-changes-1534895807

Bass drummer, Carnival parade in Uptown New Orleans (2008). Infrogmation Photography. https://commons.wikimedia.org/wiki/File:Thoth08BigasDrumEvansChalmette.jpg

The Barking Dog (2017). Source: Noun Project - https://thenounproject.com/icon/751 https://commons.wikimedia.org/wiki/File:Barking_Dog_-_The_Noun_Project.svg

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 urban plants – especially those 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://apnews.com/edc799a99bbc4043847390a279e84164 • https://www.nytimes.com/topic/subject/flowers-and-plants • https://www.nybg.org/blogs/science-talk/2018/08/bad-news-good-news-nybgs-new-report-on-the-state-of-new-york-citys-plants/ • https://www.dec.ny.gov/23.html • https://www.timeout.com/newyork/news/why-new-york-millennials-are-so-in-love-with-plants-062618 • https://www.nycgovparks.org/parks/joyce-kilmer-park/dailyplant/23507 Be sure to make connections to relevant readings. For example, a connection to the reading by Chamovitz might read like this: "Throughout this guide, we use Daniel Chamovitz's explanations for each of the senses and some of his key examples of investigations that have explored the idea that plants have senses."

Problems of urban plant experience (a draft to be completed by lead team)

The Plant Experience introduces the phenomenon of sensation and how plants might be experiencing a metropolitan area like New York City. There are many reasons to care about experience of plants, but the big two are understanding how we change the world around us for other living things and appreciating other species beyond humans. For example, plants help reduce the urban heat island effect through a process called evaporative cooling, which saves lives.

[Lead Team ought to unpack stories of plants in the urban environment and provide the STEM content background pertinent to the three workshops.]

In these three workshops, students who attend the Young Investigators Workshop will learn about plant senses and conduct investigations to find out what plants can sense (e.g., different types of light or exposures to light or different odors, etc.). We will also explore how plants can contribute to reducing the Heat Island Effect, which we study in *Air: Problems of Heat and Pollution.*

(2) CONTENT ALIGNMENT TO 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 the 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.

(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 perspectives of a plant by investigating its sensory perception. This is a topic that ought to concern urban citizens because plants are essential for cooling the urban environment and mitigating the Urban Heat Island effect. Making life comfortable for our green friends will make life comfortable for all of us! This starts with getting to know the plant's perspective (how does it perceive the environment around it) and learning what a plant knows. This objective is something we ought to be able to help children realize especially after we have hooked them with the problem situation(s) described throughout the workshops.

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 Plant Experience*, we would like students to have:

1. Developed an investigation of plant senses (sensory perception).
2. Designed a fair test.
3. Worked collaboratively to design an investigation.
4. Described what it means to hear, see, smell, taste and feel.
5. Defined senses and sensory perception in general.
6. Conducted a variable scan on both investigations to improve the investigation designs.
7. Developed a second experiment utilize data and observations from the previous one to develop ideas of plant perception further.
8. Understood each experiment needs a control investigation.

PART 2: WORKSHOP #1– WHAT A PLANT KNOWS, INITIAL INVESTIGATIONS

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.

The title of this workshop comes from Daniel Chamovitz's (2017) book title, *What a plant knows: A field guide to the senses,* which is the featured text for the background content of this series of workshops. Chamovitz explores how plants experience the world and here we ask students to do the same. Do plants have the same senses as we do? If so, what are they and how do they work? Do plants have senses that we do not? What might they be? Considering the experience and perspective of another organism is key to this workshop. One might even address the ethical question of experimenting on another organism, like a plant, for our own edification. Should the experiments students conduct here (or by others) be done? If not, how will we learn more about the sensory world of plants? This workshop ought to provide plenty of opportunity for questions and explorations.

(4A) PROBLEM SITUATION – HOW DO WE AND OUR MORE-THAN-HUMAN NEIGHBORS EXPERIENCE THE WORLD?

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?

Guiding questions and discrepant events for sensory perception

Three mystery games related to the senses are introduced at three "Sensation Stations" as students enter the YIW session:

1. *Sensation Station - Touch.* Mystery objects are placed in a box for students to feel. Each student touches the object (which they cannot see or smell), they observe through their sense of touch, make connections to their experiences, and generate inferences about the identities of the various objects.

2. *Sensation Station - Smell.* There are containers with mystery scents. Each student opens each container with a cotton ball either saturated with the scent or hiding the source in the container. They observe, through their sense of smell, make connections to their experience, and generate inferences about the sources of the various scents.

3. *Sensation Station – Sound.* Mystery sounds are played through a phone (or other computer) for student listening. Students observe through listening, make connections to their experiences, and generate inferences about the sources of the various sounds.

Each station will have a set of questions for radical listening and dialogic talk that will be used as discussion questions specific to the topic (table tent). For example:

a) How would you describe your sense of touch?
b) When we say something has a sense of touch what do we mean? For example, when we say "A dog has a sense of touch" or "I have a sense of touch" what does that mean? What is touch?
c) What living things do you think have a sense of touch? Which do not? Why?

Through the mystery explorations of touch, smell, and sound coupled with the radical listening questions, the intention is to focus student's thinking on their own senses *as well as the senses of other organisms*. Photos of other organisms ought to be provided with descriptions of how they perceive the world through their senses (e.g., compelling images of animals, ants, bacteria, plants) (see Image Credits).

Return to these images and mysteries throughout the two YIW sessions to reorient students to the object of learning (sensory perception) and to provide more opportunities to observe, notice, and interpret what they see as they learn more about the perspectives of other living things in the world (i.e., our more-than-human neighbors). Bruner (1966) might agree that **this set of activities** contain many of the elements of his theory of learning including contrast, stimulation and use of conjecture, student participation and contribution. it is not clear whether it stimulates self-consciousness in the students, but teachers ought to attend to his theory in this problem situation.

- Mystery Games at the Sensation Stations include touch, smell, and sound, but can be expanded to include other senses as the lead team sees fit.

- Instructions/game prompts are provided on the following pages. Provide these for students at the relevant tables.

- For this Problem Situation the Game Master and the Players are all students. Lead teachers are available to answer questions once all the instructions have been read and before the game begins. Otherwise, teachers ought to observe and take notes.

Sensation Station Problem Situation

The following pages include the information, materials, and technology that Team Leaders use to set-up each station.

Sensation Station: Touch Game

- Before beginning the game, you (students) should select a person in your group to be the Game Master.
- The Game Master should read the rules for the Player role as well as the Master role.

Rules for **Touch Players**:

1. Players to the Mystery Box Touch game feel various objects without looking at them.
2. Players take turns feeling objects until all the objects have been exhausted.
3. Players make an inference about what each object is.
4. Players report their inference to the Game Master. An example of an inference is, "I think it's a horse because I have observed that it has four legs, hooves, and a mane. All horses have these traits, but not all animals with these traits are horses".
5. The Game Master records each player's inference but does not reveal the identities of *any* objects until everyone has played and the all the objects have been explored.

Once the objects are revealed Players and Game Master can talk about the sensations and relate the experience of how our more-than-human neighbors (e.g., animals and plants) might experience the same objects.

Rules for **Touch Game Master**:

1. One volunteer in each group of Players is the Mystery Box Game Master.
2. The Master presents various objects to the players in their group.
3. The Master records each player's responses.
4. The Master does not *reveal* any of the objects until all players have had a chance to try the game and provide one or more inference.
5. The Game Master should not let any of the Players see the selection of objects until all the Players have played the game.

Materials (for the Game Master's eyes only!!I)

- Mystery box (This is a box with (1) a lid for the Master to place objects into the box and (2) a hole cut in the side for players to reach into the box with their hand)
- Wax paper
- Lens paper
- Plastic spoon
- Straw
- Cotton ball
- Clay (remove from plastic bag OR leave in the plastic bag).

Note: This list of scents/odors can be revised by the Lead Team

Sensation Station: Smell

- Before beginning the game, you (students) should select a person in your group to be the Game Master.
- The Game Master should read the rules for the Player role as well as the Master role.

Rules for **Smell Players**

1. Players to the Mystery Box Smell game smell various scents or odors without looking at them.
2. Players take turns smelling objects in the small containers they have all been exhausted.
3. Players make an interference about what each scent/odor is.
4. Players report their inference to the Master. An example of an inferences is: "I think it's an orange scent because I have observed that it smells like oranges I have in the morning. Most oranges smell like that, but not all objects with that odor are oranges."
5. The Game Master records each player's inference but does not reveal the identities of *any* scents until everyone has played and the all the scents have been explored.

Once the scent sources are revealed Players and Game Master can talk about the sensations and relate the experience of how our more-than-human neighbors (e.g., animals and plants) might experience the same scents/odors.

Rules for **Smell Game Master:**

1. One volunteer in each group of Players is the Mystery Box Game Master.
2. The master presents various scent containers to the players in their group.
3. The Master records each player's responses.
4. The Master does not reveal *any* of the scents until all players have had a chance to try the game and provide one or more inference.
5. The Game Master should not let any of the Players see the selection of scents/odors until all the Players have played the game.

Materials (for Game Master eyes only!!):

- Vinegar
- Basil
- Orange oil
- Cinnamon
- Rose water
- Meadow flowers, dried
- Cloves

Note: This list of scents/odors can be revised by the Lead Team

Sensation Station: Sound
• Before beginning the game, you (students) should select a person in your group to be the Game Master. • The Game Master should read the rules for the Player role as well as the Master role.
Rules for **Sound Players**: 1. Players to the Mystery Sound game hear various sounds without looking at the recording label. 2. Players listen as a group to sounds played by the Game Master 3. Players make interferences about what each sound is. 4. Players report their inference(s) to the Master. For example, "I think it's the sound of a beagle dog because my neighbor has a beagle, and it makes that barking sound. It is high pitched and staccato. Not all beagles sound like that though". 5. The Game Master records each player's inference but does not reveal the sources of sound until everyone has played, and the all the sounds have been explored. Once the sound sources are revealed Players and Game Master can talk about the sensations and relate the experience of how our more-than-human neighbors (e.g., animals and plants) might experience the same sounds and sound sources. Rules for **Sound Game Master**: 1. One volunteer in each group of Players is the Mystery Sounds Game Master. 2. The Master worked with a teacher and presents various sound recordings from www.soundsnap.com to the players in their group. 3. The Master records each player's inferences. 4. The Master does not reveal *any* of the sources until all players have had a chance to play the game and provide one or more inference. 5. The Master should not let any of the Players see the selection of sound sources until all the Players have played the game. Materials (for Game Master's eyes only!!): For example, GO TO: www.soundsnap.com and search for any sound and play the same set for all groups, such as: 1. Screech owl making ticking sounds 2. Spotted owlet sharp and distant calls 3. Pack of kookaburras cackling 4. Pigeon wings flapping 5. Car alarm honking 6. Jackhammer working 7. NYC street traffic (ambience) 8. Plastic bag crumple *Note: This list of sound sources can be revised by the Lead Team*

(4B) PROBLEM SITUATION CONT'D – HOW DO HUMAN'S AND PLANTS INFLUENCE EACH OTHER?

Once the games are resolved the conversation is directed to a PowerPoint slide show with thought-provoking images and questions outlined here. *(Note: The following images may be changed by the Lead Team, but* ***the questions should remain the same****.)*

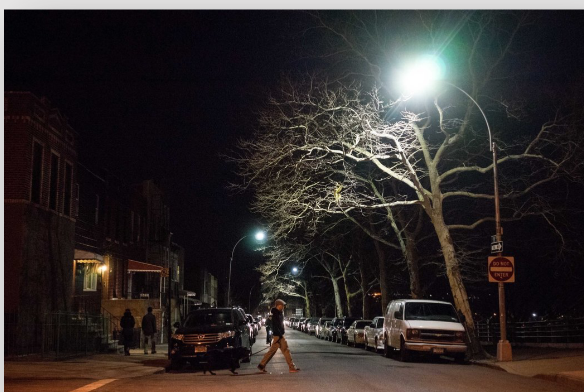
Slide 1. Can humans change the experiences of their living cousins? How or why not? Can plants change the experience of humans? How or why not?

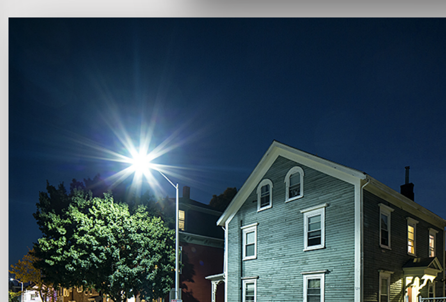
Slide 2. What is it like to be a plant in an urban environment? Is it challenging? Dangerous? Uncomfortable? If we take a plant's perspective, what might we learn?

Slide 3. Can plants smell air pollution including ozone? (photography by Matthias-Haker, 2012)

Slide 4. Ozone does effect plants. Surface ozone such as smog or haze is damaging to plant's cells. Can they smell it? (photography by USDA 2020)

Slide 5. Are plants confused by lights at night? (clockwise starting with upper left, photography by Andrew Renneisen 2015; unknown; AnthonyW n.d.; Bob O'Connor 2016)





Slide 6. Can trees feel damage? Can they feel sidewalks pushing against them? Can they feel us brush by? Can plants feel each other? (left to right photography by SF Public Works n.d.; Peetlesumber1 2013; @philavore 2015; Bruce Fritz 2013)

Slide 7. Can plants hear city noise? Can they hear us talk? (clockwise starting with far left photography by Holding Graz 2013; Firstac5 2008; Timothy Fadek 2017; Infrogmation 2018; Noun Project 2017)

(5) TARGET CONCEPT(S) – SENSORY PERCEPTION & FAIR TESTING

Section 2.5
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).

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.

Team Leaders: Follow the guidelines provided in this section and use the materials as shown here. However, review Harlen et al.'s (2001) description of variable scanning and adopt/adapt those activities for this workshop. Also, be sure to work with support staff and practice identifying the mind tools developed by students (i.e., one aspect of student learning).

Mind tools for working on the problem of sensory perception in plants

In *The Plant Experience*, students (and teachers) study sensory perception. The mind tools include the concept definitions below. These are the broader definitions, provided by Chamowitz (2012), which encompass the experiences of other organisms. Students may be more familiar with human-centered definitions of the senses.

Senses: Senses can be used to gather information from the outside world. They are the ability to perceive various sensory experiences (sight, touch, hear, smell, taste) and be changed into electrical signals that are carried to the brain (paraphrased from Chamowitz, p .5).

While plants do not have a central nervous system or a brain, "different parts of the plant are intimately connected, and information regarding light, chemicals in the air, and temperature is constantly exchanged between roots and leaves, flowers and stems, to yield a plant that is optimized for its environment" (Chamowitz, p. 5).

Sense of smell: "the ability to perceive odor or scent through stimuli" (Chamowitz, p. 29).

Sense of hearing: the ability to perceive sound by detecting vibrations.

Sense of sight: the physical sense by which light stimuli received are interpreted and constructed into a representation of the position, shape, brightness, and usually color of objects in space. Chamowitz definition of sight: "Sight is the ability to detect electromagnetic waves (light stimuli) and the ability to respond to those waves" (p. 24).

Sense of feeling: the ability to "perceive tactile sensation" (Chamowitz, p. 50).

Mind tools for developing fair tests to use in scientific exploration of sensory perception

Another goal of The Plant Experience is to teach students how to devise a fair test and how to conduct variables scans as the major means to accomplish the fair test development.

[Team Leaders ought to consult Harlan et al. (2001) for ideas on how to develop "variables scan" activities for this workshop and include those tools and models here.]
The concepts/mind tools developed with students in the YIW workshops include:

1. Designing a fair test
2. Variables scan
3. Observations
4. Inferences]

These concepts are then followed throughout the remaining YIW sessions.

As usual, we want to promote the production of new, useful mind tools for (a) the experiences of urban plants problem, (b) the urban heat island problem, and (c) related problems that emerge during the sessions.

- Record new mind tools created by students in process of problem-solving such as diagrams, processes, statements, inferences, investigative designs, etc.

Make table tents, handouts, and posters with the definitions of the senses (above) available to all students throughout the workshop. VTLA table tents with definitions of problem situation, problem posed, etc. should be made available for teachers as well.

(6) PROBLEM SOLVING MODEL – PLANT SENSES INVESTIGATION

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.

In The Plant Experience*, the problem-solving model is combined with the problem presented and will be re-constructed in collaboration with students.*

(7) PROBLEM PRESENTED – QUESTIONS OF PLANT EXPERIENCE

Section 2.7
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).

After exploring human sensory perception students are presented with the problem of how to study the sensory perception of plants.

Once situated in their groups (pre-assigned), we ask the students to discuss the ways to develop a problem-solving procedure for the various three sensory questions:

- Can plants hear? Can plants see? Can plants smell? Can plants touch?
- OR Plants can hear, but can they distinguish between different sounds? *(Revise question for seeing, smelling and touching)*
- OR Plants can hear, but what part of the plan contains the sensory "organ" for hearing in the plant? *(Revise question for seeing, smelling and touching)*

Plant Senses Investigation I

Teachers use the investigation questions to work with groups of 2-3 students on designing a fair test (Figure 1).

Investigation Questions:

1) How will you know if the plant is feeling, seeing, hearing, or smelling? What will be each plant's response in your investigation?
    a. How do you know the response you observe is the plant's response to feeling, seeing, hearing, or smelling something?
2) What data do you plan to collect and how will you collect it? How will you monitor your plant until the next meeting?
3) How will you keep your plant alive until the next meeting?
4) Additional thoughts and notes

Plant Senses Investigation

Team Names______________________

MISSION: As Sensory Plant Investigators, it is our job to determine if plants can _________.

To help you with this investigation, we will provide you with some materials. How you choose to utilize these materials is up to you.

The plant you are observing will be _______________.

Happy investigating!

A. Materials that will be used (see the list of available materials last page):

B. Please draw and describe your procedure below (or on the back).

C. What will be each plant's response in your investigation? In other words, how will you know if the plant is feeling, seeing, hearing or smelling?

D. How do you know the response you observe is the demonstrates that the plant is feeling, seeing, hearing or smelling something?

E. What data do you plan to collect and how will you collect it? How will you monitor your plant until the next meeting (you may enlist teacher help)?

F. How will you keep your plant alive until the next meeting?

F. Additional Notes:

Materials list (changes with availability)

- Various recordings of sounds (e.g., nature sounds, classical music, rock music, jazz, traffic noises, students can record sounds, etc.)
- Various light bulbs (red, yellow, green, blue, white)
- Boxes with lids (to place plants inside as needed)
- Various scents (cinnamon, vinegar, anise oil, mint oil, lemon oil, rose water, etc.)
- Objects of various textures and densities (e.g., cotton, cardboard, clay, wood blocks, aluminum foil, swabs, craft sticks, etc.)

Tools list

- Scissors
- Tape
- Twist ties
- Tall sticks
- Rulers (tape measure, tape rulers, desk rulers, etc.)
- Cameras (teacher phone cameras, for when teachers visit the plants for taking photos throughout the week)

Figure 1. Example of plant senses investigation guide given to students (3 pages, above).

(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 – WHAT A PLANT KNOWS, FOLLOW-UP INVESTIGATIONS

(6) PROBLEM-SOLVING CONCEPTS OR MODELS – FAIR TESTING

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.

Models of fair test designs for *The Plant Experience* are provided in this second YIW session (Part 3). The open-ended investigation in the first YIW session (Part 2) was used to introduce students to the idea of an investigable question, the choice/creation of overall design, the selection of data to be collected, the level of accuracy needed, and the selection of monitoring instruments. The fact that the teacher does not tell the students how to set up the investigation during the first YIW (or even later) means that students have a chance to contribute to developing ways of conducting scientific investigations (Bybee and McCrae 2009, p. 197).

Workshop #2 is focused on the idea of a fair test. NYC Scope and Sequence for grades 3-5 (Engineering design) includes:

- Planning and carrying out an investigation
- Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence, using fair tests in which variables are controlled and the number of trials considered" (NYC-DOE 2015-2016, p. 85)

Presenting the Fair Test problem-solving models begins with a teacher or student reading the following story of the *Direction Experiment* once through without interruption. Then the reader repeats the story reading slowly while the students sketch out the design of the investigation. A storyboard is provided for students to draw the results of the experiment (Figure 2).

One model for designing a fair test: The Direction Experiment

A pair of learner-scientists wanted to know if plant shoots would grow up towards the ceiling/sky and roots would grow down towards the floor/earth regardless of the position in which they were put as seeds.

They placed 12 radish seeds in a plastic bag on a moist paper towel. Before putting the seeds in the bag, they soaked the seeds in water for an hour because they thought the swollen seed would stick to the paper towel better. They put three seeds with the "dot" facing up, three seeds with the dot facing to the right, three with the dot facing left and three with the dot facing right.

They observed 11 out of 12 seeds germinated. Two of three with the dot facing the ceiling germinated. All shoots grew toward the ceiling. All roots grew toward the ground (see photo below). The learner-scientists concluded that regardless of the orientation of the seed, the sprout will always grow up and the root will always grow down. Therefore, the seed must know what is up and what is down.

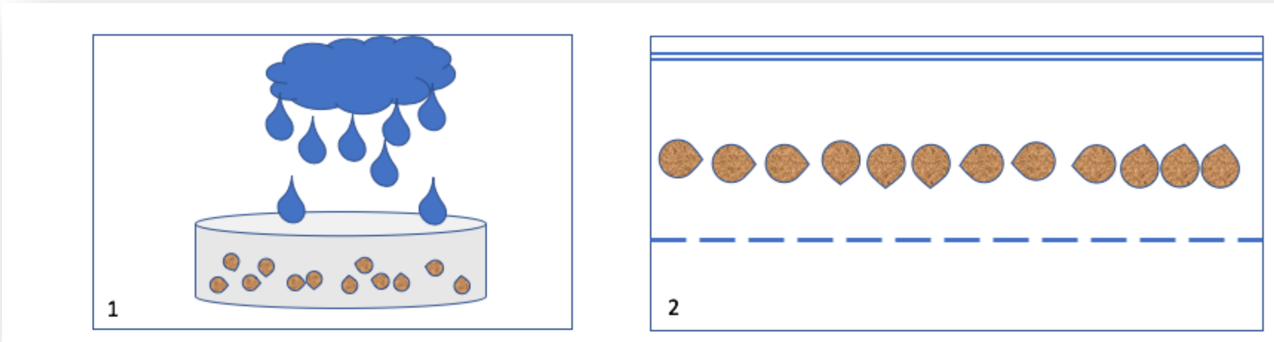


Figure 2. Storyboard of The Direction Experiment.

Students ought to find the roots and shoots that grew from seeds in the zip & seal bag shown in the photograph of the Direction Experiment. They can use the diagram in panel 2 of figure 2 to record the results of the experiment by drawing the roots and shoots on each brown shape (seed) provided. The blue dashes represent staples, the white background is meant to be the paper towel, and the two parallel lines near the top of the rectangle represent the zip & seal.

In these same groups, ask students to look at the photo and their storyboards and discuss the questions below:

1. Was this a fair test? In other words, was this investigation designed in such a way that we can reliably compare the seeds in the various orientations?
2. How confident are you in their conclusions? Why or why not?

(7) PROBLEMS PRESENTED – DESIGN FOLLOW-UP INVESTIGATIONS

Section 3.7
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).

Team Leaders: The problem is described in depth here and ought to be delivered as presented. The team leaders list materials, supplies, and technology needed for each investigation based on students' investigation design (and their quantities)**.**

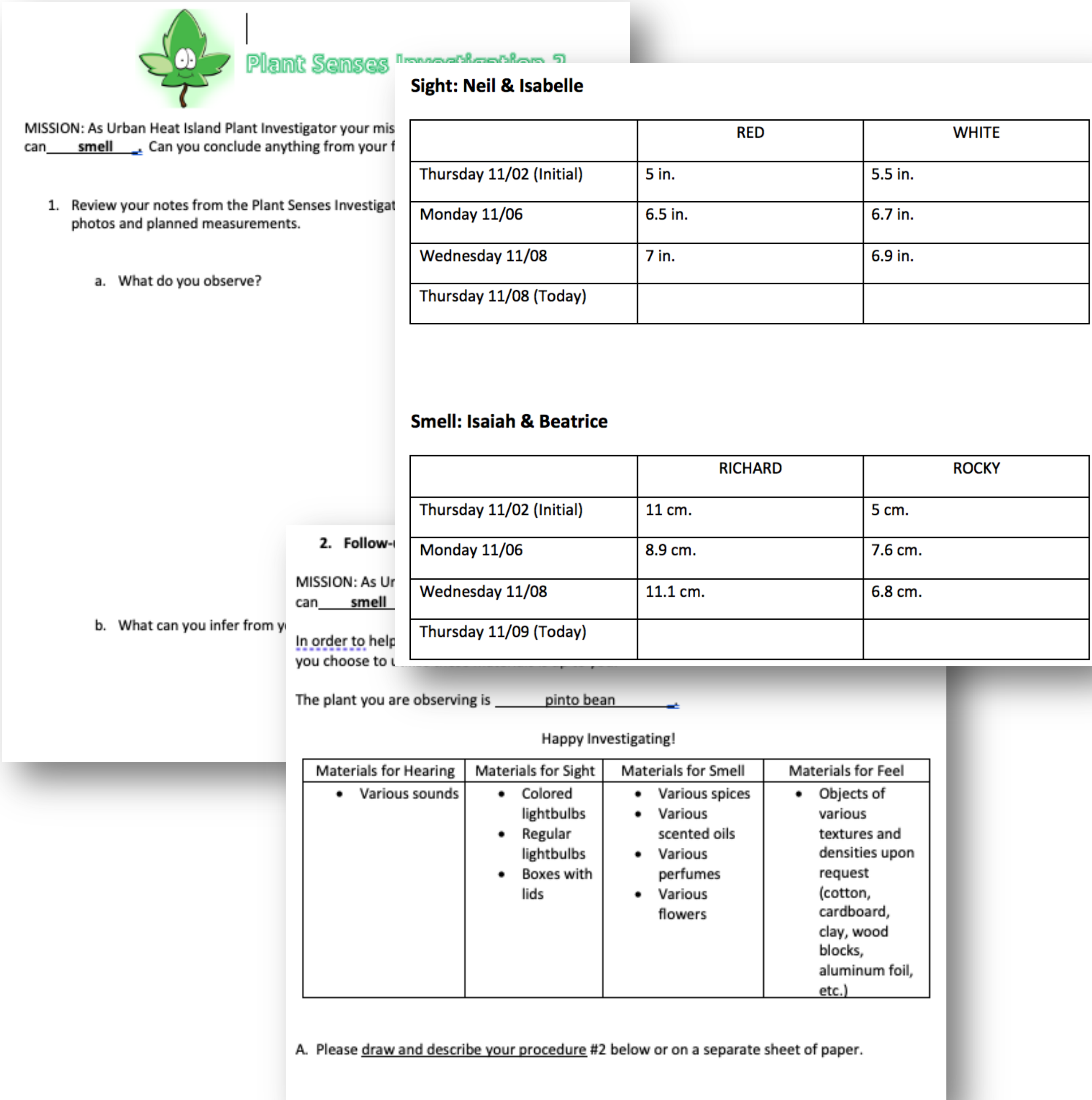
In the follow-up investigation, student expand their experiment. In science and everyday life, one test, whether it gives conclusive or inconclusive results, is not enough to give us reliable results or results we are confident about. Not only do we want to repeat investigations, but we also want to study a problem from many angles. This means that students should be asked to create various designs that approach the same problem.

Each group is provided with the same materials and will be asked to build a new model to solve the problem of if plants have senses and if so, how can the plants be tested again to demonstrate they have senses (or other related question, See Investigation 1).

Plant Investigation 2

Next, students retrieve their investigation #1 (from YIW 1 session) along with the data collected by their teachers during the intervening week. They are asked to:

- Observe the results of the first investigation, can they make any meaning about plant senses from them? Figure 3 shows the data that was collected by teachers from students' investigation throughout the week.
- Evaluate their investigation (design and data interpretations) against the fair test model created from The Direction Experiment?
- Design, and conduct a follow-up investigation. If no conclusions could be drawn because their plant(s) died during the investigation, then the team ought to focus on ensuring that their plants survive and thrive throughout the investigation. How will they do that?



Plant Senses

MISSION: As Urban Heat Island Plant Investigator your mis
can **smell** . Can you conclude anything from your f

1. Review your notes from the Plant Senses Investigat photos and planned measurements.

    a. What do you observe?

    b. What can you infer from y

Sight: Neil & Isabelle

	RED	WHITE
Thursday 11/02 (Initial)	5 in.	5.5 in.
Monday 11/06	6.5 in.	6.7 in.
Wednesday 11/08	7 in.	6.9 in.
Thursday 11/08 (Today)		

Smell: Isaiah & Beatrice

	RICHARD	ROCKY
Thursday 11/02 (Initial)	11 cm.	5 cm.
Monday 11/06	8.9 cm.	7.6 cm.
Wednesday 11/08	11.1 cm.	6.8 cm.
Thursday 11/09 (Today)		

2. Follow-

MISSION: As Ur
can **smell**

In order to help
you choose to

The plant you are observing is pinto bean

Happy Investigating!

Materials for Hearing	Materials for Sight	Materials for Smell	Materials for Feel
• Various sounds	• Colored lightbulbs • Regular lightbulbs • Boxes with lids	• Various spices • Various scented oils • Various perfumes • Various flowers	• Objects of various textures and densities upon request (cotton, cardboard, clay, wood blocks, aluminum foil, etc.)

A. Please draw and describe your procedure #2 below or on a separate sheet of paper.

Figure 3. Example of data collected for students for Investigation 1 and student plans for follow-up Investigation 2 (complete organizers for Investigation #1-2 are presented on the next 3 pages).

Plant Senses Investigation 1 - Questions, Outcomes, and Confidence

MISSION: As Urban Heat Island Plant Investigator your mission is to discover whether a plant can______________. Can you conclude anything from your first investigation?

A. Review your notes from the Plant Senses Investigation #1 and collect your data.

    a. Take photos and planned measurements.

    b. What do you observe?

    c. What can you infer from your observations?

d. Explain why you should not be confident about…

   i. Your original research question or idea

   ii. Your design

   iii. Your implementation

   iv. Your measurements

   v. Your observations

   vi. Your inferences

Plant Senses Investigation 2 – Fair Tests

MISSION: As Sensory Plant Investigator your mission is to discover whether a plant can ______________.

To help you with this investigation we have provided you with the same materials used in Investigation 1. How you choose to utilize these materials is up to you.

The plant you are observing is ________________.

Happy Investigating!

A. Please draw and describe your procedure #2 below or on a separate sheet of paper.

(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 4A: WORKSHOP #3 – WHAT A PLANT KNOWS, INTERPRETATIONS & FOLLOW-UP INVESTIGATIONS

PART 4A

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.

Lead teams will want to identify target concept(s) for this workshop as well as any problem-solving models that could be useful mind tools for students as they work on the problem presented.

(5) TARGET CONCEPT(S) – SENSORY PERCEPTION & FAIR TESTING

Section 4A.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: The learning objective ought to be clearly stated with details about why the topic ought to concern urban citizens. Performance objectives list what you would like students to be able to do and discuss (See Section 1.3). Revise and expand the concepts and ideas throughout this guide to include mind tools for this second fair testing session. Include concepts such as: claim-evidence conjecture, reasoning with evidence, uncertainty, etc.

(6) PROBLEM SOLVING MODEL – PLANT SENSES INVESTIGATION

Section 4A.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

Section 4A.6 **Problem Solving Model** **Guidelines & Information**
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:** Revise and expand the fair test models developed for and during the plant senses investigations as needed. Present revisions and expansions here

(7) PROBLEM PRESENTED – INTERPRETATIONS

Section 4A.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.]

Data collection and interpretation of data

Students and teachers collect and interpret the data from Investigation 2. (Similar to the Investigation 1 above and using the Fair Test model co-authored from the Direction Experiment as an evaluation tool).

Discussion questions

1. What are all the observations we can make? (e.g., how tall, what color, how much growth, what direction, etc.)
2. What are our interpretations? (e.g., the plant's leaves are turning yellow around the edge, which means it is dying because....)

3. What are our conclusions? (e.g., plants can smell because when we did *this* the plant responded in *that* way)
4. What are our explanations? (e.g., plants can smell because they have sensory organs in their cells that detect odors (?))
5. How confident are we in our observations, interpretations, conclusions, and explanations?
6. What follow-up investigations ought to be conducted to expand our understandings?
7. Alternative or additional questions…

Students ought to be encouraged to design a new investigation and pursue a new question or the same question, but it is not required.

SECTION 4B: WORKSHOP #3 – EVAPORATIVE COOLING (TRANSTION TO AIR WORKSHOP)

Although students have developed investigations and tools to measure and follow phenomena, we have not explored how tools (methods) are developed for scientific investigations (fair tests). A famous philosopher, Paul Feyerabend (1975), wrote a book about knowledge-production in science in which he argued that prescriptive scientific methods restrict scientific progress and scientific education. In his book, *Against Method,* he argued that there is no such thing as the scientific method and that we should not impose any single methodological rule upon scientific practices (https://en.wikipedia.org/wiki/Against_Method).

In Part 4B, students are asked to create their own tools to detect sweat produced by a plant.

In previous workshops we did provide students with a model of a fair test. If Feyerabend were to design Workshops 1 and 2, he might have asked students to develop all the trustworthy ways they can think of to test plant senses. Although we did not include this in the generation of the problem-solving models, this idea is incorporated into Plant Investigation 2 (see Section 3.7).

(3) OVERARCHING TEACHING-LEARNING OBJECTIVES

Section 4B.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.

Note: Since evaporative cooling is a new idea and somewhat a departure from the Sensation Station activities a new "overarching" big objective is provided here. (Although plants use a variety of sensors to perform this cooling process.)

Learning Objective. One of the reasons cities are so much hotter than their surrounding sub-urban and rural neighbors is that they lack vegetation. Besides providing shade, the process of evaporative cooling actively cools the area around plants and trees. In this part of YIW session 3, student briefly work on the learning object of evaporative cooling and how it cools surrounding air.

Section 4B.3 **Overarching Performance Objective(s)** **Guidelines & Information**
To work on an object with learners (e.g., "understanding evaporative cooling and why it cools the area around a plant"), 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). **Team Leaders:** Outline the performance objectives for Workshop 3 based on the descriptions in Section 4B.

(4) PROBLEM SITUATION – WHO SWEATS?

Section 4B.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?

Continuing the overarching question for The Plant Experience, "In what ways do plants change our lives?" We want to explore the idea of evaporative cooling and how this process, fundamental to plant life, benefits humans (and all living things). In this problem situation, students are hooked into thinking about how humans produce water vapor.

Lead teachers create the problem situation by asking students to engage in some sort of movement, e.g., dancing, jumping jacks, floor jacks until they begin to perspire. Some people produce sweat before others when exerting themselves.

Once most participants are perspiring, a lead teacher asks: Why do you think we sweat when we are hot?

After hearing some of the students' ideas, a lead teacher introduces some surprising observations through the following questions (e.g., see Karpov 2014):

- Do plants sweat? (yes!)

- Do fish sweat? (no!)
- Do dogs sweat? (yes!)
- Do humans sweat? (yes!)

(Teachers should do research on this topic and take care in how they answer because not all plants, humans or dogs sweat)

Settle students into a Science Talk (refer to Gallas 1995), but initiate the talk(s) with a teacher question unless there is time to generate student questions. Here are some relevant questions:

- **How do you think plants sweat?**
- Does everything sweat?
- Do all living things sweat?

Record students' comments, questions, and suggestions during the Science Talk. At the end explain that they will develop a **tool that allows them to detect sweat (or water vapor) produced by a plant.**

(5) TARGET CONCEPT(S) – PROBLEM-SOLVING & EVAPORATIVE COOLING

Section 4B.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.]

Concepts needed for problem solving.

Developing mind tools involves the following concepts. Here are provided some definitions, but these are not the only possible elements needed when developing mind tools (including scientific methods for gathering information) nor are they the only definitions (Kirch, Sabouri, Ma and Naidoo, in press; Stetsenko 2017).

- A **transformative activist stance** refers to learners recognizing that their learning is purposeful. For learners to be agents of social change with meaningful life agendas in science (i.e., co-authors of the world and themselves), learners must engage in personal transformations from rule-driven approaches to tool creation to activist stances. Tool creation (e.g., tool of agency and self-determination) with, and by, teachers and learners is a type of creative, imaginative, collaborative transformative project in which collaborators identify and change their own oppressive, detrimental, and deficit social practices and views of science and commit to contributing to the transformation of their present and future collective ways of practicing science.

- An **activist learning culture** is one through which individuals and collectives (collectividuals) build and expand new ways of being-knowing-doing in teaching-learning. In these co-authored cultures collectividuals strive towards increasing *intersubjectivity (understanding the perspective of another), honoring each other's inputs, and aiming to create tools and social practices of beneficence and empowerment.* Everyone holds not only themselves, but others in the collective accountable for transformation through critical reflection and planful action.

- When creating new mind tools we strive to **co-author tools for beneficial and empowering catalytic transformation.** At the core of teaching-learning are the activities through which individuals purposefully transform the world. Our goal is to help learners commit to changing social practices, but also contribute to the change. To this end by drawing on the transformative activist stance, scaffolds ought to be designed to help learners:
    1. recognize their own co-authored tools,
    2. develop them as tools of transformation, and
    3. analyze how they are used for change (e.g., changing how we think about the world).

  Learners should commit to testing and tracking the utility and effectiveness of their new or reconstructed tools, and ought to strive towards changing detrimental social practices in science that they encounter.

- Learning and co-creating mind tools is part of the unending **practice-theory-practice learning cycle.** At the heart of tool co-authorship is the recognition that theory and practice exist in an "uninterrupted continuum of practice-theory-practice cycles in which ideas/concepts and actions, forms of knowing and doing, and words and deeds belong to this inseparable blend" (Stetsenko, 2017, p. 102). Tools-of-the-future consciously become tools-of-the-present. In other words, tools ought to be tested and continuously revisited for their utility and transformational power.

- Developers should endeavor **to authenticate the role of mind tools in transformation.** Co-authors ought to attend to whether a particular teaching-learning practice resulted in changes in development or understanding – specifically changes in self-consciousness, other-consciousness, educative outcomes, and empowering actions (Guba & Lincoln 2001). This way, the tool creators can take control of their transformations of social practices.

- **Origin Stories Provide a Structure for Historical Reflection.** The co-author(s) of a tool ought to document the origin story of a tool through depicting a history of stance and rationale. This historicity should be located in the instructions for a tool or embedded in the tool itself to make the theoretical-practical orientations for teaching-learning transparent and accessible.
    - *History of Stance* refers to positioning (what is the author positioning himself about) and alignment (what is the author agreeing about and who are they agreeing with) (Du Bois, 2007, p. 145). The history of stance is meant to assist collectividuals in learning about analyzing a phenomenon such as teaching-learning from a new perspective (e.g., empirical, theoretical or philosophical text).
    - *History of Rationale* provides readers with the developer's reasons for the design and purpose of the tool. Making it visible could help collectividuals (a) understand the co-author's reasons for representing concepts in a particular way, (b) understand the co-author's goals for the tool, (c) make similar, or new, connections to the embedded practice-theory-practice observations or declarations, (d) recognize how findings that result from using the tool may be of interest to others beyond the user's context, (e) understand how the co-author's perspective on learning theory might be integrated into the tool thereby expanding (or destroying) it, and (f) use practice-theory-practice cycles to transform current and future mind tools and engage in transformative sense-making.

Subject specific concepts related to evaporative cooling

It is essential, at some point, to discuss why the plants sweat and what happens when they do. Part of the reason is that they are cooling the air temperature around them. The following target concepts begin to address the phenomenon of plant sweating or evaporative cooling or transpirational cooling.

- **Evaporation**: is one way that plants regulate their temperature and is sometimes called "plant sweating".

  - Blow on your wet arm, compare how it feels to blow on your dry arm. Water evaporating carries away heat. During evaporation, plants absorb heat energy and moves that heat energy from one place to another (e.g., from the ground to the sky through water). For example, when we change liquid water to water vapor that is a heat absorbing process. Anytime liquid water is changed to water vapor that process absorbs heat. Plants can do that. As plant leaves transpire, they use energy to evaporate water putting heat from the ground into the water and creating vapor. This is the cooling half the of the evapotranspiration cycle and it's the reason the air is cooler next to a plant or in a forest. When that water vapor created by the plant rises to the sky and condenses the heat energy is released into the atmosphere in the form of clouds.

- **Transpiration (plants):** provides the water for evaporation and refers to the process of water movement through a plant and its evaporation from leaves, stems and flowers (e.g., https://en.wikipedia.org/wiki/Transpiration).

(7) PROBLEM PRESENTED – BUILD AN EVAPORATION DETECTOR

Section 4B.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.]

Teachers read the problem together with learners:

> "Based on what you've learned about perspiration and evaporative cooling invent or design as many tools as you can to detect evaporative cooling in plants."

It is important to leave students with concepts of tool development and evaporative cooling and let them develop as many tools for detecting water vapor as possible.

Other ways of presenting this problem are:

- "Invent a way to detect the water moisture coming from the leaves",
- OR "Invent a way to "capture" the water moisture coming from the leaves",
- OR "Invent a way to see the water moisture that comes out of plant leaves."

How many methods and tools can the teachers invent together before working with the students? Some methods and tools for demonstrating evaporative cooling include:

1. cover soil and monitor whole plant under bag or beaker for moisture
2. wrap individual leaves look for moisture
3. cut celery in water cover water and monitor celery under bag or beaker for moisture
4. compare to cacti or succulents to a mum or other herbaceous plants to see if there are differences.

These methods should not to be shared with students however, a list of materials available from the lab supply room) could be provided to help students plan (it is pages long). When planning to present this problem, one Lead Team in a past session wrote to their support staff:

> ***Example from a Lead Team's Instruction for Support Staff Teachers:* "**Turn the experiment over to students. If they want to find out whether the plants that we have do something like sweat, then what might they start looking for? (ex. Water on the leaf, water on the ground, water on anything covering the plant). Listen to students' ideas about plants vs. humans. For example, do they think the idea of sweating could occur in plants but differently than it does in humans? As you think about setting up the investigation with students plan how you are going to put it in their hands - put them in control. "
>
> ***Instructor Comment on the Team's instructions during the Collective Reflection.*** This Lead Team has done an exceptional job in stating their commitment to students being in control as much as possible. They explain that they want students to think about outcomes as well as to compare plants to other organisms, like humans. I would remind support staff that one mind tool that students are developing and will help them to develop their own methods of investigation is the process of variable scanning. Past Lead Teams and Support Staff Teachers have guided each other in learning how to do a variable scan (see Harlen, Jelly and Elstgeest readings for reference). This activity in Section 4B builds off the YIW2 investigations and is a great time for students to learn this mind tool. Even though this is the first team to lead the YIW sessions, they continue to develop and demonstrate considerable understandings of the VTLA.

Set the stage for inventing an evaporation detector

Work with students to do a variable scan with students to initiate their invention session.

Recommended materials include:

- plants of various kinds
- plants that have been well-watered about 12-24 hours prior to the session)
- a list of materials (supply room list)
    - also, could have ready these supplies
        - heat lamps on ring stands
        - plastic wrap and baggies
        - elastic bands
        - string
        - tape and other closures.

Time ought to be invested in developing and building the detectors.

Allow approximately 15 minutes to use the detectors if they are developed and ready to use.

As the group is waiting for the plant's visible responses (sweat or not), teachers could help them:

- Observe the process (e.g., watch, measure, take photos, etc.)
- Talk about what might happen - what they are expecting to see and why

Figure 4. Photos selected from past students' work

Problem resolved?

1. How will students create mind tools that are useful for the problem at hand? How will they explain their designs and decisions?
2. What if their methods fail to detect moisture? What will they do next?
3. How will students explain what they observe? (e.g., how will they explain their observation that moisture appears on the inside of the beaker (or not)?)
4. How will students connect what they observe to the apparently invisible activity of the plant "sweating" or transpiring?
5. How will students explain what they observe (i.e., evidence for the claim that the plant sweat and caused the moisture on the inside of the glass)?
6. How will students argue that they have demonstrated evaporative cooling? What evidence will they use? How will they discuss their confidence?
7. How can we bring Karpov, Gallas, Jelly, Elstgeest and Harlen to our aid?

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

Section 4.8
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 4.9
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 4.10 **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 4.11 **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 4.12 **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 4.13 **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 4.14 **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 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").

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