



# Youths' Investigations of Critical Urban Forestry Through Multimodal Sensemaking

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## Abstract

A growing body of research suggests that digital multimodal composing can provide students multiple points of entry for making sense of local climate change issues and sharing their voices through digital activism. Building upon this scholarship, this study examined the processes of 32 small groups ( $n = 55$ ) of 7th- and 8th-grade students as they co-created a wide range of multimodal projects (e.g., videos, podcasts, infographics, posters, and cartoons) that explored the environmental, ecological, and sociopolitical impacts of inequitable access to urban tree canopy and greenspace in their city. In particular, scholarship on onto-epistemic heterogeneity, critical place-based learning, and multimodality were integrated to gain an interdisciplinary understanding of how digital multimodal composing mediated students' sensemaking about urban forestry impacts on community health and ecological well-being. Data sources consisted of field notes, audio and video recordings, survey data, student interviews, and students' final multimodal projects. Through qualitative and multimodal data analysis, five main themes emerged for how multiple modes mediated students' sensemaking about critical urban forestry: (1) embracing tree equity for compelling stories, (2) engaging authentic audiences through storytelling, (3) perspective-taking through multiple modes, (4) exploring affective dimensions of urban heat islands, and (5) developing solutions for critical urban forestry issues. These findings contribute new insights into how digital multimodal storytelling can provide a productive way for students to make sense of climate justice issues and gain agency by experiencing multiple ways of knowing.

**Keywords** Climate change · Multimodality · Storytelling · Epistemic heterogeneity

## Introduction

We live and work in a Southern U.S. city experiencing unprecedented population growth and urban development amidst the ugly shadow of redlining and other racist decisions regarding urban planning and economic development, increasing urban gentrification and construction, and dramatically decreased availability of affordable housing. Evidence of urban environmental injustice abounds—e.g., increasing urban heat exposure and vulnerability, lack of tree canopy, flooding, and respiratory disease in poorer, BIPOC urban neighborhoods. At the same time, there is burgeoning environmental advocacy and strategic planning activity in

the city, from a mayor's climate change mitigation action plan that explicitly mentions environmental racism as a critical issue to address, to local efforts to increase tree canopy in individual neighborhoods.

The authors of this paper co-designed a transdisciplinary, place-based unit aimed to cultivate diverse students' socio-ecological understandings of our city's urban tree canopy and urban heat island effect. One challenge here was to create empathy, understanding, and awareness of ecological harm without exacerbating youths' climate anxiety and perpetuating more harm (Vamvalis, 2023; Wray, 2022). We settled on digital multimodal projects as one way to do so, as they have potential to generate cultural relevance and connection (Tzou et al., 2019), agency (Vossoughi & Gutiérrez, 2016), and identity expression (Hull & Nelson, 2005). In particular, multimodal composing offers students *multiple points of entry* for engaging with issues by selecting their modes of expression and connecting with personally meaningful issues and communities (Smith et al., 2021; Jewitt,

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2008; Yi et al., 2019). The open-endedness of the projects provided us with important information about what aspects of the problem matter to youth, audiences that motivate their storytelling, modes they find engaging, and sensemaking repertoires they draw upon.

Despite these established benefits of digital multimodal composing, little research has closely examined youths' meaning-making across modalities in STEM contexts (see Grapin, 2019; Pierson et al., 2021). A few studies illustrate how multimodal composing invites multiple identities into learning spaces as legitimate ways of sense-making about difficult topics, including the climate crisis. This scholarship underscores how digital multimodal storytelling can serve as a creative means of expression for students to problem-solve local climate change issues (Beach & Smith, 2023; Jiang et al., 2020; Rooney-Varga et al., 2014) and share their voice through digital activism (Beach et al., 2017; Haynes & Tanner, 2015).

Building upon this research, this study examined the processes of 32 small groups (1–4 students per group;  $n=55$ ) of 7th- and 8th-grade students as they co-created a wide range of digital multimodal projects that explored the environmental, ecological, and sociopolitical impacts of inequitable access to urban tree canopy and greenspace in their city. We were interested in understanding how youth made sense of local climate change issues when provided multiple points of entry in the types of narratives, modalities, and digital genres they selected for sharing their message.

## Related Literature and Conceptual Framework

In this section, we provide an overview of three perspectives on learning that informed the curriculum design and research: (1) onto-epistemic heterogeneity (Warren et al., 2020); (2) critical place-based learning (Gruenewald, 2003), and (3) multimodality (Kress, 2010). The topic and practices of urban forestry animate these perspectives on learning; we begin with an overview of urban forestry.

### Urban Forestry

Climate change brings into relief problems for cities that emerge with rapid urban development and population growth, large swaths of nonporous surfaces, and high volumes of anthropocentric activity including vehicular traffic, space heating and cooling, and an array of industrial processes (Samson, 2017). As a result, cities experience increased soil, air, and water pollution and intensifying urban heat which disproportionately affect the health and well-being of poor, BIPOC communities (Campbell et al., 2022). In this context, urban forestry and greening efforts are burgeoning, and urban planners, scholars, activists,

and politicians are focusing on the environmental justice impacts of climate change for urban BIPOC communities and the importance of creating just, healthy urban ecosystems (Samson, 2017).

Our unit attended to concepts from urban forestry such as tree canopy cover, tree equity, and urban heat island. Urban forests include individual trees, assemblages of trees, and forests in and around the city. The importance of *tree canopy* for a healthy urban ecosystem are multiple—e.g., to moderate thermal stress, mitigate air pollution, sequester carbon dioxide, purify water, increase biodiversity, and enhance soil quality (Samson, 2017). Urban tree canopy distribution is spatially uneven by both race and class in many cities, including the one we live in (Campbell et al., 2022). This distributional justice lens is one aspect of the *tree equity* problem, which is receiving increased attention among urban forestry practitioners (Campbell et al., 2022). For instance, the National Oceanic and Atmospheric Administration (NOAA) led a 14-state citizen science project to map heat inequities in 14 states in the Summer 2023 (NOAA, 2023). Recently, urban forestry researchers have pointed out the need to attend to intersectional and relational greening, where spaces are understood from multiple, intersecting identities and attend to multiple ways of knowing and being in urban forestry processes and spaces (Anguelovski et al., 2020). *Urban heat island* is a phenomenon characterized by higher temperatures within an urban area as compared with rural surroundings, resulting in dramatic differences in temperature between the city center and rural landscapes (Hiemstra et al., 2017).

### Onto-Epistemic Heterogeneity and Critical Place-Based Learning

A curriculum designed to teach youth about urban forestry is fertile ground to encourage onto-epistemic heterogeneity, as the field itself fuzzies traditional disciplinary boundaries of urban planning, ecology, biology, and geography. Further, we also incorporated elements of environmental sociology in our unit. We draw on Warren and colleagues' (2020) definition of onto-epistemic heterogeneity, which highlights the interconnectivity of being (onto-) and knowing (epistemic) and emphasizes historicity, futurities, and the "critique and refusal of settled forms of disciplinary knowledge and practice" (p. 278). We view a heterogeneity-seeking curriculum (Pierson et al., 2022) as necessary for grappling with the complexity and multi-layered nature of climate change, inequity, and justice. Doing so invites learners' full humanity, lived experiences, and cultural and community-derived knowledge as legitimate meaning-making resources (Bang & Medin, 2010) that can be mobilized toward outcomes beyond settled knowledge such as evoking

emotion and care, action for change, or critique of systems of injustice.

Our unit and final multimodal project was designed for youth to engage local urban forestry via: (1) multiplicity, focused on multiple knowledges, ways of knowing, and modes of expression; (2) horizontality, which focuses on learning across spatio-temporal scales; and (3) dialogicality, which intentionally invites transdisciplinary and more-than-disciplinary ways of understanding place, thus destabilizing any one narrative about place (Warren et al., 2020).

Onto-epistemic heterogeneity operates in tandem with a critical pedagogy of place (CPP, Gruenwald, 2003); both have synergistic and overlapping commitments. One objective of CPP, for example, is decolonization, which aims to recognize past and present ways of thinking and doing that are harmful and exploitative to people, land, air, water, and more-than-humans. Doing so requires engaging in de-linking from singular, anthropocentric perspectives. Onto-epistemic heterogeneity is similarly conceptualized as a disruption to colonialist ways of knowing and being (Kayumova & Dou, 2022) that perpetuate binary thinking, artificial hierarchies in the learning environment, and a distancing of youth from their more-than-human communities (Bang & Marin, 2015). Another objective of CPP is reinhabitation, which focuses on “learning to live well socially and ecologically in places that have been disrupted and injured” (p. 9). Reinhabitation and decolonialization are synergistic with the concepts of multiplicity, horizontality, and dialogicality in onto-epistemic heterogeneity as learners consider non-dominant ways of living that are sustainable for socioecological thriving.

Both onto-epistemic heterogeneity and CPP encourage a form of *place-making*, a term we adapt from critical geography (McKittrick, 2006) that is a process of leveraging disciplinary and everyday knowledge, creativity, technological tools, and experiences to create new meanings of place. Place-making introduces elements of agency, hope, and resilience, but it also makes space for other negative emotions. Our urban forestry unit aimed to acknowledge the harm/heal dialectic so as not to paint too rosy or too dismal a picture. Since most reports of climate change are framed in negative terms, young people’s climate anxiety and “eco-grief” can become overwhelming (Ray, 2020). Storytelling, narrative forms, and transdisciplinary curricula are ways to “cultivate the muscle of radical imagination needed to... think beyond eco-apocalypse” (Ray, 2020, p. 11).

### Sensemaking Across Modalities

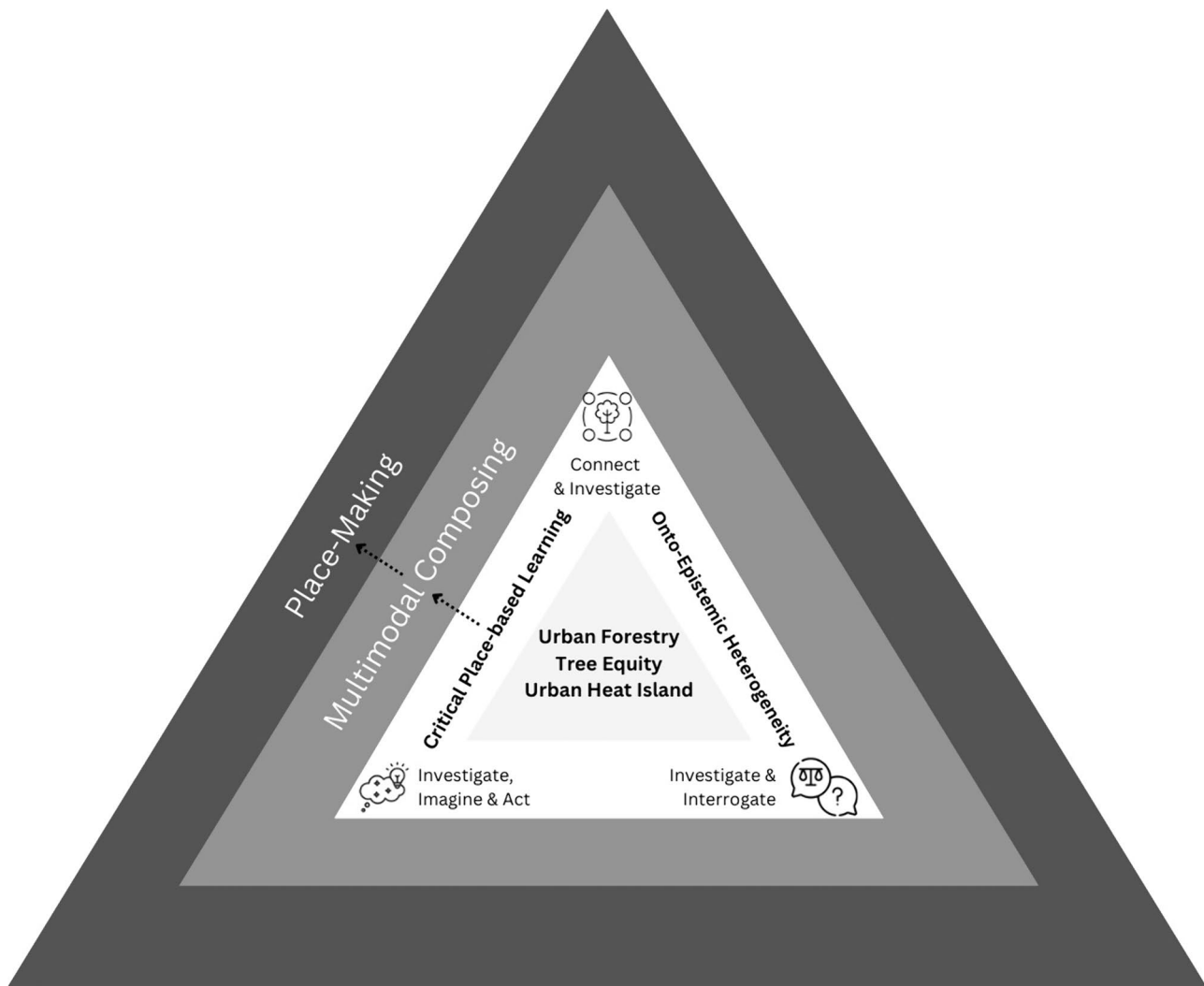
This study is also guided by a social semiotics (Kress, 2010) view of multimodality that emphasizes how various modes—including visuals, sounds, text, and movement—are integral in meaning-making. *Modes* are defined as culturally shaped resources for communication that are created through

social processes within specific communities (Kress & van Leeuwen, 2001). In the vein of onto-epistemic heterogeneity, this perspective expands our understanding of sensemaking beyond traditional, print-centric, and settled forms to consider a multimodal palette of communicative possibilities for understanding, expressing, and sharing knowledge (Jewitt, 2009; Kress, 2010). When creating multimodal products, students must consider how modes work together to create complex generative messages that no single mode can express independently (Jewitt, 2009).

Multimodal composing offers students “a multiplicity of ways to craft new language and tools for conceptualizing problems” that disrupts disciplinary and school-based boundaries (Warren et al., 2020, p. 278). Students have agency to infuse aspects of their identities, craft personally meaningful narratives (Smith et al., 2021) and leverage their funds of knowledge in individualized ways through multiple modes (González et al., 2011).

Multimodal research has explored how youth draw upon the affordances of specific modes (e.g., visuals, sound) in their digital products (Dalton et al., 2015; Hull & Nelson, 2005). Students often describe distinct modal preferences (Kress, 2010) for how they choose to communicate. For example, some students might believe that visuals or sounds are better at conveying emotions or abstract concepts (de los Ríos, 2018; Skerrett, 2018), whereas other students prefer writing for expressing ideas (Smith, 2017). Research also points to the possibility of storytelling through multiple modes as a conduit through which students can explore socioscientific issues. In particular, when students transmediate ideas into digital stories, there are rich possibilities for problem-solving, exploring different perspectives, and connecting with communities (Beach et al., 2017; Jiang et al., 2020; Rooney-Varga et al., 2014).

Figure 1 illustrates the synergistic workings of our pedagogical and conceptual frameworks. Urban forestry (inner triangle) lends itself well to a unit focused on multimodal composing, critical place-based learning, and onto-epistemic heterogeneity because of its multifaceted considerations of tree canopy amid socioecological systems. The next triangle, in white, demonstrates our pedagogical framework—i.e., the ways we designed for onto-epistemic heterogeneity, critical place-based learning, and the pathway choices laid out for students’ multimodal stories. The pedagogical framework highlights three assemblages of critical place-based learning: (1) opportunities for youth to investigate and connect in multiple ways to the city’s tree canopy, urban parks, and problems of tree equity and urban heat island; (2) investigating and interrogating the inequitable distribution of and access to tree canopy, histories of practice that perpetuate inequities, and potential solutions among diverse communities and demographics; (3) creating multimodal stories to inform others about the problem (act), which allowed youth



**Fig. 1** Pedagogical and conceptual framework

to investigate and imagine possible solutions, futures, and audiences. We view place-making (outer triangle), the creation of new meanings of place and the interconnections with community health and ecological well-being, as the outcome of critical place-based learning. We view multimodal composing (middle triangle) as a mediator because it offers multiple entry points and opportunities for expansiveness in engaging with the content, and flexibility in semiotic tools for meaning-making.

In the context of our unit, we were interested in how students engaged with urban forestry issues when provided the multiple entry points multimodal composing offers, including which modalities, genres, and digital tools they selected for conveying their message. We were also interested in how multimodal composing, as a way to enact place-making, could help students navigate the anxieties and tensions imbued in climate change education. As such, the study was

guided by the following research question: *How did digital multimodal composing mediate students' sensemaking about urban tree canopy impacts on community health and ecological wellbeing?*

## Methods

### Setting and Participants

This study took place in a pullout STEM enrichment program for public middle school students in grades 7 and 8 in a major southern U.S. city. This 18-hour, 5-week unit, co-designed with researchers and teachers, included field trips to three urban parks, data analysis and discussion using urban ecology and environmental sociology lenses, and a final multimodal project. Researchers built

connections with students by leading lessons and facilitating discussions.

Participants included four classes of 7th- and 8th-grade students during their weekly 3 hour-long science enrichment program. All students participated in the curricular unit and 55 students consented to be part of the research study. Demographically, the 55 student participants were 49% female, 45% male, 2% non-binary, and the remaining 4% preferring not to answer; 71% white, 13% Black, 13% dual-heritage, 2% Latinx, and 2% Middle Eastern. The students applied to participate in the program and self-identified as being interested in STEM; however, their specific interests varied widely from computer science to sports medicine to marine biology. While the majority of students were excited to study ecology and be in nature, there was a minority who expressed that the content of the unit “was not science.”

This cohort of students constituted a distinct collective within the educational landscape, showcasing a captivating interplay of demographics, interests, and preconceived notions regarding the subject matter. The group primarily comprised attendees of middle-class public schools catering to a predominantly white demographic. This context provided a rich backdrop for studying their engagement with the polemics of politics. Preceding the start of the forestry unit, these students manifested a spectrum of viewpoints reflecting their familial and socio-economic backgrounds. A noteworthy pattern emerged as some students’

inclinations leaned toward activism and liberalism, while other students’ stances often encompassed more conservative or non-liberal perspectives. These differences in students’ viewpoints introduced an element of complexity to the overall program dynamic. This unique amalgamation of middle-class, predominantly white students from families with varying degrees of liberalism and conservatism offered a lens through which to explore the diverse tapestry of political thought within this educational context (Table 1).

### Multimodal Storytelling Project

As a culminating project, students created a multimodal product related to what they learned about urban tree canopies for audiences they deemed important. During a 3-hour composing session, we asked students to communicate their learning using one of the following pathways and guiding questions:

- **Connect** Pathway - How can you persuade others of the importance of urban heat island and tree canopy through storytelling?
- **Investigate** Pathway - How can you explain the problem to others with a scientific argument?
- **Interrogate** Pathway - How does urban heat island and tree canopy affect different communities differently?
- **Imagine/Act** Pathway - How can we inspire others to take action through storytelling?

**Table 1** Lesson descriptions for the Urban Forestry unit

| <i>Lesson</i>                               | <i>Description</i>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | <i>CIIIA Framework</i>                              |
|---------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------|
| 1: Introduction (3 h)                       | We assessed students’ familiarity with ecology and sociology, introduced potential career prospects, and urged them to adopt the perspective of urban ecologists and environmental sociologists to examine natural resource distribution. Students practiced these perspectives by exploring and observing the school yard.                                                                                                                                                                                                                                                                                                                                                                                         | Connect                                             |
| 2: Field study in local parks (3 h)         | Each class explored and investigated a local urban public park. Students collected ecological and sociological information.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Connect/Investigate                                 |
| 3: Field study data analysis (3 h)          | Students analyzed data collected by the four classes across three different parks in the field the previous week. They examined the data for trends and interrogated the trends for meaning for community and environmental health.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Investigate/Interrogate                             |
| 4: Map study and solution exploration (3 h) | Students analyzed maps of the local metropolitan area. They layered transparency maps of tree canopy cover, temperature, lung disease hospitalizations, income, and race over a base map to analyze patterns. They confirmed the link between tree canopy and temperature and then formulated their own questions and findings. Many identified their neighborhoods on the maps and assessed tree coverage accessibility. Some also compared tree canopy availability based on economic and racial diversity. Students then compared four solutions for urban heat management (tiny urban forests, green roofs, cool roofs, and vertical farming) and deliberated methods to address tree distribution disparities. | Investigate/Interrogate                             |
| 5: Multimodal storytelling project (3 h)    | Students composed multimodal products to communicate their learning about urban tree canopies to authentic audiences.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Connect/Investigate/<br>Interrogate/Imagine/<br>Act |

Working in pairs or small groups of their choosing, students had flexibility on the focus, genres, and digital tools they used for their projects.

Students received support throughout their multimodal composing process while also maintaining freedom to follow their own unique composing paths (Smith, 2017). Explicit instruction targeted design and technical aspects of students' processes. During mini-lessons, instructors reviewed different tool and genre options such as Canva and Pixton comics, and shared examples of infographics, posters, and comics to inspire students when creating their own projects. We also scaffolded the composing session so students could receive feedback from peers on their in-process work. Students' completed projects were organized and displayed on a website.

### Data Collection

Data sources consisted of field notes, audio and video recordings, survey data, student interviews, and students' final multimodal projects. Researchers' field notes included observations of whole-class discussions, field-based investigations, and other group activities throughout the unit, particularly attending to rich discussions of environmental and social justice in the context of local urban tree canopy. We placed audio recorders at each table as a secondary source to supplement field notes. Researchers transcribed design-related discussions as students collaboratively composed their multimodal projects. During park visits, researchers wore GoPro cameras to capture students' embodied experiences and physical interactions with the local environment.

Additionally, we conducted four different student interviews during the unit, as well as a follow-up focus group interview near the end of the academic year. Particularly relevant to this study, a 30-min, semi-structured interview after students created their final projects provided insight on students' multimodal composing (see Appendix 1 for sample interview questions). During this interview, students reflected on their decision-making around the targeted audience, intended message, justification for their chosen modalities, opportunities for improvement in their final product, and any challenges experienced throughout the creation process. Many groups made curricular connections to key activities of the tree canopy unit, including field-based investigations and a local map study of tree equity. Others discussed the social implications of environmental inequities and suggested plausible solutions to climate issues. Overall, the team inquired about students' sensemaking as they considered, engaged with, and created multiple genres and modalities of scientific communication that deeply impacted their understanding of the urban heat islands and tree canopy issues in their local community.

### Data Analysis

Qualitative data analysis (Glaser & Strauss, 1967; Strauss & Corbin, 1998) was an iterative three-phase process. We began by open coding across data sources to develop emergent categories for students' sensemaking through their digital multimodal composing processes. This phase involved identifying and categorizing the different ways students designed their projects to engage with urban heat islands and tree canopy issues. To gain these insights, we first relied on students' perspectives for how they collaboratively created their projects, including specific design decisions and goals. We attuned to instances in which students described the affordances and constraints of different modalities or digital tools when designing and the impact it had on their understanding of the issues.

After open coding the 55 student interviews, we used axial coding (Strauss & Corbin, 1998) to examine the 32 projects to connect how students created their projects in relation to their goals and use of modalities. We traced the specific design decisions students described making with how they represented tree canopy issues through their multimodal designs. Multimodal transcripts (Flewitt et al., 2009) were created for all the dynamic digital products (e.g., videos and podcasts) to closely analyze how students layered modalities and designed for specific purposes and audiences.

For the final phase of analysis, we circled back across data sources—including interviews, projects, and field notes—to further develop and refine themes for how students made sense of tree canopy issues through multiple modes. We also calculated percentages for many of the themes and sub-themes to demonstrate their prevalence across students and projects. Throughout this process, the research team met regularly to discuss emerging themes and student examples, as well as to seek any disconfirming evidence that challenged our interpretations.

### Trustworthiness

We worked to strengthen the trustworthiness of our findings by triangulating different sources and conducting member checks with students at the end of the study (Erlandson et al., 1993). Instead of forcing our own interpretation of how different modes mediated students' sense-making, we strove to forefront their explanations so that we could understand meaning-making processes through their eyes.

### Findings

Digital multimodal composing offered students the freedom to follow individualized paths for making sense of critical urban forestry issues. Across student groups, there was wide

**Table 2** Categorization of students' multimodal projects

| CATEGORY             | Visual |                 |             |              | Text | Sound          |       | Movement        |           | COUNT |
|----------------------|--------|-----------------|-------------|--------------|------|----------------|-------|-----------------|-----------|-------|
|                      | Photos | Pre-fab. Visual | Student Art | Table/ Graph | Text | Recorded Voice | Music | Performance Art | Animation |       |
| Podcast              |        |                 |             |              |      | ●              | ●     |                 |           | 8     |
| Infographic          |        | ●               | ●           | ●            | ●    |                |       |                 |           | 7     |
| Poster               |        | ●               | ●           | ●            | ●    |                |       |                 |           | 2     |
| Comic/ Cartoon       |        | ●               | ●           |              | ●    |                |       |                 |           | 3     |
| Multimodal Interview | ●      | ●               |             | ●            | ●    | ●              |       |                 |           | 1     |
| Video                |        | ●               |             | ●            | ●    | ●              |       | ●               | ●         | 6     |
| Multimodal Poem      |        | ●               |             |              | ●    |                |       |                 |           | 2     |
| Model                |        | ●               | ●           | ●            | ●    |                |       |                 |           | 1     |
| Sculpture            |        |                 | ●           |              |      |                |       |                 |           | 1     |
| Written Story        |        | ●               |             |              | ●    |                |       |                 |           | 1     |
| Total                |        |                 |             |              |      |                |       |                 |           | 32    |

variation in the use of different modalities, digital tools, and project genres (Table 2). Below, we outline five interconnected themes for how students leveraged multiple modes for sensemaking, including (1) embracing tree equity for compelling stories, (2) engaging authentic audiences, (3) perspective-taking, (4) exploring affective dimensions, and (5) developing solutions.

### Embracing Tree Equity for Compelling Stories

Though many identified urban heat island as “everyone’s problem,” one-fourth of the students drew on their experiences in the unit that focused on tree equity. Most of the youth framed tree equity as a problem of distributional justice (Campbell et al., 2022), which emphasized inequitable access to urban trees and the disproportionate effects on BIPOC communities and other vulnerable populations. Many youth who chose to center tree equity issues also fashioned themselves as advocates in other areas of their lives—e.g., participating in Black Lives Matter and LGBTQ marches and protesting gun laws at the capitol. The option to choose the “interrogate” pathway for their final projects was a way to connect social and scientific onto-epistemologies.

Reflecting on their learning experiences, students shared: “[We learned] how poor people had less trees. I found that really interesting. And that’s kind of what I based my podcast on” (Lily) and learning about tree equity “really opened my eyes” (Barry). When asked about surprising or insightful experiences, a student noted “the places where there are people [who] had less income and more people lived there, and like that specific area, and

also [areas where] there are more people of color. Those were the places that had the most dreadful respiratory diseases and the least trees” (Meredith). Issues of fairness and equity worked their way into students’ projects. For instance, Georgia created an infographic about the lack of trees in communities of color and low-income neighborhoods (Fig. 2). Syd and Erin created a “political comic” illustrating the effects of urban heat islands on two dogs who had unequal access to tree canopy. They drew from their prior lived experiences raising pets as one way to elicit empathy and advocate for tree equity in the larger community: “You’re sad, you feel bad for this...vulnerable little dog on the street” (Syd) (Fig. 2). In this project, Syd and Erin infused multiple modes to emphasize their point—they noted deliberate decisions about color, use of visuals to symbolize wealth, “industrialization,” and burning paws as well as the use of data they collected during the unit, alarming statistics, and solutions. Their projects leveraged disciplinary knowing, empathy, and ethics as legitimate, multiple ways of knowing and communicating the tree equity problem, moves that destabilize singular, colonialist ways of knowing place.

Some students also expressed frustration with urban planning, people “in power” who could “make changes” but may choose not to, rapid urban development, and real estate profits as more important than community thriving. Their projects and interviews about tree equity illuminated a need, in future iterations of this unit, to provide more examples of local groups’ organizing to disrupt youths’ notions that adults are indifferent to the problem and show that individual power is not a prerequisite for successful action. At the same time, it is clear that, given their agency



Fig. 2 Sample student projects highlighting tree inequities

to create any kind of project, youths' appeals to justice and ethics point to their readiness and enthusiasm for engaging critical perspectives of place. Such a focus is motivating for middle school youth who take on advocacy roles in other aspects of their lives.

### Engaging Authentic Audiences

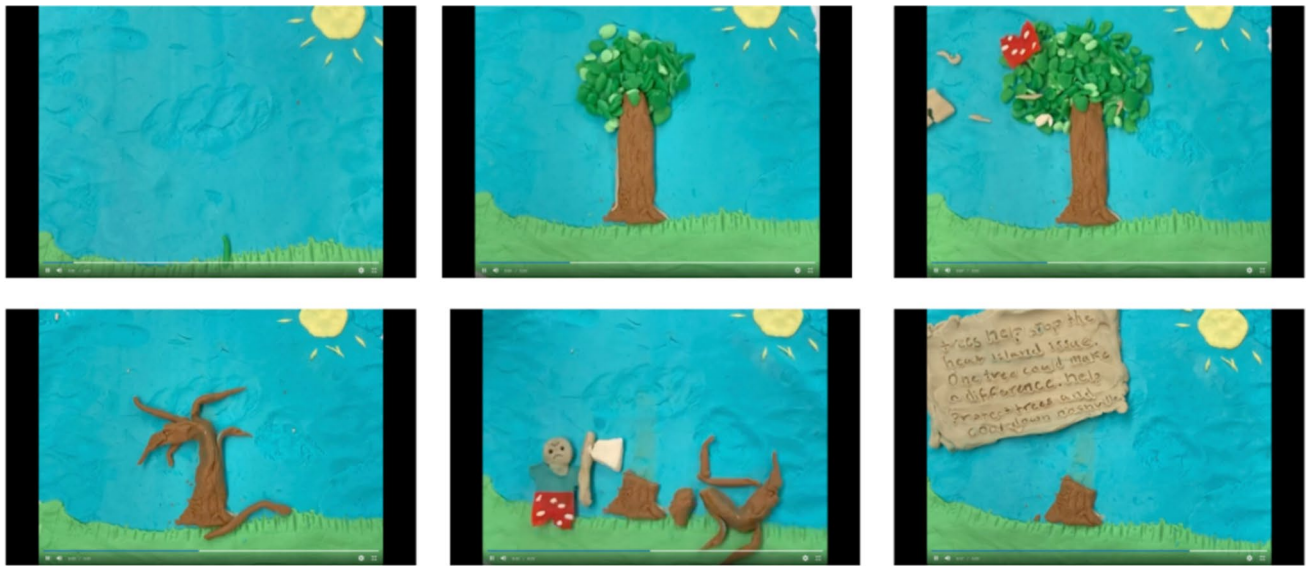
All of the students designed their digital multimodal projects to appeal to audiences that were authentic to them—i.e., those who might be directly affected by urban heat islands or able to enact change. When students compose for authentic audiences, they are motivated to connect with real and receptive stakeholders beyond the context of the classroom who are likely to engage with their work in meaningful ways (Magnifico, 2010). Many groups of students ( $n=9$ ) targeted their projects at either “younger” viewers or peers like themselves who have the capacity to learn and work toward change. For example, Alicia explained who she had in mind when creating her project:

I think really everybody because adults definitely can like change the way that they think about the environment, but also kids because they're just like finding like, their, their brains are still developing, and ours are too. But it's important to like, get that ingrained in

your brain that the environment, like it's really important too.

Some students also described designing for individual children they knew: “The preschool across the street, walking by them every day and seeing them walk out... They should know more about animals and trees and stuff” (Leon).

Other groups targeted audiences they saw as capable of responding to the issue right away, such as government officials ( $n=2$ ), business owners ( $n=1$ ), or adults who could “help” ( $n=4$ ). Some students described wanting to reach a general audience ( $n=7$ ) or local residents ( $n=2$ ) who could be affected by critical urban forestry issues. With various audiences in mind, students presented tailored multimodal narratives, persuasive appeals, and solutions they felt would receive uptake. For example, one group created a stop-motion animation “about a tree's life cycle” out of clay (Fig. 3). In their interviews, the group detailed how they designed their video for “kids [their] age” by making the message simple—something that would grab a viewer's eye on social media (e.g., TikTok or Instagram) with “cool” visuals. Another group composed a mix of audiobook and an interview in their project, which included a fictional story that “The kids ... don't have to think too hard to get the message” and the interview presenting more complex problems to “affect more like adults or like older people” by using



**Fig. 3** Stop motion animation video emphasizing the importance of trees in mitigating urban heat islands

“some bigger words and more details” (Wyatt). In projects targeting audiences who have the power to address urban heat island issues like government officials and construction companies, besides proposing related actions such as changing the color of buildings, students also attended to ways to catch their audience’s attention. For instance, Simon and Garrison’s video speaking to the local mayor adapted verbal expressions as “a much better way to spread a message ... and show more efforts” (Simon) and colorful images to “convey their [our] mood and emotions” (Garrison). In concert with previous scholarship, targeting audiences that feel authentic to youth increased student engagement and motivation (Chase & Laufenberg, 2011; Magnifico, 2010), while also providing a productive outlet to nurture a sense of personal and collective efficacy (Christensen et al., 2023).

### Perspective-Taking Through Multimodal Storytelling

Almost half (44%) of the projects involved perspective-taking through multimodal storytelling, with 16 different perspectives highlighted across 14 projects. In these projects, students employed visuals, sounds, text, and animation to portray the experiences of trees, animals, and humans negatively affected by urban heat islands. Out of those who used perspective-taking, students most commonly evoked the perspective of an animal (other-than-human) or a tree ( $n=5$ ), with the goal of using storytelling to decenter human perspectives (Damico et al., 2020) and elicit empathy. In doing so, their stories align with critical place-based learning’s goal of decolonization—i.e., to challenge anthropocentrism

and recognize the agency of non-humans in ways that connect, rather than distance, humans from the natural world (Bang & Marin, 2015). For stories written from human perspectives, there were three different subgroups. Four projects told the story of fictional locals, with stories referencing specific locations and experiences of their city. An additional four projects provided the perspective of fictional people with authority, ranging from firefighters to social scientists, who used credibility and ethical appeals from their respected fields to persuade audiences. The final three projects provided the perspective of humans in fictional situations such as survivors of the end of the world living on another planet.

Students described portraying different human and more-than-human perspectives in their digital stories as a means to explore experiences, engage audiences, and express creativity. Their reasoning also centered on conveying an “understandable” narrative to educate and move their audience. For example, one group explained their decision to center a bird’s perspective in their multimodal poem (Fig. 4) in terms of maintaining audience engagement: “We know that people can easily get bored with reading facts. So we wanted to do something where they could pay attention and not be, like, distracted easily” (Elena). The poem’s emotional tenor, painting a dystopian future and told from the perspective of a bird, communicates a more-than-disciplinary way of knowing that youth leveraged as a form of persuasion, framing it as a compelling and legitimate form of knowing. Storytelling was also viewed as a means to reach peers: “[T]elling them a story is probably an easier way for them to like, understand it” (Leon).

In accord with previous research (Swim & Bloodhart, 2015), perspective-taking was an effective way for students



**Fig. 4** Multimodal poem from a bird's perspective with an animated swaying tree branch

to gain a multidimensional and empathetic understanding of the importance of climate justice issues: “When I got to look at it, through someone else’s point of view, I was like, oh my goodness, I never realized that that could be an issue for someone. So it definitely helped me learn” (Harrison). Perspective-taking was also related to the diverse formats and modalities that students employed in their projects. For example, some students who took the perspective of fictional people with authority (e.g., media personalities, scientists) structured their projects as podcasts with audio-recorded interviews.

### Exploring Affective Dimensions of Urban Heat Islands

Students’ stories often delved into the affective dimensions of urban heat island issues. Many groups explained how they designed their projects to evoke empathy and emotional responses to show how urban heat island effects had personal, local, and devastating impacts. Students drew inspiration from their life experiences and memories when underscoring the emotional aspects of urban forestry issues. For example, the group that focused their multimodal poem on a story about a bird forced out of its home due to the decreasing tree canopy (Fig. 4) drew from their observations

of the dwindling presence of trees and animals in their backyards. The tone and content of their poem’s text, as well as the animated image of a lone swaying tree branch and silhouetted birds against a plain background evoked feelings of loneliness and despair. Syd’s illustrated story about the dogs (Fig. 2) reflected their experiences walking their dog when they lived in the high desert in the Southwest US. Other students described using specific modalities to encapsulate the emotional tenor of climate injustices, including melancholy music, alarming statistics, or striking visuals to affect viewers and readers.

Several students also focused their multimodal compositions on the moral aspect of unfairness to citizens in their local community. For example, one group emphasized wanting to underscore how local people would be directly affected by climate change to invoke empathy: “It’s the part like where we, because I know there’s not a lot of trees, but I want to talk about the PEOPLE and how they are, how THEY are affected. I think that’s an important thing to talk about is, well, it’s the people who are being affected badly. I want them to know WHY. And how, why is there respiratory disease?” (Bobby). Others focused their emotional appeals on the inequity of who is affected by climate change. One group contrasted the living conditions between people with

high- and low-income levels through drawing and aimed at getting people to care: “So it’s like, if you live here, you’re obviously living comfortably. So it’s like a lot of people don’t know what other people are going through” (Eleanor).

Many students expressed their concern about the impact of urban heat island issues on the future of citizens in their community. By creating a podcast interviewing the survivor of a world-ending disaster, Jeremy expressed his distress about human suffering from environmental issues and the potential severity of unmitigated urban heat islands: “What if there were like barely any trees? ...that was kind of the reality I was trying to think about in the story.”

Climate justice scholarship emphasizes how youth are particularly attuned to the affective dimensions of climate change issues (Tao et al., 2022). Digital multimodal storytelling offered layered opportunities for students to explore the injustices human and animal victims incur as a powerful means for persuading others.

### Developing Solutions for Critical Urban Forestry Issues

Nearly all projects mentioned solutions to the tree canopy and urban heat island problem. Twenty-two youth mentioned in interviews that they designed their projects to persuade others to care about the problem, have empathy for affected communities, and/or take action. Proposed solutions ranged from individual actions (e.g., planting trees, painting your home a lighter color;  $n = 16$ ) to urban planning (e.g., city parks, tiny forests, green roofs;  $n = 11$ ) to persuading companies, government, or people “with power and money” to change their practices ( $n = 6$ ). Many (70%) saw their projects as a form of advocacy for change, however few projects implied a form of civic participation from “regular folks” ( $n = 4$ ). Instead, students referred to adults in authority positions as the ones with the power to effect change. Some appealed to powerful adults to address tree canopy problems. For example, Simon and Adam created a video message to the city’s mayor advocating to replace “old, useless, dead, and broken buildings” with a “young, useful, living, and beautiful park.” However, many used satire and humor to convey distrust or anger with adults in “power,” who “are not changing things” or “don’t care.” Others turned to the next generation ( $n = 9$ ) and expressed overwhelming beliefs in younger children—“There could be so many more solutions that children come up with” (Lily).

Students’ inclusion of solutions in their projects was reassuring, especially since this was not a required part of the project. Students included solutions even in projects that conveyed frustration, alarm, sadness, and dystopian futures. However, it is interesting that the hopeful inclusion of solutions was sometimes tied to belief in the next generation, and for many was countered by distrust in older generations. This is especially so because the unit intentionally

highlighted solutions, such as tiny forests and green roofs, that are already being developed and implemented. Overall, the projects enabled youth to understand that the problem is real but solvable, and that solutions are feasible.

## Discussion

### Affordances of Multimodal Composing for Sensemaking

This study contributes new insights into how students designed with multiple modes in digital spaces to make sense of critical urban forestry issues. When provided compositional flexibility in genres, digital tools, and modalities, students crafted a wide range of products—with podcasts, videos, infographics, posters, and cartoons being the most prevalent. Given the multilayered freedom in communicating their ideas, these findings also reveal what students chose to prioritize when sensemaking about climate crisis issues. Many students tailored their projects to specific audiences who were directly affected or can take action. Students’ projects and perspectives revealed how they viewed exploring the stories of trees, animals, and humans impacted by urban heat islands and the affective dimensions of their stories as effective ways to move others.

Within the burgeoning field of multimodality, main themes of findings to date have focused on engagement, identity expression, and youth’s purposeful use of different modalities. The majority of this scholarship has taken place in literacy contexts with limited studies examining science learning through multiple modes (see Smith et al., 2021 for a review). The handful of studies exploring how students make meaning of climate crisis issues through digital multimodal composing emphasize how students can leverage their creativity to problem-solve local climate change issues (Jiang et al., 2020; Rooney-Varga et al., 2014) and share their voice through digital activism (Beach et al., 2017; Haynes & Tanner, 2015). These findings echo previous work while also contributing a new understanding to how students can gain agency by experiencing multiple ways of knowing. Students were not confined to specific genres, tools, conclusions, or solutions. Alternatively, there was variation in the tree canopy issues they addressed, the purpose of their projects, the perspectives they evoked, the audiences they addressed, and how they constructed their narratives. Notably, this ability to forge their own sensemaking trajectory was a main reason the vast majority of students cited it as their favorite project of the year. Digital multimodal composing afforded students the opportunity to make sense of local tree canopy issues in individualized, creative, and personally meaningful ways.

These affordances of multimodal sensemaking are particularly salient considering the context of this study, which

was with middle to upper-middle-class, predominantly white students from families with varying degrees of liberalism and conservatism. The multimodal projects offered multiple points of entry for all students to engage with climate crisis issues despite the engrained political views they brought to the classroom.

### Youths' Place-Making at the Intersection of the Harm/Heal Dialectic

Designing for middle school youths' critical place-based learning is somewhat of a balancing act—where it is necessary to understand harm, exploitation and inequity alongside human care and ingenuity, connectedness, and socioecological thriving. Pedagogical aims in this unit included nurturing students' understanding of the existence of, reasons for, and disproportionate effects of the urban heat island effect on vulnerable populations in our city and to position the urban heat island problem as addressable with practices from urban forestry, community organizing, and everyday acts of individuals. In other words, we aimed to create opportunities for youth to engage the tensions of harming and healing—or what we call the harm/heal dialectic. This is a tall order for an 18-hour unit, but it is necessary if we want to continue doing this work without perpetuating more harm for students.

The connect-investigate-interrogate-imagine-act embodiments of critical place-based learning, coupled with the multimodal project, was a quest to encourage “epistemic openness, or where multiple knowledge systems can respectfully coexist,” becoming resources for one another's learning (Tzou et al., 2019, p. 309). The epistemic openness provided us a window into how youth navigated the harm/heal dialectic and new meanings of their city, the increasing heat and inequitable distribution of tree canopy in the city. Students invoked empathy, humor, everyday heroes, scientific reasoning, dystopian futuring, a distrust of adults with power and money to affect change, perspective-taking, art, and other literary forms like poetry, comics, and drama to persuade and educate multiple, imagined audiences.

Many of students' sensemaking processes aligned with hopeful, action-oriented ways of coping with climate change issues (Christensen et al., 2023)—including focusing on solutions, contextualizing the problem, and targeting policy makers. At the same time, in all but two cases, students who used a futuristic lens ( $n = 8$  projects) painted a scary, dystopian future. This is not unusual, nor is it necessarily “bad”—dystopian fiction, for instance, can be a way to cope with a stressful reality or can be used as a persuasive technique to raise awareness about the urgency of the problem (Hughes & Wheeler, 2013). The project provided space for students' place-making as they imagined a “world without trees” or a bird without its habitat or a girl who moved to the city center

from a green, rural part of the state. These were often design decisions, too. As Elena said, “The whole point of [using a made-up scenario with a bird] was so that we could kill it in the end...so someone could grow an emotional bond towards, and then realize, ‘Oh! It dies!’ Like, ‘Really sad.’”

This study underscores the role of stories and multimodality for supporting students' sensemaking around the tensions of harming and healing. For a subject that by its very existence generates anxiety, particularly of social or ecological nature, the variety of multimodal projects produced by students indicates freedom to face their anxiety through their own lenses. Multimodal storytelling offered the communicative freedom and individualized pathways for processing the complex emotions that arise with local climate change issues.

### Appendix 1. Sample Final Interview Questions

- What were you trying to do/show/express with this project?
- What audience did you hope to speak to with this project?
- How did you create that project to appeal to that audience?
- How did you use different modes like visuals, sound, or text to persuade your audience?
- Why did you pick this format?
- For those who had some sort of perspective-taking: Why did you choose to use these characters/etc to tell your story? What was it like taking on a different perspective to connect to urban heat island issues?
- What was your favorite part of creating your project? What was the most challenging?
- Did creating this project help you to understand better the issues connected to urban tree canopies/heat islands? Why or why not?
- Is there anything else you'd like to tell me about this project or your process creating it?

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## Declarations

**Ethical Approval** This study has approval from the IRB of Vanderbilt University and is following those ethical guidelines.

**Informed Consent** Student participants and their guardians have completed informed consent.

**Consent to Participate** Students (and their guardians) have completed consents to participate.

**Consent for Publication** Students (and their guardians) have completed consents to participate.

**Statement Regarding Research Involving Human Participants and/or Animals** The students in study have agreed to participate and we have followed the procedures outlined in our approved IRB.

**Competing Interests** Not applicable.

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