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Board 4: Work in Progress: Development of a Culturally Responsive, Community-based Fluid Dynamics Mini-Unit for Middle School

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Introduction

Fundamental engineering concepts, such as those principles governing fluid mechanics in aerospace applications, can be perceived to be too complex to teach to young learners [1] [2]. Furthermore, many primary and secondary educators are hesitant to teach engineering, believing that doing so requires specialized preparation [3]. These views have prevented widespread adoption of K-12 engineering curricula in the United States [4]. Since interest in STEM subjects peaks for women and other minoritized populations in middle school [5], the lack of engineering outreach at these grade levels has negatively impacted efforts to recruit a more diverse population of students into the discipline [6]. In this paper, I demonstrate how an accessible and inclusive middle school mini-unit on fluid mechanics can be constructed using principles of culturally-relevant pedagogy, community-based learning, and the Ambitious Science Teaching model. By doing so, I hope to push back against dominant perceptions about teaching engineering to young learners and offer an example mini-unit plan for other educators to adapt for teaching aerospace or other relevant engineering concepts.

Conceptual Framework

This mini-unit – playfully titled “Cool It!” – was developed using principles of culturally responsive and sustaining pedagogies (CRSP), community-based learning (CBL), and the Ambitious Science Teaching (AST) framework. An overview of the development and key concepts of CRSP, CBL, and AST are detailed below so that their use in the development of the “Cool It!” mini-unit can be understood.

Culturally Responsive and Sustaining Pedagogies

Culturally responsive and sustaining pedagogies (CRSP) comprise a strain of educational theory that is central to today’s scholarship on teaching and learning across all ages and subject areas. CRSP was first popularly articulated by authors such as Gloria Ladson-Billings [7] and Lilia Bartolomé [8] in the early 1990s, who referred to it as “culturally relevant pedagogy” or “culturally responsive instruction,” respectively. The now-burgeoning and diverse collection of scholarly work surrounding this topic is connected by its core motivation to address systematic academic achievement gaps that exist across racial, ethnic, and socio-cultural student backgrounds in the United States K-12 educational system. Educational scholars such as Ladson-Billings had been investigating the underlying causes of these persistent gaps since the 1970s, but their approach was uniquely influenced by the work of an earlier theorist: Lev Vygotsky.

Vygotsky’s sociocultural theory of learning posited that students’ social development – that is, their progress from ‘peripheral’ participants to ‘full’ participants within the classroom – was, in addition to their mastery of subject area content, an important factor in academic outcomes [9]. Ladson-Billings built upon this insight by postulating that a major barrier to students' social development was a tension between students' pursuit of academic achievement, which is evaluated by teachers, and their motivation to maintain their cultural integrity as judged by members of their own communities [7]. Each domain – the home community and the academic – has its own metrics of success and its own gatekeepers, and these can be at odds with each other. Put another way, the traditional K-12 classroom has its own culture, one which emphasizes certain norms and behaviors as key to academic success, and integration into this culture may come at the cost of a student's competency in their home culture [10]. Faced with the possibility of sacrificing cultural competency for the sake of academic achievement, some students may choose to remain passive participants in the classroom rather than moving towards a Vygotskian "full" participation.

Compounding the tension between community and classroom is the possibility that teachers may view such passivity (e.g., not participating in class discussions) as a "problem behavior" inherent in the student [11]. This deficit-framing of non-normative student behavior compels some educators to pose solutions to socio-cultural achievement gaps that focus on reducing problem behavior through more stringent assimilation into classroom-normative culture [12], further exacerbating the tension identified by Ladson-Billings. In the most extreme cases, the native cultural norms of a student are viewed as being at odds with academic success – inherent defects needing to be "fixed" [13].

In opposition to such deficit-framing, CRSP offers an asset-based perspective in which educators intentionally construct learning environments and curricula that both recognize and build upon culturally different ways of learning. Indeed, CRSP scholar Bartolome goes so far as to posit that learning can only occur as part of a process in which students are invited to bring knowledge and ways of knowing that they have gained outside of the classroom (e.g., in their home cultures) into the classroom where it is then linked to new information and competencies [8]. This idea is closely aligned with the theory of knowledge transfer, which was formulated outside the domain of CRSP theory and holds that students best develop mastery over taught content when they are able to apply – or "transfer" – skills and knowledge learned in one context into a novel context [14]. Thus, CRSP scholars argue that improved academic outcomes can and should be achieved by inviting students to transfer their cultural knowledge and competencies into the classroom, instead of excluding them all together.

However, CRSP-based practice has not been without its shortcomings. Chief among the defects of purportedly CRSP-aligned curricula is a tendency to essentialize culture down to its mere artifacts, such as dress, music, and food, with which educators create stereotypes that they expect students to inhabit within the classroom [15]. This misstep occurs when educators misunderstand what culture actually constitutes. Culture, aside from what it produces, should be understood as "an amalgamation of human activity, production, thought, and belief systems" [16]. In other words, culture is an ongoing process through which students interpret and interact with their environment. As such, it cannot be artificially introduced within a classroom, and should instead be sought out where it is formed: within students' home communities.

Community-Based Learning

Community-based learning (CBL), a recent strain of CRSP, has emphasized the importance of students' home communities in classroom learning. In community-based learning, these communities can function as both sources of knowledge and as learning environments [17]. In keeping with the mastery theory of knowledge transfer, educators can ask students to either investigate or recall phenomena experienced at home in preparation for linking that information to new science or engineering concepts introduced in the classroom. They can also assign projects to be conducted within a home or community environment such that students further link and see the applications of new concepts to real-world processes. This treatment of the home or neighborhood goes beyond seeing it as a setting to go over a set of practice problems from a textbook, but rather views it as a dynamic environment that students interact with and experiment in as part of the learning process [18]. In such an environment, abstract knowledge introduced in a classroom can be tested and new understandings forged in a students' home culture can strengthen their grasp of scientific concepts [19].

In addition to knowledge transfer, engaging students in their communities during the learning process can aid in their development of critical consciousness, or the capacity to evaluate social, economic, and political inconsistencies [20]. This process can be aided by encouraging students to interact with their classmates, who may come from communities of differing social, economic, or political standing. The achievement of critical consciousness was one of Ladson-Billings' three central tenets in her original formulation of culturally relevant pedagogy, and she recently elevated it to the primary outcome of such practice [7] [21]. Figure 1 illustrates these three tenets of culturally relevant pedagogy and how they can inform the development of CBL models.

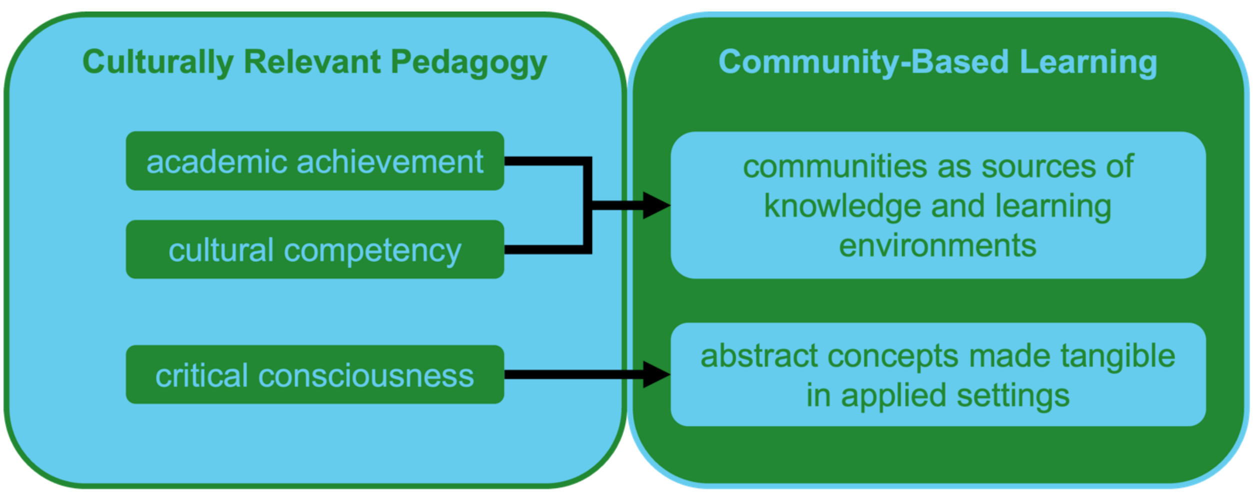

Fig. 1. Connections across culturally relevant pedagogy and CBL.

For engineering educators, critical consciousness has relevance in the emerging scholarship surrounding the unequal benefits of new technology (or, in extreme cases, its harmful effects) across social strata [22]. Recently, scholars have proposed models of CBL that directly address such engineering "blind spots" through partnering with community stakeholders across the engineering design process, from needs-identification to implementation of solutions [23]. This model can be translated into homework assignments that task students to identify and solve a problem as it appears in their home communities. In assignments such as this, where students themselves are also community stakeholders, the opportunity for learning science and engineering concepts, engaging cultural competencies, and developing critical consciousness are all present and mutually supportive.

Ambitious Science Teaching

The Ambitious Science Teaching (AST) framework [24] was chosen to plan and structure the "Cool It!" mini-unit specifically because it is a student-centered model, allowing educators to plan science and engineering lessons that incorporate students' cultural knowledge while using practices that promote critical consciousness. Though it was developed outside the domain of explicit CRSP and CBL research, AST naturally integrates many of the tenets discussed in the previous sections, such as transfer of knowledge and legitimizing different cultural ways of knowing. Indeed, AST was developed in partnership with teachers in school districts with highly diverse student populations, and their refinement of the framework in their classrooms imbued it with culturally-responsive best practices [24, p. 5]

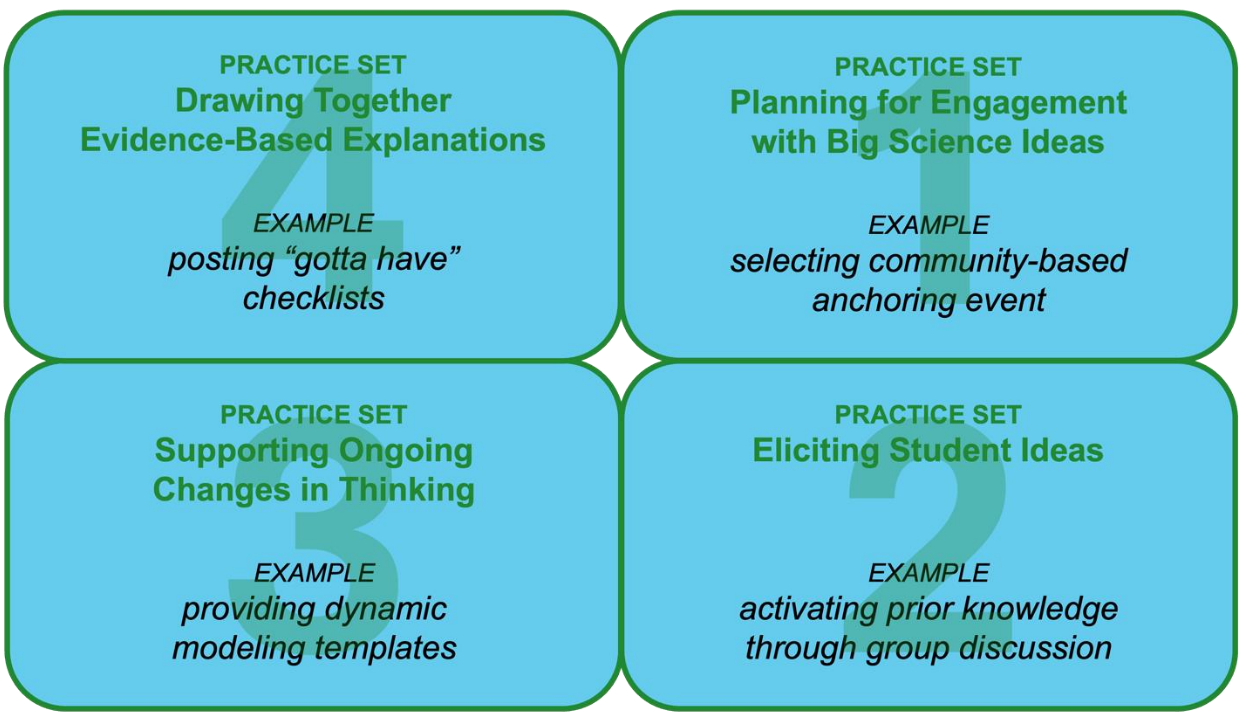

Fig. 2. Ambitious Science Teaching's four practice sets.

AST lesson planning is structured by four sets of related teaching practices: (1) planning for engagement with big science ideas, (2) eliciting students' ideas, (3) supporting ongoing changes in thinking, and (4) drawing together evidence-based explanations. Teaching practices are defined as "regularly recurring teaching activities that are devoted to planning for, enacting, or reflecting on instruction [24, p. 4]." Above, Figure 2 provides examples for each set of teaching practices that will be described in further detail throughout the remainder of this section. Though lesson planning can and does progress through these practice sets in sequence, it should not be treated as a simple linear progression to adhere to. Indeed, within a given instructional period, a well-designed AST lesson will move back-and-forth between practice sets as needed to support students in their developing understanding of the big science idea in focus. That is the goal of the AST framework – student-centered learning – and each of its four practice sets, outlined below, are structured towards this outcome.

1. Planning for Engagement with Big Science Ideas

From the start, students' knowledge and experiences are incorporated into AST lesson planning as the educator works through the first set of practices. While one must first identify the big, or core, science ideas (e.g., flow velocity and static pressure are inversely related in a moving fluid) that make up the subject to be taught and are necessary to explain the phenomena in question (e.g., airflow past an opening), AST asks the educator to then select an anchoring event and formulate an essential question to present to students. This critical step sets the stage for student engagement by providing a purpose or goal that will motivate their progression through the lesson. Ideally, this motivation is intrinsic to the student and thus the chosen anchoring event should be familiar or relatable to most if not all of them in some way. This can be accomplished by selecting a culturally-relevant event that is common across communities, like something that can or does happen at home (e.g., feeling a cool breeze move through their bedroom on a hot day). From this event, the educator must create an essential question (e.g., why does the air move through my room even though I don't have a fan turned on?) that students can reasonably answer by the end of the lesson or unit through articulation of important science ideas. Therefore, the educator should carefully plan and sequence a sufficient amount of learning activities for this to be accomplished.

2. Eliciting Student Ideas

AST lessons begin with the educator presenting the anchoring event and posing the essential question, but they should immediately get students talking about it. Here the educator invites students to discuss openly their initial understandings of the phenomenon and begin to form explanations. This can be helped by intentionally activating students' prior knowledge. Prompting students to connect the event and question to relevant experiences from their own lives will facilitate transfer of knowledge into the classroom discussion. At this stage, students' understanding of the phenomena and its underlying science ideas is likely only partial, but it's important to not delegitimize their emerging knowledge (which is likely built upon cultural knowledge) and to allow them to follow their own leads. In this, encouraging students to start a dialogue with each other can be helpful (rather than allowing just student-to-teacher talk), as this provides ample opportunities for students to try out new lines of thinking in a low-stakes environment while also bringing them into contact with new, potentially influential (and perhaps conflicting), ideas from fellow students. Practices such as this, which promote peer-to-peer interactions, can aid in students' progression from "peripheral" to "full" classroom participants as described by the sociocultural model of learning [9]. The educator should be ready to adapt their planned instruction based on these initial conversations in order to allow students to continue to engage with the anchoring phenomenon through their own unique cultural lenses as much as possible.

3. Supporting Ongoing Changes in Thinking

After initial classroom discussions surrounding the anchoring event and essential question, students should be given ample opportunity to investigate the phenomena and associated big science ideas further. This can be done through a variety of means – in-class activities, targeted readings, at-home assignments – but the educator should build and sequence these opportunities such that the students are provided with an appropriate frequency of new ideas and evidence to support, challenge, and generally spur a growth in their understanding. This can be done individually between the student and the educator or educator-provided material, but ample opportunity for student-to-student collective thinking is encouraged. Techniques such as those described in the previous section can be employed to spur collective thinking. What is important here is that the student is actively engaged both in making sense of new material as well as becoming aware of their own evolving changes in thought.

An excellent way to support this awareness in students is through the incorporation of modeling activities in the lesson. Models are visual representations of science phenomena, ranging from simple pictorial models drawn and annotated by students on paper to complex computer simulations that students can run with appropriate assistance. More important than the complexity or medium of the model is the model type itself. Instead of "static" models which visualize only things or objects (such as the structure of a cell) AST advocates that educators employ "dynamic" models that illustrate physical processes (such as cell mitosis) which are context-rich, taking place in specifically-defined environments [25]. Such an orientation promotes students to actively make sense of phenomena in the world; if the context includes their home communities then the model can incorporate elements of their lived experiences as well. Consistent with the principle of supporting ongoing changes in students' thinking, the model format chosen by the educator should allow students to frequently return to it and revise it to include new information or understandings.

4. Drawing Together Evidence-Based Explanations

In addition to supporting changes in students' thinking, educators should be mindful to provide ample prompts, either verbal or written, for students to articulate their understanding of the anchoring phenomenon and associated science ideas through evidence-based explanations. This builds students' ability to make scientific arguments from evidence, and is best promoted by providing frameworks for students to identify and connect the sometimes disparate science ideas encountered in varying learning activities. One such framework is the "gotta have" checklist [24, pp. 217–220], whereby the educator provides students with four to five prompts to explain a science concept (e.g., “how are pressure and velocity related in a fluid flow?”). Ideally, these prompts should be selected in such a way that students can see connections across the checklist items. Best practice also includes instructions for students to identify key pieces of supporting evidence from learning activities that can be used in building scientific explanations. In making these explanations visible, such as in a checklist, the educator can monitor and assess students’ evolving thinking, and adapt their lesson plans to address gaps in understanding.

“Cool It!” Mini-Unit Description

This section presents an outline of the fluid mechanics mini-unit designed using the theoretical frameworks detailed in the previous section. The objective of this unit is to teach students a fundamental property of fluid flow – Bernoulli’s principle – which relates flow velocity to its static pressure. This science concept is made relevant to students through a homework assignment on passive cooling, where differences between inside and outside pressure are used to create airflow within a house.

As designed, the “Cool It!” mini-unit covers a span of three 55-minute instructional periods. Two in-class experiments and one teacher demonstration are included to introduce students to Bernoulli’s principle prior to their homework assignment. These activities were modeled after science demonstrations, which can be viewed online at [26]–[28]. The only specialized equipment required are air/vacuum nozzles with adjustable flow rates, which can be found in many standard science classrooms with lab benches. Additional materials include rubber air hoses, funnels, and ping-pong balls. An outline of instructional activities, their associated AST practice set, and estimated timing is included in Appendix A.

Instructional Period #1

As the class period begins – ideally as students are entering the room and finding their places – the educator displays a “Do Now” questions for students to think about and answer on their own. This initial question is designed to condition students to begin recalling their prior experiences with passively cooling their homes, introducing knowledge that potentially could be built upon to answer this mini-unit’s essential question. The suggested prompt is as follows:

> It’s a hot summer day and the AC is out at your place (or you don’t have one). What are some things you can do to cool down the room you’re in? List both the actions you can take and try to describe how things in the room change as a result of your actions.

After giving students time to recall, brainstorm, and jot down responses on their own, the educator invites students to share their answers aloud, initiating a whole-group discussion. The educator (or a designated student scribe, if the classroom management structure provides for such a role) visibly records key details of student answers for all to see. One method to graphically organize student responses for this particular discussion is to record responses in two columns: one for student actions and another for resulting changes in the room (as perceived by the students). This information should be recorded in such a way as to be available for reference in future activities or discussions; therefore, the use of butcher or chart paper is recommended over writing on a white board.

When the discussion has ended, the educator transitions to presenting the anchoring event and associated essential question for the mini-unit. They should make clear to the students that this will orient all their activities for the remainder of the unit. A variety of presentation formats will be suitable, ranging from simple verbal presentations to videos, but a general script is presented as guidance below:

> After a hot summer day playing outside, you come inside your home. When it gets dark outside, you have dinner with your family and then sit down in the living room (or comparable family space) to read a book. It's still so hot inside that after a while you can't stand it and decide to go to bed. You go to your room (imagined to be located upstairs), where you notice a slight breeze moving through your room. This seems odd, as there's no fan or AC on in your house. It's at this moment that you notice a whistling sound coming from over by your window, which you had closed earlier to keep out a swarm of mosquitos. You walk over to investigate and notice that someone cracked it open. You can tell that there's wind blowing across the window outside, but it's not blowing any air in through the window. Instead, there's some air flowing from inside your room out through the open window space. You breathe a sigh of relief that your bedroom is cooler than your muggy living room downstairs due to this airflow. But then you start to wonder: *what is causing the air to move through your room and vent through the open window?* You ponder this question as you lay down on your bed, still puzzling over it as you drift off to sleep…

The educator then passes out a graphic organizer to each student. This will be the template on which they will begin to construct their visual model of what is happening in the room, returning to update it throughout the mini-unit as needed. The template can be created in various ways, but should include a simple schematic of the bedroom, with an open door on one side and the cracked-open window on the other. An arrow or two can also be pre-drawn on the template to indicate the airflow and its direction. Depending on the prior experience of the class with creating scientific models, the educator may need to explain that models use simple visuals (such as the arrows) to represent real, often complex phenomena. The educator directs students to use this template to jot down what they think is happening in the room, using both illustrations and explanatory text as they see fit. If the classroom seating arrangement is organized into groups or clusters, students can discuss their models with each other as they work.

The next portion of class time should be dedicated to allowing students to investigate relevant airflow phenomena and the effects of varying flow velocity when interacting with space constraints and objects. This can be done as self-directed activities in pairs or groups at exploration stations set up by the educator beforehand. Stations of two types can be set up using standard science lab air/vacuum turrets with flow adjustment handles, attachable air hoses, and some ping-pong balls. Each student group will experiment at one station type only. Representative video demonstrations for both station types can be found online at [26] and [27].

At one station, students will alternate between two activities. In the first, they will attach a funnel to the end of the air hose (oriented pointing down) and suction air through the funnel while placing a ping pong ball in the funnel close to the hose. For the second activity at this station, they will remove the funnel and point the air upward. With the air now blowing out of the hose, they will suspend a ping-pong ball in the stream and try to maneuver the hose at various angles while keeping the ball suspended in the stream. For both activities, they will vary the velocity of the airflow and note the change in behavior of the ball. At the second exploration station, students will blow air between two ping-pong balls suspended on strings or supported by straws, experimenting with both the spacing between the balls and the flow velocity. At both stations, students should be recording their observations to use in post-activity conversations. Give enough time for all groups to experiment at one exploration station.

After the exploration station activities have concluded, student groups should partner with a group or pair that conducted the activity at the other exploration station. In these pairings, they should describe their experiment to the other group and summarize results. Conversation stems (e.g., “I think…because…”) can be provided by the educator to aid in discussions. Next, the educator should reconvene the whole class and have student groups present in turn what they’ve learned. After this discussion, the educator instructs students to individually return to their initial models of the anchoring phenomenon and update them based on new information acquired through the exploration stations and resulting discussions (clean templates can be provided as needed). These will be turned in as exit tickets for the educator to review before the next instructional period.

Instructional Period #2

As before, this class meeting should begin with a “Do Now” question. This prompt should allow students to activate prior knowledge from the previous meeting. A suggested prompt is as follows: “Using what we learned yesterday, how can we cool off this room?” A brief whole-class discussion should be facilitated to discuss student ideas regarding this question. Before proceeding into the next learning activity, the educator should preview the culminating homework project that will be assigned at the end of this instructional period and discussed in the third and final instructional period. A description of this project is provided at the conclusion of this section.

The educator will then commence a brief presentation in which they describe the big science ideas relevant to understanding the phenomena observed at the prior instructional period’s exploration stations. This should include references to exemplars from that period’s exit tickets where appropriate. During this presentation, the educator introduces the concept of Bernoulli’s principle, highlighting how velocity and static pressure are inversely related in fluid flow [29], as can be represented mathematically as

$$P + \frac{1}{2}\rho \times v^2 = constant$$

where P is static pressure, ρ is fluid density, and v is flow velocity. This should be directly tied back to the phenomena students observed in the exploration stations. The presentation will end with a demonstration of the Venturi effect – an observable result of Bernoulli's principle. The educator will fill a basin with water and hold a glass tube upright, with one end in the basin and the other pointing up into the air. Using an air hose, they will then blow air over the exposed end of the tube, which will result in water flowing up the tube and out into the room in a fine mist. This demonstration and an explanation of its underlying science ideas can be found online at [28]. Students will then be given time to revisit their models of the anchoring phenomenon and update them using this new information.

At the close of this instructional period, the educator will introduce a homework assignment that will allow students to answer the anchoring event's essential question and then apply that understanding to a practical home cooling project. The first part of this assignment is for students to make final revisions to their anchoring event model. From this finalized model, they are instructed to then write an explanation of the airflow observed in their room as posed in the essential question. This explanation should include references to observations made in the exploration stations as well as an explicit reference to Bernoulli's principle. It is suggested that the educator provides a "gotta have" checklist of the relevant big science ideas for students to include in their explanations. The second part of this assignment has students sketch a blueprint of their home, indicating doorways, windows, and other ventilation points that allow exchange of air between the interior and exterior. The educator should introduce one final big science idea both in their in-class instructions and in the homework written instructions: that hot air rises from lower levels of a home to higher levels. Using their blueprints, and through experimentation at home, students are instructed to come up with a scheme of opening and closing ventilation points in order to create an optimum airflow pattern that will cool desired areas of their home. A possible extension activity is to have students design a contraption that will increase the airflow through their window when wind is blowing outside.

Instructional Period #3

The majority of this period should be given to students presenting their homework projects to the class. Educators can choose a format that best fits their classroom management structures. One suggested procedure is to have students first post their assignments (including responses to the essential question and their home cooling scheme) around the room and then participate in a gallery walk. During this activity, students walk around the classroom and read their classmates' project results. For each assignment, they leave a comment – either an affirmation or a suggestion for improvement – on a sticky note. After this gallery walk concludes, students then take turns presenting their homework results to the class. The instructional period should conclude with enough time left for students to write a brief reflection on how they might incorporate feedback from their peers to improve their presentations. These reflections will be turned in as the final exit ticket of this mini-unit.

Conclusion

The "Cool It!" mini-unit described above has been conceptualized following theories of culturally-responsive and sustaining pedagogies, community-based learning, and the Ambitious

Science Teaching model. It has been provided here in order to showcase how fundamental aerospace engineering content can be adapted for middle school learners using these principles. However, no curriculum can be considered finished until tested in the classroom. Therefore, this mini-unit will likely undergo further revisions following classroom testing. In the meantime, it is hoped that this example of curriculum development from popular educational theories can be used to spark the conceptualization and development of new K-12 engineering-relevant curricula from interested educators.

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Appendix A – Outline of Instructional Activities

Grouping	Activity Timing/ *Cumulative Time*	Learning Activity	AST Practice Set
INSTRUCTIONAL PERIOD #1			
Individual	3 min *3 min*	"Do Now" Question 1 *Prompt: "It's a hot summer day and the AC is out at your place (or you don't have one). What are some things you can do to cool down the room you're in? List both the actions you can take and try to describe how things in the room change as a result of your actions."*	AST 2: Eliciting Student Ideas
Class	7 min *10 min*	Discussion of "Do Now" reflections *Scribe records student responses in tow columns: one for student actions and another for resulting changes in the room*	AST 2: Eliciting Student Ideas
Class	2 min *12 min*	Introduction of Anchoring Event through an essential question *Prompt: "After a hot summer day playing outside, you come inside your home. After it gets dark outside, you have dinner with your family and then sit down in the living room (or comparable family space) to read a book. It's still so hot inside that after a while you can't stand it and decide to go to bed. You go to your room (imagined to be located upstairs), where you notice a slight breeze moving through your room. This seems odd, as there's no fan or AC on in your house. It's at this moment that you notice a whistling sound coming from over by your window. You walk over to investigate and notice that you left it cracked open. You can tell that there's wind blowing across the window outside, but it's not blowing any air in through the window. Instead, there's some air flowing from inside your room out through the open window space. You breathe a sigh of relief that your bedroom is cooler than your muggy living room downstairs. But then you start to wonder: what is causing the air to move through your room and vent through the open window? You ponder this question as you lay down on your bed, still puzzling over it as you drift off to sleep…"*	AST 1: Planning for engagement with Big Science Ideas

Grouping	**Activity Timing/** ***Cumulative Time***	Learning Activity	AST Practice Set
Individual	5 min *17 min*	Initial modeling of Anchoring Event *Educator provides blank model template*	AST 3: Supporting ongoing changes in thinking
Groups	4 min (directions) 12 min (experimentation) *33 min*	Exploration stations *Two station types: blowing air between two balls and suspending a ball in the air. Students should record their observations for use in following conversation.*	AST 3: Supporting ongoing changes in thinking
Paired Groups	5 min *38 min*	Exchange results *Educator can provide conversation stems to initialize discussions between groups*	AST 3: Supporting ongoing changes in thinking
Class	12 min *50 min*	Group presentations of findings to class	AST 3: Supporting ongoing changes in thinking
Individual	5 min *55 min*	Exit Ticket 1 – revise initial model of Anchoring Event *Prompt: "Using the knowledge presented in class, start to model what's going on in the anchoring event"*	AST 4: Drawing together evidence-based explanations
Teacher reviews Exit Tickets to prepare for Day 2 opening discussion			
INSTRUCTIONAL PERIOD #2			
Individual	3 min *3 min*	"Do Now" Question 2 *Prompt: "Using what we learned yesterday, how can we cool this room off?"*	AST 2: Eliciting Student Ideas
Class	7 min *10 min*	Discussion of "Do Now" reflections	AST 2: Eliciting Student Ideas

Grouping	**Activity Timing/** ***Cumulative Time***	**Learning Activity**	**AST Practice Set**
Class	15 min (presentation) 6 min (Venturi demo) *31 min*	Educator-led presentation – Bernoulli's Principle *This should include references to exemplars from Day 1 Exit Tickets where appropriate. During this presentation, the educator introduces the concept of Bernoulli's principle, highlighting how velocity and static pressure are inversely related in fluid flow; connections to student observations from Day 1 Exploration Stations should be made explicit. The presentation will end with a live demonstration of the Venturi Effect.*	AST 3: Supporting ongoing changes in thinking
Individual or Groups	7 min *38 min*	Revise Anchoring Event models	AST 3: Supporting ongoing changes in thinking
Class	10 min *48 min*	Homework assignment overview *The first part of this assignment is for students to make final revisions to their anchoring event model. From this finalized model, they are instructed to then write an explanation of the airflow observed in their room as posed in the essential question. This explanation should include references to observations made in the exploration stations as well as an explicit reference to Bernoulli's principle. It is suggested that the educator provides a "gotta have" checklist of the relevant big science ideas for students to include in their explanations. The second part of this assignment has students sketch a blueprint of their home, indicating doorways, windows, and other ventilation points that allow exchange of air between the interior and exterior.*	AST 4: Drawing together evidence-based explanations
Individual	7 min *55 min*	Homework planning	-
INSTRUCTIONAL PERIOD #3			
Class	45 min *45 min*	Student presentations – structure as needed	-

Grouping	**Activity Timing/** ***Cumulative Time***	**Learning Activity**	**AST Practice Set**
Individual	10 min *55 min*	Exit Ticket 2 – incorporating feedback from peers *Prompt: "Think about the comments your classmates made about your presentation. How might you revise your presentation based on their feedback?"*	AST 3: Supporting ongoing changes in thinking