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Food for thought: Immersive storyworlds as a way into scientific meaning-making

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Abstract

Science communication aims to equip the public to become critical consumers of, advocates for, and sometimes producers of science. However, many studies suggest that audiences participating in such programs already benefit from strong cultural messages and social resources that encourage their engagement with science. The field is thus seeking to develop new models of science communication that can engage those who do not already seek out science engagement opportunities. In this article, we share findings from a study of an emerging sector of science communication that stages events in non-science settings, such as nightclubs or music festivals. In particular, we examine a science communication program that leverages the genre of immersive storyworlds to engage non-science-seeking audiences at an annual country fair. Leveraging Bakhtin's conceptualization of carnival as a theoretical lens, we ask the questions: How do immersive storyworlds operate to attract and engage non-science seeking public audiences in science conversations? In what ways do immersive storyworlds afford opportunities for participants to see science in relationship to themselves? We find that the storyworld creates an aesthetically and emotionally saturated context, with

improvisational roles and routines that accommodate diverse perspectives and position participants' prior experiences and interests as the means for productive participation. Jointly producing the storyworld affords opportunities for belonging, which in turn appear to support sustained science conversations among participants and science communicators. The study contributes to the nascent evidence base for how such approaches might serve as an inclusive form of science communication, in particular by proposing new ways to think about "belonging" in science.

KEYWORDS

Bakhtin, belonging, carnival, immersive storyworlds, informal science, science communication

1 | INTRODUCTION

Decades of research have shown the importance of science communication programs for developing the public's interest in, relationship to, and understanding of science (National Academies of Science, Engineering, and Mathematics, 2017). However, a growing number of studies suggest that audiences most likely to benefit from science communication programs—including public engagement and informal science education—are those who already benefit from strong cultural messages and social resources that encourage their participation in and engagement with science (Dawson, 2014; Kennedy et al., 2017; Philip & Azevedo, 2017). Feinstein and Meshoulam (2014) argue that science communication programs as currently construed can therefore exacerbate inequities in science engagement rather than ameliorate them. Thus, if it is to serve as a force for expanding who engages with science, the field of science communication needs to develop new models, new settings, and new strategies for engaging audiences that historically have been excluded from science (Bevan et al., 2020; Canfield et al., 2020).

Public engagement with science programs include a wide range of approaches to communicating science, with a general aim of supporting mostly adult audiences to become critical consumers and producers of science in everyday settings (Bisbee O'Connell et al., 2020; Bucchi, 2008). There is a growing literature on citizen science programs, which engage adults, over a period of months to years, in what might be called public science engagement opportunities (e.g., Cooper et al., 2021; Shirk et al., 2012). In addition to a range of programs designed to appeal to those already interested in science—such as science lectures, science festivals, maker fairs, citizen science, and many forms of science media production—there are efforts afoot to design public engagement programs to reach new audiences: those who do not actively choose to attend programs clearly labeled as science (Bisbee O'Connell et al., 2020; Bultitude & Sardo, 2012; Rosin et al., 2021). Sometimes called "stealth science," these programs, such as Science Stand Up, the Phage at Burning Man, and Guerilla Science, tend to provide more socially edgy, artistic, transdisciplinary, and participatory opportunities to engage with science

FIGURE 1 Sensory speed dating exploration of taste

than many others (Mejias et al., 2021; Kaiser et al., 2013). For example, Guerilla Science regularly hosts *Sensory Speed Dating*, a blindfolded speed dating event in which participants explore tastes, sounds, and smells of their speed dating partner (Rosin et al., 2021). The event is emceed by an early career neuroscientist who, in between speed dating interactions, explains the phenomenon participants have just experienced, such as the role of pheromones in sexual reproduction (see Figure 1). These types of programs take place in non-science specific settings such as music festivals, nightclubs, or country fairs. In seeking to illuminate the relevance of science to social life, they often push the intersection of science and society from "headline" socioscientific issues such as health and climate change to more immediately personal, and sometimes titillating, topics like the science of hallucinogenic drugs or the psychology of social media addiction (Bultitude & Sardo, 2012; Dance, 2016).

While edgy science engagement programs have been shown to attract or appeal to young adult audiences (Bisbee O'Connell et al., 2020), it is challenging to demonstrate their impact without disrupting the experience. Research methods like surveys or interviews require extracting participants from the intellectually and emotionally saturated experiences the program designers are seeking to provide (see Michalchik & Gallagher, 2010; Peterman & Gathings, 2019). Participants at the Sensory Speed Dating event, for example, are definitely hoping to strike up a conversation after the event is over but not with the program evaluator. Moreover, much of the work is momentary and unrepeated, taking place within the context of a much larger experience (such as a music festival). For this reason, the work is largely undocumented in the research literature. Thus, perhaps even more than many other kinds of informal science efforts, these edgy science engagement programs grapple persistently with the questions: What kind of science learning is happening here? And how do we know?

This article seeks to make methodological and theoretical contributions to the study of such science communication efforts by using a Bakhtinian conceptualization of carnival as a lens for exploring how such programs can support participants' belonging in science. While there is an robust literature documenting and defining "belonging" (e.g., Baumeister & Leary, 1995; Walton & Brady, 2017), many studies in science education reference it in ways that are inconsistently intertwined with concepts such as identity, motivation, attitudes, and representation, among others (e.g., Brockman, 2021; Fredricks et al., 2004; Trujillo & Tanner, 2014). Perhaps almost as frequently, many researchers use the term but do not define it (e.g., Gonsalves

et al., 2021; Schmidt et al., 2020) perhaps because, as Baumeister and Leary (1995) describe, it is a fundamental human need—something we all know and feel when it is present and when it is absent. Most studies of belonging take place in K-12 or higher education settings, and numerous are concerned specifically with the ways in which belonging relates to learning in terms of supporting persistence and ultimately commitment to a social setting, such as school, or disciplinary practice, such as biology (e.g., see Korpershoek et al., 2020). Many science education scholars suggest that fostering a sense of belonging may be especially important for students from communities who are under-represented in a setting or a disciplinary field such as science (Ong et al., 2018; Trujillo & Tanner, 2014). Further, some scholars have focused on the design of settings that can promote a sense of belonging, or rightful presence (e.g., Calabrese Barton et al., 2021; Varelas et al., 2021; Walton & Brady, 2017). But few studies, likely for both conceptual and methodological reasons, have explored what belonging may mean in a short-term, everyday experience, despite the fact that leading scholars of belonging have noted the importance of everyday opportunities for developing a sense of belonging, including in the context of being a stranger in a social setting (Baumeister quoted in Allen et al., 2021, n.p). In this article we explore theoretical and methodological approaches to understanding how short-term (often limited to minutes) science communication activities may be designed to contribute to a sense of belonging in science, which we define, following Goodenow (1993), as a feeling of being accepted, valued, and respected within a specific social context or setting (see Walton & Brady, 2017). Specifically, our study uses Bakhtin's conceptualization of carnival to explore how a particular science communication strategy—immersive storyworlds—can foster a sense of belonging in a discursive science space or setting, which is the storyworld itself, and how such belonging leads to sustained conversational engagement about scientific topics and ideas. Our study addressed the research questions: How do immersive storyworlds operate to attract and engage non-science seeking public audiences in science conversations? In what ways do immersive storyworlds afford opportunities for participants to see science in relationship to themselves? In this article, we share how we integrated qualitative and quantitative methods to identify the ways in which edgy and theatrical approaches to science engagement created sustained opportunities for belonging in discursive spaces or settings centered on scientific conversation and meaning making.

2 | BACKGROUND IN THE LITERATURE

Our study adopts ecological and socio-cultural theoretical perspectives that conceptualize learning as a process that develops over time and setting, marked by deepening interest, identity, understanding, and commitment that develop in and across a range of different experiences and opportunities (Barron, 2006; Herrenkohl & Mertl, 2010; Nasir et al., 2014).

Most research on learning, perhaps naturally, attends to sustained (years-long, year-long, and months-long) participation in formal and informal educational, family, and community settings. There is less documentation of one-off designed experiences, despite scattered accounts of experts citing a seminal experience in a museum or theater as a catalyst for a life-long pursuit of learning (e.g., Steven Jay Gould and the American Museum of Natural History). Research on short-term science engagement events in science settings (such as science festivals or science museums) have found that most participants already affiliate or identify with science (DeWitt & Archer, 2017; Falk et al., 2016; Kennedy et al., 2017). There is even less research on science events set in non-science settings, and how such short-term experiences may contribute to

longer term arcs of engagement (but see Bultitude & Sardo, 2012; Monzack & Petersen, 2011; Streicher, Unterleitner, & Schulze, 2014). Yet, Holland et al. (1998), studying adult development of identity through such settings as Alcoholics Anonymous, note the importance of improvisational opportunities for people, of all ages, to undertake activities "in the moment." Through such socially situated improvisations, people develop a set of heuristics that can support the emergence of identity and agency. They note: "In our view, improvisations, from a cultural base and in response to the subject positions offered in situ, are, when taken up as a symbol, potential beginnings of an altered subjectivity, an altered identity. ... Such productions, we believe, are always being appropriated by people as heuristic means to guide, authorize, legitimate, and encourage their own and others' behavior" (Holland et al., 1998, p. 18). Indeed, they note that "to the extent that these productions are used again and again, they can become tools of agency or self-control and change" (p. 40).

Such views suggest that productive short-term engagements with science have the potential to make meaningful contributions to longer term arcs of engagement with science (Bransford & Schwartz, 1999; Davies & Horst, 2016; Mutonyi, 2015). They can reinforce existing interests and identities; they can extend, broaden, or deepen existing understandings; they can serve as the social site for the development of heuristics to be deployed in the future; and they can spark new interests and understandings, contributing to the development of scientific identities. Compelling short-term engagements may be especially important for people who do not already have science as an embedded social practice or topic of conversation in their day-to-day lives, operating to reposition science as a subject of interest and relevance to their lives (Banks et al., 2007; Erstad et al., 2009), by creating opportunities for them to feel accepted, valued, and respected in the context of a scientific discursive space.

2.1 | Immersive storyworlds

Many short-term science events involve forms of storytelling—whether in theater, podcasts, films, or readings—to communicate both the products and processes of science (Dahlstrom, 2014; Martinez-Conde & Macknik, 2017). Recently the field has addressed how storytelling can be an important tool for engaging diverse and non-science affiliated audiences (Joubert et al., 2019). Its utility for science communication includes addressing multiple dimensions of learning (visual, auditory, and embodied), embedding science within a narrative structure to aid with meaning-making and memory, and creating a programming template or format that science communication professionals can adapt and expand to new topics or audiences (Finkler & Leon, 2019; Martinez-Conde & Macknik, 2017).

While traditional storytelling typically consists of a linear narrative arc with a central protagonist, there is a growing form of story-based leisure time activity called immersive storytelling. In immersive storyworlds participants become actors in a storyline, which is usually characterized by branching plot lines that allow for varying degrees of improvisation and authorship by participants (see Bevan et al., 2021). Immersive storyworlds leverage and compete with purely digital media, and include multimedia experiences using augmented reality such as Pokemon Go; physical narrative experiences such as Escape Rooms or Punchdrunk Productions; and "transmedia" experiences such as the Marvel Cinematic Universe and affiliated spin-offs, World of Warcraft, and Comic Con.

While the term "immersive" is contested in the literature (Gröppel-Wegener & Kidd, 2019), the general notion of becoming a character or taking on a role within a fictitious world appears

to be a central characteristic of immersive storyworlds (Warren, 2017). As noted by Bevan et al., 2021, communications scholar Henry Jenkins distinguishes between interactive and participatory storyworlds, with the first offering choices within a participation structure (such as many video games) and the latter offering more opportunities to fundamentally change the nature of the experience. In both cases, he describes transmedia immersive storyworlds as leveraging multiple different modalities and media, unfolding over time in serial form, and entailing performance on the part of participants (Jenkins, 2006, 2009). In a discussion of the neurological and cognitive dimensions of immersive experiences, Martinez (2014, p. 111) notes that storyworlds may generate "attention priming, empathic attachment, and emotional involvement in narratives." Scholars also note that role-playing within storyworlds can be rewarding for both recognizing existing expertise and knowledge, thus legitimating one's value in a communal activity, and for providing opportunities for accessing new insights and skills (Finnegan, 1997; Hergenrader, 2020; McAdams, 1993).

The aesthetically and emotionally saturated immersive storyworlds of Guerilla Science, the program we report on here, scaffold elements of theater, experience design, and the visual arts into rich narratives that physically place participants in relationship to science. In taking up roles within the storyworld, participants must engage in scientific practices and conversations. In the case of Guerilla Science, participants role-play being patrons at a diner that serves exclusively a range of roasted insects (see Figure 2). Taking the plunge, embracing the role, and constructing the story through active participation involving eating the insects opens up opportunities for developing a sense of belonging in sustained science conversations.

3 | CONCEPTUAL FRAMEWORK

Our conceptual framework rests on two premises. First, engaging individuals who do not already affiliate with science requires designing experiences that can promote an affective sense of acceptance, value, respect or "belonging" in science. Second, Bakhtinian conceptions of *carnival* can illuminate the ways in which fictionalized storyworlds can be designed to invite participation, contribution, and belonging, including for those who have not set out to engage with science, by positioning participants' prior histories and selves as the very means for participation within a collective social experience characterized by scientific conversation.

3.1 | Affect and belonging in science

Belonging has been described as a fundamental need by scholars Baumeister and Leary (1995). Belonging has been linked to a range of positive outcomes, both academic and social–emotional (see Allen et al., 2021 for an overview). Scholars have referenced belonging in terms of the "belongingness hypothesis" (Baumeister & Leary, 1995) and "a sense of belonging" (e.g., Hurtado & Carter, 1997; Trujillo & Tanner, 2014). Others have described it as "fitting in" (Rosenberg & McCullough, 1981 cited in Brockman, 2021; Walton & Brady, 2017). Recognition, a key definitional component of identity (e.g., Carlone et al., 2015) is also seen as a key feature of belonging (Dou & Cian, 2021; Trujillo & Tanner, 2014; Walton & Brady, 2017). Others have described belonging as involving a feeling of importance within a social setting such as school (e.g., Finn, 1989). It has also been described as having a sense of membership (Hurtado & Carter, 1997). Most of these studies have occurred in the context of schooling, and thus are able

FIGURE 2 Wait staff inviting patrons to the Entomophatron diner

to observe and consider belonging as it evolves over time within more or less stable social contexts. Yet scholars have also noted the importance of opportunities for belonging as requiring both frequency and duration, and as being nurtured across settings including in casual out-of-school (e.g., family, peer) conversations and activities (Dou & Cian, 2021; Hurtado & Carter, 1997). Such views reflect an ecological approach to understanding how one develops, learns, and becomes across time and setting (Barron, 2006).

There has also been important work on designing social settings to support a sense of belonging (Calabrese Barton et al., 2021; Ong et al., 2018; Varelas et al., 2021). Walton and Brady (2017) describe how small social cues can shape initial reactions to whether a person feels that they belong or not. Creating welcoming and inviting spaces and relationships is key, as well as explicit moments of recognition that a person is present and "fits" in. Settings can be designed to support a sense of togetherness or camaraderie. Researchers have explored how such settings can create "counterspaces" (Ong et al., 2018) for those marginalized from science, contributing to their motivation to persist and commit to the social context (Brockman, 2021; Trujillo & Tanner, 2014).

Designing spaces for belonging thus blends strategies for supporting cognitive, embodied, as well as affective dimensions of participation in the activities of the social space. For example, research has noted the importance of affect in motivating and sustaining engagement with science (Martin et al., 2016; McKinnon & Vos, 2015), including how it is inextricably intertwined with the disciplinary practices of doing science (Jaber & Hammer, 2016). Over the past two decades, a growing body of sociological research has documented the role of emotion in science classrooms, focusing, in particular, on gestural, physical, and vocalized forms of emotional engagement (Bellocchi et al., 2017), and in particular laughter (Morrison, 2008; Roth et al., 2011; Scott, 2011). Scholars have noted the ways in which such emotions are both markers of and resources for deepening participation in learning (Bolen, 1999; Linnenbrink-Garcia et al., 2016). Importantly, emotions are explored not as individual traits but as emergent characteristics within social settings (Roth et al., 2011). Davis & Bellochi (2018, p. 366) argue that, in social contexts, emotions, in the form of feelings, constitute a "we-relationship," suggesting a sense of shared perspective, community, and belonging. Roth et al. (2011) argue that laughter, in group contexts, is a mutually performative act that forges feelings of solidarity. Solidarity in turn reinforces a sense of belonging.

Research has documented how science programs designed for individuals from communities historically excluded from science demand particular attention to building a sense of solidarity and belonging (Calabrese Barton & Tan, 2020; Leggett-Robinson et al., 2018; Nasir et al., 2014). Belonging is constructed dialectically through both individual activity—actively participating, contributing, and leveraging one's own experiences in an activity—and group activity—building on and developing shared purpose, language, routines, and a growing sense of identity (Heath & McLaughlin, 1993; Lave & Wenger, 1991; Nasir & Cooks, 2009). Thus, science education programs seeking to enhance a sense of belonging for individuals who do not, for different reasons, affiliate with science, seek to ensure that the lived experiences and cultural practices of individuals—their histories and their selves— are positioned as the means for successful participation in science learning, and not as barriers that must be overcome (Bang et al., 2013; Nasir et al., 2014).

The emerging field of "inclusive science communication" builds on this research in its calls for science communication to more intentionally design for people who do not already identify, and may not feel a sense of belonging, in science (Canfield et al., 2020; Massarani & Merzagora, 2014; Polk & Diver, 2020). This literature suggests that a sense of belonging can be promoted through a range of pedagogical tactics such as using asset-based framing, integrating everyday science practices and language into the engagement, and framing science around issues of interest and importance to the target audience (Canfield et al., 2020; Gunter et al., 2021). Our study brings the importance of belonging into tension with short-term, context-dependent interactions in which a sense of belonging may be ephemeral and tied to belonging in the moment itself (rather than to a disciplinary practice or social construct such as "Science"). Like Holland et al. (1998), we propose that such momentary, even serendipitous, experiences are important windows into spaces not typically traveled that can provide, over time and space, the social means for constructing interests and identities.

3.2 | Carnival and belonging in immersive storyworlds

As described by Bakhtin in *Rabelais and His World* (1968/1984; Bakhtin, 1984), *carnival* is a form of immersive storyworld that draws on theatrical techniques (such as costume, drama,

spectacle, comedy, and parody), and creates roles and routines that, for a day, are activated to upend power structures and provoke dialogue (Bevan et al., 2021). As with the more contemporary forms of immersive storyworlds described above, carnival is intensely physical: it is sensorially and emotionally saturated, with the embodied self as a central actor in the group narrative. In carnival, Robinson (2011, n.p.) notes:

> Everything (except arguably violence) is permitted. It occurs on the border between art and life, and is a kind of life shaped according to a pattern of play. It is usually marked by displays of excess and grotesqueness. It is a type of performance, but this performance is communal, with no boundary between performers and audience. It creates a situation in which diverse voices are heard and interact, breaking down conventions and enabling genuine dialogue. It creates the chance for a new perspective and a new order of things, by showing the relative nature of all that exists. ... On an affective level, it creates a particular intense feeling of immanence and unity—of being part of a historically immortal and uninterrupted process of becoming. It is a lived, bodily utopianism.

Atkinson (2011) has described carnival as an experience that leans into "that which is not yet," what Holland et al. (1998) would call "a figured world." In many ways, carnival represents proto-historical instantiations of participatory transmedia experiences. For example, carnival has dimensions of seriality, multimodality, and performativity. However, contemporary transmedia storyworlds are often described as deeply saturated across time and space as afforded in particular by digital technologies in ways that carnival and the immersive science program we describe here are not designed to offer. Where transmedia events are generally co-constructed by and for self-avowed fans or aficionados, the form of carnivalesque immersive storyworlds we describe here are more ephemeral, designed to waylay the person who bought a ticket to a music festival or a country fair, and thus may not be actively seeking to engage with science.

Bakhtinian theories of carnival have a rich history as a research lens. In addition to their use in understanding the contemporary festival and its position as an emancipatory space for learning and development (Anderton, 2018; Bennett & Woodward, 2016), as noted by Bevan et al., 2021, they have been used to study language learning in elementary classrooms (Iddings & McCafferty, 2007; Lensmire, 1994; Manyak, 2001), early childhood learning (Tallant, 2015), second language learning (Ahn, 2016), drama instruction (Tam, 2010), learning in museums (Jun & Lee, 2014), and science learning in the classroom (Roth et al., 2011). Scholars note how, within the play of carnival, participants take on roles, routines, and speech patterns that invert power structures (e.g., students playing the role of teacher) and allow for the development of hybrid positionalities with respect to the subject matter (e.g., language, science, and drama) that open up opportunities for learning (Iddings & McCafferty, 2007; Tam, 2018). Manyak (2001) reported how negotiating such role-playing created a sense of agency among students as they leveraged their experiences to reproduce official forms of authority (such as voicing the role of a teacher).

Importantly, in carnival, such roleplaying differs from that of traditional theater, as carnival makes no distinction between performer and audience. "Footlights would destroy a carnival. As the absence of footlights would destroy a theatrical performance," wrote Bakhtin (1984, p. 7). "Carnival is not a spectacle seen by the people; they live in it, and everyone participates because its very idea embraces all the people." Carnival is constructed through acts of participation and belonging. Some researchers have referred to this phenomenon as "living the carnival"

(Vigmo & Lantz-Andersson, 2014). In living the carnival, participants enter a figured world where, with irony or humor, they collectively challenge or even transgress social norms, often through embracing the grotesque, the blasphemous, or the obscene. In educational contexts, as described above, the grotesque is characterized by settings that are organized orthogonally to archetypal classrooms, where the context is deliberately ridiculous, chaotic, or perhaps unguided. Carnival is fully dialogic, emerging from social interactions that leverage diverse perspectives to construct the communal play and its meaning. Researchers argue that the dialogic nature of carnival creates opportunities for new ways of understanding, where participants, at an individual as well as a collective level, internalize, integrate, and relate new ideas and perspectives into their own evolving worldviews and understandings (Morson, 2004).

Through this Bakhtinian lens, the central conjecture of our study is that (1) the Guerilla Science storyworld—constituted by the theatrical roles, routines, props, and the central transgressive narrative conceit itself—creates an emotionally-saturated context that invites and scaffolds participation, where (2) participants' embodied selves and prior histories are positioned as resources for successful participation in roleplay within the storyworld, which in turn (3) enhances a sense of belonging in the storyworld that motivates and sustains ongoing participation and scientific conversation. These three dimensions of our central conjecture guide the coding and analysis reported below.

4 | STUDY SITE AND METHODS

Our study was undertaken through a research-practice partnership (RPP) co-led by two university-based researchers and two Guerilla Science program leaders, operating as teams in New York and in London. In each city, the program director led their local staff in the design and production of public engagement events using a range of formats including, in some cases, immersive storyworlds. They hired scientists or science communicators to serve as the presenters at these events. The US- or UK-based researcher led data collection at these events and activities. The RPP team together developed and refined the research questions, analyzed, and reviewed data, and collectively made meaning of the findings. All of the data collection took place in non-science specific settings such as music festivals, country fairs, nightclubs, and the like.

In this article, we report on one event, an immersive storyworld constructed around science related to food sustainability and insect agriculture staged at a country fair in the Hudson Valley in New York. This event was aimed at a broad cross-section of ages, including family groups, adult friend groups, and teen friend groups.

4.1 | The Entomophatron

In the summer of 2018, we observed Guerilla Science's *Entomophatron* at a country fair 90 minutes north of New York City. Each year, audience members—a mix of families, teens, and adults made up of local small town tradespeople and professionals, weekenders from New York City, and seasonal agricultural workers—come to the fair to see local livestock, ride roller coasters, hear country western music, and eat carnival fare like deep fried blooming onions, hot dogs, cotton candy, shaved ice, and the like. In 2018, in one corner of the fair they encountered a booth fitted out as a 1950s American diner, with a linoleum counter and four vinyl covered

stools (see Figure 3). Participants were often lured to the diner counter by an old fashioned popcorn maker that was producing free bags of popcorn, which they were then told had been seasoned with agave worm salt. Male and female wait staff, all wearing pink and black polka dotted dresses, following the Blondie comic strip motif, beckoned customers to sit down on a stool and take a look at the menu. The diner had three counter stools, but was able to accommodate crowds seated and standing of up to about 10.

The food at the *Entomophatron* was free, visitors were assured. A glance at the menu revealed descriptions of four different courses with enticing names; but the fine print revealed that each involved dried and roasted insects—crickets, mealworms, and ants (see Figure 4). These included, in the order listed: A blind taste test involving a cricket versus a bean nacho chip; the Bugtucky Derby, which was not a meal but a race between giant Madagascar Hissing Cockroaches; whole roasted mealworms; and The Chef's Surprise of "ants-on-a-log." Additionally, almost always participants were offered a roasted whole cricket, and frequently science

FIGURE 3 Guerilla Science's Entomophatron at a country fair

FIGURE 4 Menus with a live Madagascar Hissing Cockroach

communicators offered participants a palmful of roasted whole ants. Typically, the interactions between the waitress/waiter and the diner patrons moved from initial expressions of surprise or apprehension into questions and dialogue about food sustainability and the role of insect protein in the human diet, historically, culturally, and in the future.

4.2 | Data collection

A primary principle of our RPP was that the data collection would not disrupt the participant experience in the immersive storyworld. We, therefore, attached a handheld video camera and directional microphone to a corner of the diner booth. The camera was angled to pick up primarily hand gestures and dialogue; most people's faces were only partially visible in the recordings. When the diner was crowded, some participants were entirely off camera. A sign, graphically treated to fit within the aesthetic of the diner, was posted at the booth notifying participants that video was being recorded for a research study.

Over 3 days, we video-recorded a total of 48 social units (families, couples, and friend groups), involving a total of 134 individuals, participating in the activity. Each interaction, from when participants first came to the counter to when they walked away (which averaged almost 12 min [SD 7.8]), constitutes a "clip." When social units overlapped in time (e.g., two families sat at the counter at the same time) but did not interact with one another, we coded the same video data as separate clips. To identify clips that offered rich glimpses of the performative and dialogic nature of the experience (Derry et al., 2010), we initially coded the 48 clips for instances where: (1) An insect was ingested; (2) a participant expressed prior awareness of insects as a human food source; (3) a participant shared some aspect of themselves (diet, allergies, and prior experiences); (4) there was a verbal Q&A exchange between science communicator and participant; or (5) the science communicator shared factual information. When at least one person in a social unit met three or more of the initial criteria, we subjected those clips to secondary coding. The 31 clips we identified through this process were almost twice as long, on average, as those that did not meet our criteria for secondary coding. The 12 clips that we did not subject to secondary coding, and thus that are not included in the analysis discussed below, documented people observing and listening, but speaking little or not at all (as can be seen in Table 1), and often not eating an insect. Therefore, though they may or may not have listened with interest, and walked away with new insights or not, our non-intrusive data collection methods do not allow us to make any meaning of their participation.

The rest of this article refers only to the 31 clips we subjected to secondary coding. Although we did not collect any demographic data from participants, the 102 participants in the transcripts subjected to secondary coding appeared to be mostly in their 30s–60s, with just under one quarter appearing to be teens or children, and five individuals appearing to be in their 20s. They overwhelmingly presented as white, as is representative of the region. Participants appeared to be evenly split between female and male.

4.3 | Secondary data coding

The 31 clips, constituting a total of 363 video minutes, were transcribed into 31 Word documents. The research team combined a thematic content analysis of the transcripts with

TABLE 1 All data collected at country fair

				Number (and %) per interaction				
	Clips (social groups)	**Average duration**	**Number of participants**	**Ate insects**	**Shared prior awareness of insect farming**	**Shared info about self**	**Engaged in Q&A about science**	**Exchanged facts about science**
Extended interactions (subjected to secondary coding)	31 groups	0:11:45	102	29 (94%)	17 (35%)	15 (48%)	31 (68%)	23 (94%)
Limited interactions (primary coding only)	17 groups	0:06:28	40	11 (65%)	1 (6%)	1 (6%)	6 (24%)	4 (35%)

theorized constructs identified in the literature cited above to iteratively develop a list of tentative codes. Because our RPP involved a mixed team of researchers and practitioners engaged in collaborative analysis, it was important that our codes reflected both theoretical and practical perspectives about what constituted meaningful themes or constructs. As Xu and Zammit (2020) note, "Informed by grounded theory, codes can come from the data itself (inductive coding) as well as particular theoretical or epistemological positions (deductive coding; DeCuir-Gunby et al., 2011)." They note that this blend of inductive and deductive coding provides "a balanced, comprehensive view of the data, instead of purely relying on the frequency of codes decontextualized from their context" (p. 3). In our project, this process initially yielded four categories (theater/storyworld, emotional response, science ideas, and scientific epistemic practices). To address issues of trustworthiness (Lincoln & Guba, 1986), we standardized coding across the three coders by developing a codebook that included definitions and examples. Each transcript was coded by two coders. We reconciled questions and inconsistencies through discussion, achieving over time a shared understanding and agreement across coders. We then reviewed and consolidated the codes to create a new set of four top-level codes, with a total of 20 sub-codes and definitions (see Table 2).

Because faces and bodies were often off-screen, for reasons described above, we did not formally code for gestures. However, when the transcript contained words that could be interpreted in more than one way—such as "Really?" or "No, no, no," where these utterances could have been stated with either apprehension or humor—coders reviewed the video data to attend to vocal intonation, or facial or bodily expressions, to clarify meanings. This meant that we brought our own cultural perspectives to bear on recognizing and coding emotions, which limits the claims this study can make about the particular dynamics of emotion and engagement in the storyworld. Finally, as described in the next section, to address confirmability (Lincoln & Guba, 1986), or lack of researcher bias, we ran descriptive analytics of frequencies and patterns of codes. That is, each of the transcripts had several more or less dramatic aha-type moments that shaped our emerging understanding of the patterns among the constructs. Running the descriptive analytics allowed us to check the frequency of these patterns across all lines of the transcripts, including the much smaller moments in the interactions.

The sub-codes for Theater represent elements that could be leveraged to create and sustain the storyworld. For example, the central conceit, meaning the underlying fictitious premise, of the insect diner could be asserted verbally when a waitress asked people to come join them at the counter, or reasserted, in the course of an interaction, by the waiter making claims about "the culinary standards" of the establishment. A participant, playing the role of diner patron, could formally request the next item on the menu. Both wait staff and customers could use the menu as a prop for sustaining participation by offering or inquiring about an item on the menu. Routines were organized around stages in the menu, such as introducing a blind taste test or contrasting the nutritional value of gummy worms compared to mealworms. Both science communicators and participants could reassert their roles of waitress or customer to initiate new phases of conversation or participation.

The sub-codes for Emotion represent, broadly, the range of reactions to the Entomophatron experience evidenced in the video recordings. Sub-codes for Belonging, conceptualized as having a sense of acceptance, value, and respect (Goodenow, 1993), were evidenced in the ways in which participants participated at (a) an individual level, for example, by sharing aspects of

TABLE 2 Coding framework, top-level codes, second level sub-codes, and descriptions

Framework	Top level code		Second level	Description
Immersive Storyworld	Theater		Conceit	The idea of a diner (versus a festival booth)
			Prop	Using or referencing a diner prop (e.g., menu, diner counter)
			Role	Roleplaying as waiter, waitress, or customer
			Routine	Enacting parts of the "script," e.g., offering a menu; clearing a counter; proposing a "next course"
	Emotion	Positive	Delight	Expressing happiness, approval, or excitement
			Humor	Laughing or joking
		Negative	Apprehension	Expressing hesitation, fear, or discomfort
			Disgust	Expressing dislike or disapproval
Engagement with Science	Science	Practices	Investigating	Exploring materiality (taste, texture) of insects or asking factual questions about insect farming or consumption
			Sense making	Contrasting tastes and textures, sometimes relating to everyday (like pumpkin seed), or discussing environmental or other benefits of increasing insect consumption
			Critiquing	Considering competing explanations or conclusions and developing evidence-based understandings
		Ideas and facts	Environmental sustainability	Discussing the positive or otherwise benefits to the environment (air, water, land use, etc.) of insect diets
			Human food practices	Discussing human cultural practices of insect consumption, including FDA allowable amounts in processed foods
			Insect farming	Discussing the existence and details of raising insects for human consumption and details of edible insects
			Insect facts	Discussing specific facts about insects including nutrition, anatomy, etc.
			Scientific enterprise	Discussing features of how science is practiced, including the federal science agency's interest in studying [Edgy Science]
Participation	Belonging		Camaraderie	Expressing a sense of togetherness, including encouraging or teasing one another, and through double voicing
			Membership	Expressing being "in the know," one of "us" (insect connoisseurs)
			Prior experiences	Sharing prior understandings or experiences
			Self	Sharing personal likes, dislikes, or beliefs

themselves or their histories, and (b) a group level, for example through encouraging or daring one another in the shared activity at the diner.

Science codes include the nature of the topics of scientific conversation that emerged in the data, whether expressed by the science communicator or the participant, as well as the participant's practices of science as defined by McNeill et al. (2015) in their parsing of the nine science practices identified by the U.S. National Academy of Sciences (2012). We coded for investigation when participants (a) engaged in explorations of the materiality (taste, texture) of insects or (b) asked factual questions about the insects (e.g., edible insect production and preparation). We coded for scientific sense-making when participants (a) verbally contrasted or discussed tastes and textures, in other words made meaning of their embodied experiences at the counter, or (b) discussed the possible benefits of increased insect consumption in Western diets. We found no examples of scientific critiquing.

Because we were coding the nature of the interaction and conversation, where participants and science communicators all took on improvisational roles, we coded utterances by all parties. The purpose of our analysis is not to assign a particular valence to one side or the other but to understand the nature of the interaction as a jointly produced social interaction in the context of science. The vast majority (78%) of utterances coded as scientific facts or ideas were made, as would be expected, by the science communicator, whose role in "the play" was to introduce these ideas to participants. The majority (67%) of utterances or actions coded as scientific practices, when people were initiating an investigation or beginning the process of sense-making, were made by participants, in their roles as "diner customer."

4.4 | Frequencies and patterns

The central conjecture of our study is that the storyworld creates an aesthetically and emotionally saturated context that affords opportunities for belonging in the science-rich discursive setting that is the storyworld, which in turn can support sustained science conversations among participants and science communicators. To enhance trustworthiness (Lincoln & Guba, 1986), we explored whether this relationship among constructs occurred with any regularity. That is: When passages were coded as Theater, did passages coded as Emotion follow? When clips contained a large number of instances that were coded as Belonging, were there more utterances coded as Scientific Practices, Ideas, or Facts? Additionally, we conducted a statistical analysis of the codes to determine whether there were any patterns confirming or disconfirming our conjectures.

Across the 31 clips, there were 1402 coded utterances. We ran descriptive analytics of code frequencies, both in terms of numbers of instances and in terms of percentage of total conversation, within interactions and also analyzed by duration of interactions. We first conducted a correlation analysis across the 31 clips (using the Pearson product–moment correlation coefficient) and found there to be moderate to strong correlations between all instances of the codes (see Table 3).

To explore the relationship between codes within a given conversation, we considered the adjacent two-point correlation functions for successive entries; that is, instances where two

TABLE 3 Frequency of combination of codes across conversations

Code	Pearson coefficient
Belonging and Theater	0.75
Emotion and Belonging	0.73
Science and Belonging	0.71
Theater and Emotion	0.71
Emotion and Science	0.58
Science and Theater	0.55

Note: The Pearson correlation coefficients for the occurrence of the two codes are listed in column one, across the 31 separate conversations in our dataset. The first four coefficients listed here, varying between 0.71 and 0.75, indicate the associated codes are strongly correlated. The final two coefficients, 0.55 and 0.58, indicate the associated codes are moderately correlated.

particular codes appeared immediately next to each other in the transcripts within a single conversation. We analyzed the frequencies of each pairing, e.g., the number of instances in which Theater was followed by Emotion, and so forth (see column B in Table 4). One interpretation (but see Limitations section) of the correlated two-point codes is that the former code triggers the latter. That is, for example, if the presence of Theater and Emotion are frequently correlated, asserting Theater generally *triggers* Emotion; this is an assumption in the practitioner literature about how stories can engage science participation (Martinez-Conde & Macknik, 2017). For the four top-level codes, this led to 16 combinations, into which we sorted our 1402 data points, while retaining statistical significance. We were not able to analyze the data using the sub-codes, as the 4000 (20 times 20) different two-point combinations precluded our results being statistically significant.

Table 4 shows the results of this analysis. We found that in 13 of the 16 combinations there was a degree of correlation between adjacent codes that could not, at the $p < 0.05$ level, be explained by chance alone. The associated Chi-squared analysis supporting this, under two distinct interpretations, is shown in Table 4. Our results were robust, whether or not we assume that, in the first instance (column C), the presenter steers the conversation with a script, and in the second instance (column D) the conversation is more reciprocal and free flowing. In reality, as the excerpts below will show, the interactions were somewhere in the middle: Presenters typically followed a common sequence of activities and deployed variations of set roles, routines, and science ideas and facts that they introduced at key moments in the interactions, regardless of when these moments arose. (An example is at whatever time they introduced the taste test they referred to "specimen A and specimen B.")

We also segmented our results by conversation-duration using time windows of <5 minutes, 5–10 minutes, and >10 minutes to see how the length of the conversation related to its structure. We found no significant difference in the structure between these windows, except the unsurprising result that longer conversations contained more instances, but not a greater *percentage*, of certain codes. We found our results to be robust for other similar time windows. In the next section we provide a qualitative analysis of the patterns that emerged in this statistical analysis.

TABLE 4 Chi-squared analysis of correlated codes

(A) Pairing	(B) Number of adjacent two-point pairs	(C) Chi-squared contingent variables	(D) Chi-squared independent variables
Belonging, Belonging	109	0.924	0
Belonging, Emotion	63	0	0
Belonging, Science	152	0	0
Belonging, Storyworld	61	0	0
Emotion, Belonging	121	0	0
Emotion, Emotion	35	0	0.696
Emotion, Science	102	0	0
Emotion, Theater	39	0	0.792
Science, Belonging	156	0.002	0
Science, Emotion	92	0.007	0
Science, Science	169	0	0
Science, Theater	57	0	0.001
Theater, Belonging	48	0.855	0.083
Theater, Emotion	102	0	0
Theater, Science	51	0.534	0.026
Theater, Theater	14	0	0

Note: The table shows the Chi-squared test results to three significant figures for two-pair occurrences of codes (first column) under two analyses. The first analysis (see second column), shows the result of both codes appearing sequentially by chance as independent variables. The second analysis (see third column), shows the result of the second code appearing, given that the first has appeared, ie., they are contingent variables. Under an analysis in which we assume the audience is responding to prompting by the host, the latter analysis applies. Under an analysis in which we assume the audience and host are in unforced dialogue, the former analysis applies.

5 | STORYWORLDS AS A STRATEGY FOR SCIENCE COMMUNICATION

In this qualitative analysis we share excerpts from six clips that illustrate how storyworlds invite participation and afford opportunities for belonging which can support sustained science

conversations. We have selected excerpts that provide rich and also relatively parsimonious illustrations (see Derry et al., 2010) of the patterns that emerged in the quantitative analysis:

Clip 1. Ella and Omar. A 6-year-old girl and a boy of about 9, who do not appear to know one another; their caregivers hover in the background. They are attended to by Waiter Y, who is a professional actor.
Clip 2. John, Joanna, and Nancy. A male–female couple and their female friend, all appear to be in their 50s–60s. They are attended to by Waitress R, a professional actor, and Waitress M, a program manager.
Clip 3. Exterminator. A man who declares that he is a professional exterminator joins an existing group consisting of a woman and her son, and another woman who appears to be her friend. They are attended to by Waiter Y and Waiter T, a cricket farmer.
Clip 4. Manuel and Ernesto. Two males, both of whom work as chefs. The older male, in his 50s, is from Mexico, and the younger male, perhaps 30s, is from Ecuador. The older male translates for the younger male. They are attended to by Waiter T.
Clip 5. Greg and Lisa, Ted, and Mike. A couple, an older man, and a teenage boy find themselves at the counter, attended to by Waiter Y.
Clip 6. Roger and Father. A boy of about 13 and his father, seemingly in his 40s, join a cricket chip blind taste test already underway. They are attended to by Waiter Y.

5.1 | Storyworlds inviting and scaffolding participation

In this section we provide examples of how the theatrical elements of the storyworld—the central fictional conceit or premise, the roles, routines, and props—were leveraged to initiate and scaffold participation. By "routines" we mean the ways in which science communicators call on a number of activities or discursive assertions within an improvisational framework, in response to the moment. For example, the routine of the blind taste test is usually but not always offered first. A discussion of cricket farming often but not always ensues, and waiters typically share a set number of facts at these moments, sometimes more and sometimes less. In these examples, participants' emotional responses to the storyline—apprehension, disgust, bravado, and humor—are also highly salient. Our conjecture that the theatrical dimensions of the storyworld would create emotionally saturated contexts that invited participation was confirmed in our quantitative analysis which found that conversations in which Theater was asserted frequently were conversations in which Emotion was expressed frequently: The Pearson correlation coefficient $= 0.71$. Furthermore, we found that when a theatrical dimension of the storyworld was asserted there were 102 instances of emotions expressed immediately afterwards (47% of the time). A chi-squared test shows this result cannot be explained by chance at the $p < 0.05$ level.

In Clip 1A, the waiter is clearing the counter and putting away insect food items after the departure of a large crowd. A boy, about 9-years old, who we call Omar, had been hovering in the back of the large crowd for at least 10 min but has now made his way onto a stool at the counter. He is silently, patiently watching the waiter clean up when a 6-year-old girl, who we call Ella, clambers up to kneel on the diner stool and leans forward to see what is happening. She is accompanied by her mother and another woman with two children who do not come to the counter until later. The waiter acknowledges Ella's arrival and offers her a menu.

Clip 1A—Ella and Omar: Roles and Props		
5	Waiter Y	*[Addressing Ella, while clearing materials from the counter]* **Let me get that counter cleaned for you sweetheart. In the meantime, can I get you a menu? Here.** *[Hands menu to Ella]* **Why don't you check out what we have on the menu?**
6	Ella	*[Ella looks at menu; her mother's friend peers over her shoulder to read the menu]*
7	Ella	*[Says something unintelligible to the mother's friend, who walks away from booth and is seen in the background getting popcorn for two other children]*
8	Waiter Y	**Now we have a lot of options so if you want a suggestion just come to me. I've had everything on the menu. It's all good.**
9	Omar	**Can I have one?**
10	Waiter Y	**Can you have one?**
11	Omar	**Yep.**
12	Waiter Y	**Have one what?**
13	Omar	**A menu.**
14	Waiter Y	**A menu? Absolutely.**
15	Omar	**Thank you.**
16	Waiter Y	**Here you go. You're very welcome. Have you made a selection yet? What if I start you off with a little something, how does that sound?**

Clip 1A illustrates how the science communicator initiates the storyworld through repeatedly asserting his role as the waiter and the role of the participants as customers at the diner. The prop of the menu scaffolds the interaction, providing the young people a sense of the experience to come. In line 16, the waiter calls on one of his routines by suggesting he can start them on the menu, which will be the blind taste test of a bean and a cricket chip.

In asserting the storyworld, in many cases the initial invitation is met by reactions of playful horror, disgust, and a kind of morbid curiosity. In Clip 2A, a middle-aged male–female couple, who we call John and Joanna, and their female friend, who we call Nancy, are walking by the booth when they stop for popcorn. The waitress beckons them over to the counter.

Clip 2A—John, Joanna, and Nancy: Playful Humor		
1	Waitress R	**Join me!**
2	John	*[Wryly addressing companions as he walks to the counter]* **We're going to be eating insects and worms.**
3	Waitress R	**Join me at the counter. Grab a seat. We only serve the finest insects in town. Welcome to the Entomophatron.** *[John takes off glasses and picks up menu to read]* **Most people are comfortable starting out with a blind taste test. Chip versus chip. Can you tell me which one contains cricket powder?**
4	John	**These are really bugs?** *[laughs nervously]*
5	Waitress R	**Yes.**
6	John	**Eww, I don't know about that.** *[laughs]*
7	Joanna	**My name is not Andrew Zimmern!** *[laughs]*
8	Waitress R	**They're chips. So, insects actually contain a ton of protein.**

Clip 2A—John, Joanna, and Nancy: Playful Humor		
9	Joanna	*[Plays along]* **Alright.**
10	Waitress R	**Crickets are able to turn feed into protein 12 times more efficiently than cattle. So with the population growing we're going to be over 9 billion by 2050. We need different ways of feeding people. A quarter of the Earth's population already eats insects, and the United States and in the UK ... we're on the back end of this. A lot of times we have a hard time from visualizing. But do you think you'd be able to tell me which chip contains cricket powder?**
11	Joanna	**I'm going to guess it's A.** *[Points to a jar]*
12	Waitress R	**Well, you gotta taste them.**
13	Joanna	**Huh?**
14	Waitress R	**You have to taste them.**
15	John	**You gotta taste them.**

The hesitation of the participants is noted in lines 4–7, and also in line 13. In line 15 the male participant echoes the waitress by ironically reinforcing the rules of the diner. Initial disgust or dismay was common, but it was generally playful. In our analysis of whether initial expressions of disgust versus delight correlated more strongly with a choice to participate we found no notable difference, suggesting that the storyworld successfully scaffolded emotional reluctance into full participation.

Playfulness and laughter saturated most of the interactions, as can be seen in line 15 above and also in Clip 3. In the next example, a man who has shared that he is a professional exterminator has joined the counter, where a woman and her son (about 12 years old), and an adult female friend of hers, have been participating for about 5 minutes already. As he joins, he notes the male waiters' dresses and comments that clearly he is joining "a fancy party." The group at the counter has already completed the blind taste test and eaten a roasted cricket, and now Waiter Y offers a jar of mealworms.

Clip 3—Exterminator: Roles and Routines		
13	Waiter Y	**Now we're moving on to one of our most flavorful dishes ....**
14	Mother	*[Groans]* **Oh, God**
15	Waiter Y	*[Presents jar of worms]* **Mealworms!**
16	Female	*[Groans and leans back with laughter]* **Ooooh.**
17	Mother	*[Groans with laughter, son cringes and takes his mother's hand to cover his own mouth, mother turns to smile at son]* **Oh.**
18	Exterminator	**Yummy!** *[Group laughter]*
19	Waiter Y	**Mealworms are where it's at when it comes to flavor. Crickets might have them beat for protein, if I'm not correct, [Waiter T]?**
20	Waiter T	**Uh, I actually don't know. I know that they have higher fat in the mealworm—**
21	Waiter Y	**Mm hmm.**
22	Waiter T	**—so I would say that the crickets have to have a higher protein percentage.**

(Continues)

Clip 3—Exterminator: Roles and Routines		
23	Exterminator	*[Holds out his hand as if measuring a level]* **Cholesterol level?** *[Tips head quizzically]* **I might be concerned.**
24	Female	*[Turns to the exterminator and agrees, pointing at the jar]* **Yeah. I can't have that.**
25	Waiter Y	**Cholesterol level?**
26	Waiter T	**No, no, no, no. They have less than chicken.** *[Mother laughs]*
27	Waiter Y	**Well, what I would counter is this is the smallest steak you've ever eaten—** *[Group laughs while Exterminator gives a thumbs up in response]* **and so it might not have the largest impact on your body just to eat one. Yeah. Think of it as a ... we're just facilitating tiny tastes.**
28	Exterminator	*[Humorously]* **Well, that is "the thing" right now. Tiny foods.** *[Gestures with his fingers]*
29	Waiter Y	**Tiny foods. That's right. Again—**
30	Exterminator	**You're all ahead of—**
31	Waiter Y	**The more blank space on a plate, the more it costs.**

In this clip the exterminator plays the role of diner patron by, in line 23, asking questions about the cholesterol of mealworms as if he was considering food options. This provides an opportunity for solidarity when a woman at the counter, in line 24, humorously plays along with cholesterol being the reason not to eat the mealworm. The roles of the two participants create an improvisational opportunity for the waiters to share, in lines 19–26, information on protein and fat levels of mealworms and crickets as compared to other kinds of food. In line 27–30, both Waiter Y and the exterminator reaffirm one another's role in the storyworld by engaging in the pretense of the diner as a fine dining establishment.

5.1.1 | Analysis

A theater without footlights, the storyworld—the conceit, roles, routines, and props—create an opening for a wide range of individuals to enter into social interactions, in this case organized around science. Roles are available to participants from the age of 6, in Clip 1A, well into middle age, in Clips 2A and 3. Roles are not fixed in carnival, but fluid and improvisational, thus allowing each individual to contribute in their own way to the unfolding of the interaction, earning acceptance, value, and respect through the roles that they create and enact.

In joining others at the counter, participants committed to living the carnival, taking a leap into the grotesque by committing to the conceit of the diner and its menu of roasted insects. The grotesque provided opportunities for people to assume varied roles and positionality with respect to the storyline (groans of dismay or cries of "yummy!"), thus creating a space for individual agency and at the same time building the group's communal experience of the storyworld.

As with all carnival, the grotesque is also mildly transgressive which lends itself to forms of irony and humor as illustrated in Clips 2A and 3. Notably, the humorous aspects of the storyline are asserted both by the science communicators and the participants in their roles, as seen in both Clips 2A and 3. Humor is prevalent throughout the 31 clips, with laughter coded on average almost once a minute, with 326 laughs recorded in 363 minutes of clips. Laughter is the currency of carnival, and operates both to take authority down a peg (in this case the

authority of science as disembodied and elite) and to forge solidarity. In our analyses of the data, we find that both social groups and groups of strangers lean into the humor to take a deep breath and ingest items they had not planned on eating earlier in the day; thus, the intertwined nature of the grotesque and the humorous invite and sustain participation.

5.2 | Leveraging present selves and prior histories as resources for successful participation

The dialogic nature of roleplaying affords opportunities for belonging in the science-rich discourse space of the storyworld. In their roles as diner patrons, participants are able to assert their past experiences, their likes and dislikes, and their opinions in relation to the experience and conversation at the diner. There were 213 instances where participants shared prior experiences, understandings or otherwise shared some aspect of themselves, including dietary restrictions or food likes and dislikes. We also saw many instances of in-group-ness, which we coded as camaraderie or membership within the science-rich discourse space. Overall, there were 270 instances of statements or gestures that were coded as Camaraderie in terms of urging, approving, revoicing, or otherwise indicating belonging in the play of the storyworld. Such utterances or exchanges represent about 27% of the total number of coded exchanges, and they increased in number in the longer events. Our conjecture that the theatrical or carnivalesque dimensions of the storyworld would create opportunities for belonging in the scientific discourse that constituted the storyworld was confirmed in our quantitative analysis: we found that conversations in which Theater was asserted frequently were conversations in which Belonging was expressed frequently (Pearson correlation coefficient = 0.75). The number of adjacent two-point correlation instances, that is when an occurrence of Theater was immediately followed by a sense of belonging, was 48. However, this two-point correlation result does not pass the Chi-squared test at the 5% confidence level, suggesting that if the assertion of a storyworld does lead to a sense of belonging, our data do not suggest that it does so instantaneously.

In the next example we draw again from Clip 1, just over 10 minutes into Ella and Omar's experience at the diner, to illustrate how the two children leverage their roles as patrons at the diner to assert themselves and their likes and dislikes into the dialogue with the waiter. Ella's mother and friend, with two boys about 7-year-old, are also present at this stage in the clip. We omit a couple of lines of dialogue between the friend and her boys.

Clip 1B—Ella and Omar: Self		
114	Waiter Y	**...Now we're on the Chef's Surprise. We kind of moved straight to the end of the menu: "ants-on-a-log." Who thinks they'd like to try it? Now if you're allergic to peanuts this might not be for you. And by that, I mean it's not for you because you'll die.**
115	Ella	**I'm not. I'm not allergic to anything.**
116	Waiter Y	**You're not allergic to peanuts?**
119	Ella	**I don't like celery.**
121	Omar	**I'm allergic to nothing!**
122	Waiter Y	**You're allergic to nothing. Nothing can kill you.**

(Continues)

Clip 1B—Ella and Omar: Self		
123	Ella	**Me too!**
124	Waiter Y	**Alright. Well, if that's the case—**
125	Waiter Y	[*Acknowledges Ella's comment*]**—same as you? So if that's the case then the way we eat it is really simple. Just pick it up by the stick and you go—***[He eats a piece of celery with ants]*
126	Ella	*[Leans away apprehensively]* **Mmm....** *[Adult caregivers laugh]*
127	Waiter Y	**Mmm. Right?**
129	Ella	**No thanks.**
130	Ella's mother	**Ah, that's where she draws the line, huh?**
131	Waiter Y	**It's sweet and it's salty and it's and it's so—**
132	Omar	**I'm not afraid!**
133	Friend	**Oh, he's going for it.** *[All turn to watch Omar eat the ants-on-a-log]*
134	Waiter Y	**So, just like any kind of food, right? We like to eat some things and we don't like to eat others but remember when you were saying people don't eat bugs because they think they won't like it? But then you ate some bugs and they were tasty. So some bugs are good, some bugs maybe we don't like so much.**
135	Omar	*[Addressing Ella]* **You gotta taste the ants.**

Omar not only asserts his embodied self, when he says in line 121 that he is allergic to nothing, but as shown in line 132, he also asserts his emotional bravado in eating the ants. Ella too asserts herself in line 123 as having equal qualifications for belonging as does Omar. Later, in line 135, Omar turns to Ella to both encourage her and to communicate his own in-group membership in the insect diner culture.

Clip 4A offers a different view of how the storyworld supports roles and routines that afford belonging, as the diner creates a context for a man to share part of his cultural heritage with a younger colleague.

Clip 4A—Manuel and Ernesto: Prior Experience		
80	Manuel	**You know, back in my country ... it is a lot more insects but I never tried because I was young. I tried the most I can when I grew up.**
81	Waiter T	**Yeah.**
82	Manuel	**But you know I'm here. I'm old. And I remember and we actually—we ate the bugs like, you know, just toasted. In Oaxaca, yeah, you've been in Mexico?**
83	Waiter T	**I haven't been, I haven't been but I—**
84	Manuel	**So—Oaxaca they think they have so many variations—insects and—In the whole country I think the most is [in] Oaxaca. Part of the south, like I said—We have these little worms. And we have like a huge worm you know the maguey. You know? They are like a cactus kind of thing.**
85	Waiter T	**Yeah.**

Clip 4A—Manuel and Ernesto: Prior Experience		
86	Manuel	**Okay. They are inside the thing but they're like this big. They roast 'em up and they're so good. They're so good. It is big. This is like—***[Illustrates by making small shape with hand. Ernesto laughs.]*
87	Waiter T	**Tiny.**
88	Manuel	**No, I want him** *[motions towards Ernesto]* **to try, because I know. Because I used to try, you know? I used to just to pick it alive, put it in the** *[unintelligible]***, toast 'em up a little bit and go like** *[makes sound and motions with hand]* **they go straight and grind them up and make tortilla, you know, some salsa and** *[makes sound and motions like eating]***—some peppers. Protein is, like, I don't think many people know how much protein they have, you know? Like, really this is—**
89	Waiter T	**Yeah. So dense in protein.**
90	Manuel	**Yes.**
91	Waiter T	**So dense in omega 3 s each one.**

In Clip 4A, Manuel expresses a sense of belonging (acceptance, value, respect) at the insect diner, and in the science-rich discursive space it constitutes, by repeatedly sharing his knowledge and experience of a wide variety of insects and their culinary properties. He also references his homeland in Oaxaca and shares, in line 88, his intention of educating his colleague about these valued cultural and culinary practices. Throughout, Manuel asserts his knowledge as valuable to the science communicator and in the process, which intertwines the nostalgic and also instructive stories from his personal life with his professional expertise as a chef, establishes a sense of belonging in the dialogue.

In Clip 1C we return to Ella and Omar to illustrate how group membership in the discourse space has evolved. A young boy, who we call James, of about the same age as Omar has been watching from the side for just over a minute, but rejects an invitation to try the ants-on-a-log (see Figure 5). Soon James is joined by his father and brother. The father is interested in the insects, and, at first, when his father examines a piece of the ants-on-a-log, James chants "Eat-it, Eat-it, Eat-it" and then lifts his arms in victory when his father eats the ants and shouts "Yay!" But this attitude soon changes as the interaction continues below.

Clip 1C. Ella and Omar: Membership		
169	Ella	**I love the popcorn.** *[Eating agave worm popcorn and addressing the waiter]*
170	Waiter Y	**You love the popcorn?**
171	Father	*[to Son2]* **You should try it.**
172	Waiter Y	*[Addressing Ella]* **Then have some more popcorn.** *[Waiter Y pours more popcorn in front of Ella who laughs in delight and begins to eat the popcorn.]*
173	Son2	**Ooh, I want some popcorn.**
174	Waiter Y	**One to one ratio right there.** *[Addressing James and his brother]* **Do you want to try some of this popcorn? It's got agave worm on it**. *[Omar peers at James to see his reaction]*

(Continues)

Clip 1C. Ella and Omar: Membership		
175	Ella	**Have it, have it.** *[Holding out some popcorn to her mother]*
176	Ella's mother	*[to Ella]* **I know. You're eating worms today.**
177	James	**Disgusting.**
178	Waiter Y	**Disgusting?**
179	Omar	*[to James, argumentatively]* **It tastes really good!**
180	Waiter Y	*[Pours more popcorn in front of Omar, who eats the popcorn.]* **Tasty, yeah! Our young friend here knows the trick.**
181	Father	*[Addressing Son2]* **Do you know what that is? The black thing in my teeth? What is it?**
182	Waiter Y	*[Addressing the father]* **Sir, if you'd like to get a more direct experience of that ant flavor I can give you a little palm full and you can pop em.** *[Father puts out hand for ants. Waiter Y shakes some ants into his palm.]*
183	James	**Oh no! Papa, don't do it!** *[Tries to push his father's outstretched palm away]* **No, Papa!**
184	Waiter Y	**That's the real way to know what it tastes like. Oh, it's delicious. He's gonna love it.**
185	Father	**I'm just trying to understand it.** [*Peering into his palm]* **Eww.**
186	James	**Don't eat it!**
187	Omar	**Do it!**
188	Ella and Omar	*[In unison Ella and Omar chanting]* **Eat-it! Eat-it! Eat-it! Eat-it!**
189	James	**Papa! Don't eat the ants!**
190	Father	**Let me make sure the peanut butter's** *[unintelligible]*
191	Waiter Y	*[Referring facetiously to James]* **Oh, he's right. Don't eat it. It's full of nutrition and delicious flavor. Oh, wait! That means "Eat it"! Right?**
192	James	**No it doesn't! Bugs are disgusting!**
193	Waiter Y	**I got confused. I got confused. You were saying don't. But there's no reason not to.**
194	James	**Bugs are disgusting**.
195	Son2	*[Son2 sits on a stool between Ella and Omar]* **I don't want to eat. I just want to see.**
196	James	**They taste terrible!**
197	Omar	**Your appetite is disgusting!**
198	Waiter Y	**Have you ever eaten bugs?**
199	James	**Yes! I've eaten a worm.**
200	Ella	*[Offers popcorn to James]* **Try this. Try the popcorn.**
201	Waiter Y	**You've eaten a worm? Well, did you know that there's over 1900 kinds of edible bugs? And that's way more than you can count. So you ate one bug and you're trying to say all bugs are gross?**

The excerpt in Clip 1C illustrates how the emotional context created by the storyworld is saturated with risk, fear, disgust, bravado, and delight creating varied opportunities for

belonging in the science-rich discourse space. In this example, James both expresses his disgust with his father eating ants and reveals, in line 199, that he himself has previously eaten a worm. The camaraderie expressed by Ella and Omar, in the chanting they do in line 188, echoing the chanting James had done earlier, suggests a feeling of in-group or membership within the storyworld. Ella also asserts membership in line 175 when she tries to get her mother to try the agave worm salted popcorn. Omar asserts membership in lines 179, 187, and even 197 when he scorns James's rejection of the value of eating insects. In line 200 Ella seeks to include James in the storyworld "cast of actors" by offering him popcorn.

In Clip 2B, John, Joanna, and their friend Nancy engage in various scientific sense-making activities, related to appraising and responding to the insects, while referencing their personal experiences in an ironic manner. The excerpt starts with the waitress putting away the prop of a jar of gummy worms that the science communicators commonly present as a comparative way of introducing the nutritional value of mealworms.

Clip 2B—John, Joanna, and Nancy: Camaraderie		
107	Waitress R	*[Puts away gummy worms and presents mealworms]* **Well, we only serve the finest product here. So we don't serve these** *[gummy worms]* **here. They're disgusting. What we do have or serve ...roasted mealworms.** *[Places jar of mealworms on counter. Nancy doubles over and draws back, laughing.]*
108	Nancy	*[Grimaces]* **I don't know about that.**
109	John	**Eww**. *[laughs]*
110	Waitress R	**So these have the same texture as the crickets because they are roasted. But it's not as much because they're smaller.**
111	Nancy	*[Side conversation to Joanna]* **This popcorn is good.**
112	Joanna	**It's really good.**
113	Waitress R	**This has a—***[Stops to acknowledge the side conversation]* **I love that.**
114	Joanna	**That is good.**
115	Waitress R	*[Continuing with her routine]* **These have more of a nutty taste to them. They have a better flavor than the cricket.**
116	Nancy	*[Puts out hand to waitress to receive worm; looks at man]* **Come on, John.**
117	John	**I'll try one.** *[Puts out his hand]*
118	Joanna	**Oooh**. *[Apprehensive; puts out her hand to receive mealworm]*
119	Nancy	**I'm not even gonna look at 'em. I'm just gonna ...**
120	John	**Don't even look.** *[Pops it into his mouth. Joanna continues to look at the mealworm in her palm.]*
121	Waitress R	**Just crunch 'em.**
122	Nancy	**Do you want another picture?** *[holding worm to mouth, talking to Waitress M, laughs]*
123	Waitress M	**Sure. Hold on. Thank you.** *[Takes photo. Nancy eats mealworm]*
124	Joanna	**These look like the things that dry up in the basement. Like sometimes in the family room. And I pick 'em up and throw 'em out.**
125	John	**Now you can eat 'em.** *[All three eat mealworms.]*

(Continues)

Clip 2B—John, Joanna, and Nancy: Camaraderie		
126	Waitress M	**An important thing to know is that we didn't just find these bugs. These are FDA certified food grade insects. They were raised to be—**
127	John	**But I know after this I'm going to need a beer.** *[Laughs]*
128	Nancy	**I'm gonna go on a bug diet.**

In Clip 2B, the excerpt shows how individuals expressed in-groupness through forms of camaraderie. In lines 108–109, two participants in the triad voice shared apprehension. In lines 111–112, the two female participants agree that the agave worm salt popcorn is good, and the waitress, in line 113, agrees, sanctioning a shared experience. In line 116, Nancy, the friend, urges John to take the plunge and eat the mealworm. Joanna reluctantly joins in, line 118. In line 122, Nancy mugs for another one of the science communicators who is taking pictures of the event. In lines 124–125, the married couple makes a joke about dead insects they see in their basement. In this context, the science communicator is able to share the idea that mealworms are raised for human consumption—that there is an agricultural enterprise around insect production.

5.2.1 | Analysis

The improvisational roles provided by carnival afford participants' selves and lived experiences becoming valued parts of the storyline and dialogue. In this way carnival leverages the intellectual, emotional, and cultural resources of the participant in the context of, in this case, science conversations. In Clip 4A, Manuel's boyhood memories both motivate his participation and become the basis for conversation with the waiter. His personal history as a chef allows him to leverage his professional dispositions and interests to extend the dialogue into issues of insects as food beyond the framework of what is provided in the current storyworld. The storyworld thus rewards him for what he brings to the engagement and further rewards him by expanding his knowledge base. In a different way, Ella and Omar are able to leverage their respective lack of allergies as a sign of being "up to" the role and storyworld. The waiter invites them to share their likes and dislikes as legitimate parts of the story and interaction. These moments are small and yet represent dimensions of asset-based or culturally responsive communication strategies that can support belonging within the science-rich discourse space that is the storyworld of the Entomophatron.

In these accounts we also see the dialectic of individual and group participation in the storyworld emerging. Across the diversity of experiences and backgrounds found in Clips 1C and 2B emerges a strong sense of camaraderie and group membership expressed, in Clip 1C, as opposition to a resistant member of the science-rich storyworld and, in Clip 2B, as a bonding experience among friends urging one another to be brave. In living the carnival, belonging in the storyworld differs from the engaged but passive feelings of solidarity that an audience at a comedy show or stage play might have, but rather lends itself to more agentive feelings of solidarity, knowing that the group itself can shape what unfolds.

In this way carnival assigns agency to participants. At the Entomophatron, agency exists not only in the roles people take on, with respect to self and in relation to other, and in the power to shape the conversation based on their own experiences and interests, but also in their position as authority and arbiter of the investigation itself (Anderton, 2011). The carnival does not take place without their embodied role and response to the investigation (the blind taste test or

FIGURE 5 Images of ants on a log

any of the other meals). In the context of science, the physical and embodied nature of carnival operates to challenge or equalize authority, in this case between science communicator and participant, shifting what might be an otherwise technical and one-way conversation about insect agriculture, recounted by experts to the public, to a physical, lived experience emanating from participants themselves. In this way, carnival not only invites and includes but centers the active contributions (the acts, the ideas) of the participants.

5.3 | Belonging as a motivator of sustained participation in science engagements

Our statistical analysis of the frequency of codes found that the more time participants spent at the counter the more science ideas and practices were engaged. We found that across the

31 clips, the percentages of codes were fairly consistent, with a mean of 37% (SD 0.11) of coded activities relating to science. However, the number of science coded exchanges was substantially higher for longer events, although the relative proportion of the conversation coded science remained fairly constant: 37%, 41%, and 34% in the long (>10 minutes), medium (5–10 minutes), and short (<5 minutes) conversations, respectively. Put simply: with more time, there were many more moments coded as scientific ideas or practices.

Our conjecture that developing a sense of belonging in a science-rich discursive space, afforded by the storyworld, would sustain participation and thereby contribute to increasing opportunities for science conversations was born out by our quantitative analysis, where we found that conversations in which Belonging was asserted frequently were conversations in which Science was expressed frequently: The Pearson correlation coefficient = 0.71. We found 156 and 152 instances respectively of utterances coded as Science being immediately followed by, and proceeding, utterances coded as Belonging. This corresponded to instances of Science being followed by Belonging 32% of the time, and instances of Belonging being followed by Science, 39%. Both of these results cannot be explained by chance at the $p < 0.05$ confidence level.

We analyzed the nature of the factual or conceptual exchanges that occurred across the different courses. The main science concepts described or discussed included: (1) the overall enterprise of farming insects for human consumption, including tastes or reactions to the taste; (2) the long-standing human practices of consuming insects either intentionally as a valued part of the diet, or unintentionally in terms of the FDA approval of specific amounts of insect content in human foodstuffs; (3) the efficiencies and sustainability effects of increasing insect consumption in the human diet; (4) facts about insects, such as their names, behaviors, and nutritional properties; and (5) features of science as an enterprise, such as taste tests, data points, the National Science Foundation's interest in supporting the Entomophatron study, and so on. By far, the majority of the science idea exchanges (41%) focused on insect facts and nutritional features. The next most common (28%) were exchanges about the enterprise of insect farming; and then (16%) discussions about historical and contemporary human practices of eating insects. There were no discernible patterns about the distribution of the conversational foci and the duration of the events.

In this section we illustrate how conversations developed to address a range of scientific ideas. Clip 5 excerpts a 23-minute interaction, illustrating how the storyworld created opportunities for individuals to ask and respond to questions. At the counter are a couple in their 30s, Greg and Lisa, a man in his 50s, Ted, and a teenager who we call Mike; Mike and Ted each arrived independently and alone to the counter. In this case, a factual question about the agave worm salted popcorn from Greg leads to a conversation in which both Lisa and Mike make observations that lead into a discussion of human cultural practices with respect to eating insects.

Clip 5—Greg and Lisa: Diverse Perspectives		
86	Greg	**What's the salt to a worm kind of ratio?**
87	Waiter Y	**That my friend—**
88	Ted	*[Referencing an earlier question from Greg]* **He likes his ratios.**
89	Waiter Y	**Okay, he likes his ratios, which is good. I've got a whole stack of ratios in the list for you once we get to crickets.**

Clip 5—Greg and Lisa: Diverse Perspectives		
90	Greg	**Really?**
91	Waiter Y	**Yeah.**
92	Greg	**Good. I like my numbers.**
93	Waiter Y	**You want to have a conversation about food efficiency? Cool, let's do it. Let's talk "food efficiency."**
94	Greg	**I don't know where to start but you tell me and I'll ask questions.**
95	Waiter Y	**Start with meat. So cricket and a cow. A cricket is 12 times more feed efficient than a cow. So with a twelfth of the feed you're producing the same amount of protein.**
96	Greg	**Okay.**
97	Ted	**Makes sense.**
98	Waiter Y	**A cricket and a cow: when you compare them with water it's even better. A cow for a pound of beef: we're looking at about 2000 gallons of water. For a pound of cricket we're looking at a gallon.**
99	Greg	**Okay.**
100	Waiter Y	**Think about land usage now. You can pack an enormous amount of crickets into a small space. And not only is it possible, it's beneficial. Because crickets *like* to live all pressed up together. Confined, controlled, consistent spaces. Sort of the dream of agriculture.**
101	Greg	**Um-hmm** *[yes]*
102	Waiter Y	**And it's a recipe for good care** *[unintelligible 0:06:25.1]***. Especially crickets. You don't have the methane emissions. And you can feed them from the waste. You can take organic waste that we normally wouldn't have a use for. You got produce. You got byproducts of other processes. And you can feed insects that.**
103	Greg	**Okay, yeah.**
104	Waiter Y	**And so you can be generating crazy amounts of protein on free or reduced costs. Now in a smaller space of land and fast turnaround.**
105	Greg	**So basically it sounds to me there's a marketing issue now. But once there's a point where the cost issue, because of the** *[unintelligible 0:07:02.5]* **labor intensive, the cost on a pound for pound thing is going to be much lower than beef or pork. So it will be more market efficient at that point so how is that—**
106	Lisa	**It sounds like, sorry to interrupt you, but it sounds like the only problem is... Is that no one's done it before. But that's also a good thing too because no one's done it before so you guys are doing it first.**
107	Mike	**Aren't there societies out around the world that actually do have** *[unintelligible]* **for insects?**
108	Waiter Y	**Yes. So he's right. Actually [almost 25%] of the world's cultures are eating bugs. 2 billion human beings. That's one in four human beings. So it's not necessarily that it hasn't been done before but it certainly hasn't been done widely in the United States. I think you're kind of hitting on a really interesting question, which is two things are going to happen over time. Eating bugs is going to become more accepted in the United States and it's going to become much cheaper. The question is in what sequence of order will they happen?**

The diverse perspectives in Clip 5 collectively construct the science conversation that starts with facts about insect production and moves on to social issues about marketing human consumption of insects which leads to a reflection that many humans already eat insects.

In Clip 6, a man and his son, who we call Roger, walk up to the counter and are immediately asked to join the blind taste test of the cricket chip. After an initial expression of apprehension, the boy carefully participates in the investigation in a particular way—by choosing to smell the chip first—which provides an opportunity for the waiter to expound on scientific approaches to sense-making.

Clip 6—Roger: Hybridization		
1	Waiter Y	*[Addressing the boy and father]* **We're in the middle of a blind taste test so your timing is very good**!
2	Roger	*[Apprehensively]* **Oh, no**. *[Father laughs]*
3	Waiter Y	**So here's**—*[Places a chip on a napkin in front of Roger]*
4	Female Bystander	*[Encouraging Roger]* **They're very good. They're very good**.
5	Waiter Y	**I know what you're thinking: "Blind taste test: That means one of these chips doesn't have bugs in it. What a waste of my time." But, it's for science! So, if you'll permit me, we'll start with kind of a 50/50 bug.**
6	Roger	*[Notices live Madagascar Hissing Cockroaches in tube on side of booth and points]* **Oh there's—**
7	Waiter Y	**Yeah, those are all fourth place winners** *[of a cockroach race they ran each day]*. **Those ribbons? You can't just take those. So, I'm going to give you each one of specimen A and one of specimen B. One of these chips has cricket flour in it. One of them is just a normal tortilla chip.**
8	Father	[*Unintelligible*] **Oh, I just ate them ants out there so—**
9	Roger	*[Ironically]* **So the cricket flour isn't that bad** *[Picks up the chip]*.
10	Waiter Y	**Hold on. Hold on. I'm going to give you both** [Specimen A and B] **because I want you to really have the chance to compare and contrast.**
11	Roger	**I'm going to smell them** *[Leans over to put nose on chips in front of him]*
12	Father	**Yes.**
13	Waiter Y	**You gotta smell them! Exactly! Right?**
14	Roger	**I feel like that one has the insect flour in it.**
15	Waiter Y	**In science, we're all about data points. And so, if you taste it, that's a data point. If you look at it, that's a data point. If you smell it, that's another data point.**
16	Roger	**Yeah.**
17	Waiter	**Alright. There you go. Specimen A, specimen B—which one's got bugs? It's time to see.** *[Father and boy pick up chips. Boy smells the chip and then pops it into his mouth.]*

Clip 6 illustrates how the science communicator is able to accept, value, and respect (lines 13 and 15) Roger's approach to investigating the chips. This acknowledgement serves both to welcome the boy and his father to the group process already underway, and also

shifts a power dynamic by positioning the boy as having insights into the scientific process of gathering "data points." This in turn allows the science communicator (in lines 5, 10, and 13–15) to expand his waiter role to that of a person speaking for science. His representation of what constitutes an appropriate way to investigate is both serious (line 15) and humorous (line 5).

In Clip 4B, Manuel and Ernesto discuss ants with the waiter, however in this case it is Manuel who is sharing his understanding of insects and human food consumption.

Clip 4B—Manuel and Ernesto: Science Investigations and Facts		
34	Waiter T	**Here we go, yes. So I have inside of this** … *[Men lean in as waiter shows insect]* **This is a little black ant.**
35	Manuel	**Okay.**
36	Waiter T	**And if you want to try it; it makes a formic acid as a defense mechanism.** *[Men speak to one another in Spanish]* **So it basically makes itself zesty and delicious so that it won't be eaten. I don't think that works so good. But you have to tell me. I think this is a great ingredient.**
37	Manuel	**I eat ant eggs before.**
38	Waiter T	**Yeah?**
39	Manuel	**So I never eat the ants actually but I eat—back in my country I eat the eggs. The larvas** [sic].
40	Waiter T	**Yes, ant eggs.**
41	Manuel	**Ant larvas** [sic].
42	Waiter T	**Are you sure it's not termites?**
43	Manuel	**No, no, no, no.**
44	Waiter T	**It's ant eggs?**
45	Manuel	**People go into the hole and get the ants and just grab the, you know, the nest and they just peel off the—and they just eat the larvas.**
46	Waiter T	**Yeah, I think they're great to eat.**
47	Manuel	**They are good to eat, you know, that's—I've never eaten one I want to try it.**
48		*[Ernesto laughs as Manuel eats ants. Ernesto asks Manuel a question in Spanish. Manuel is tasting the ant. Ernesto takes one and chews it carefully, while Manuel watches him. Ernesto takes a picture of ants then eats more ants]*
49	Waiter T	**Like a sour—Interesting for sure.**
50	Manuel	*[Speaks to Ernesto in Spanish and then addresses Waiter T]* **Limon. Like a little bit something lemon–lime.**
51	Waiter T	**Yeah.**
52	Manuel	**You know, like zesty flavor.**
53	Waiter T	**Yeah, I'd love to have that like ground up and distilled a little bit more.**
54	Manuel	**So this is—this is all—that's it, right? You guys don't put anything on it you just—**
55	Waiter T	**No lime, no salt, no nothing.**
56	Manuel	**Okay. So that's the natural flavor [of] the insect?**
57	Waiter T	**Yeah.**

5.3.1 | Analysis

Carnival leverages diverse perspectives, where the play without footlights provides space for a wide range of lived experiences to contribute to the storyworld. Clip 5 captures a moment when a couple and two other strangers not known to them find themselves at the counter in dialogue with Waiter Y. Greg, who "loves his ratios," finds his way into the conversation about insect food by asking about ratios of salt to agave worm in the popcorn. Lisa, his partner, is able to reflect on the social enterprise of farming crickets, praising the waiter for being on the leading edge of a new business, whereas the teen, Mike, contributes his understanding of other cultures' practices of eating insects into the conversation. All thus stake out a legitimate position in the five-way discourse about insects as human food. Diversity of perspectives, as part of the storyworld, enhances the communal experience and in science communication it opens up opportunities for enriching the science conversation in ways that might not be possible without the group buy-in to living the carnival.

In addition to bringing diverse voices to the conversation, these clips illustrate how hybrid forms of discourse and interaction are forged while participants and presenters interact in the play. For example, in Clip 6, lines 13–15, Waiter Y takes on the positionality of Roger by underscoring the importance of smelling the chips as a data gathering activity. In Clip 5, he riffs off of Greg's focus on numerical facts to present new information. By leveraging the improvisational, the play allows for forms of multivocality that can challenge traditional power structures, for example with the waiter voicing the ideas of the child/customer or following Greg's meaning-making approach. In carnival, these hybrid acts operate to forge greater sense of solidarity—in opposition to the traditional forms of authority (Iddings & McCafferty, 2007; Manyak, 2001; Tam, 2018).

Conversation in our data consists largely of factual questions and answers, as well as explanations. However, at the heart of the conversations, we suggest, is a form of scientific investigation and meaning-making that reflects more everyday conceptions of science as well as personal and group processes of social meaning-making. Clip 4B shares what scientific investigation and sense-making might look like within a storyworld. In this case it involved the exploration, consideration, and discussion of a particular insect item in the context of the larger enterprise of insect food as a broader human cultural practice. In line 36 the waiter previews the purpose and experience of eating the ant. In lines 37–47, Manuel shares both his personal history and knowledge about ants as food. In line 48 he carefully chews the ant, exploring the materiality of the insect, which, in lines 49–52, he describes to the waiter. This is followed by more of a discussion about how the ants are prepared (lines 53–57), reflecting dimensions of the everyday science practices associated with food preparation. Throughout Clip 4, Manuel and the waiter equally share their knowledge and insights about insects as food, disrupting common power dynamics in science communication where the professional communicator is the source of scientific information and the participant is a recipient.

6 | CONCLUSION: IMMERSIVE STORYWORLDS AS CONTEXTS FOR BELONGING IN AND WITH SCIENCE

Our study sought to investigate, in unobtrusive ways, if and how an immersive storyworld engaged the public with science. We did not seek to substantiate a causal relationship between what participants knew or thought before and after they engaged in the storyworld, but rather

to theorize and document if and how immersive storyworlds engaged them and thus potentially constituted a productive science experience within the local science learning ecology. The "how" aspects of our study—theorized and empirical instantiations of a Bakhtinian conceptualization of carnival—have provided language and framing for the program leaders that they are able to leverage while discussing their work with other colleagues and funders. In this conclusion we reflect on the insights we gained and possible implications for both research and practice.

6.1 | Methodological approach and implications

Our data collection methods were designed to document and make sense of transient and fluid science communication events in ways that did not disrupt the experience for either the participants or the science communicators. The commitment to study and learn together, while not interrupting the creative fiction of the storyworld designed by Guerilla Science staff, was crucial to the success of our research-practice partnership.

Our iterative thematic analysis, generating both theorized and grounded coding schemes, was also important to our collaborative work in the research–practice partnership (Xu & Zammit, 2020). Practitioners brought particular values to their analysis—such as the importance of humor and camaraderie in the participant experience—that led us to call out Belonging more forcefully as a top-level theme in the second iteration of the codebook, identifying the four different ways belonging was manifested in the data (see Table 2), rather than a single indicator for Emotion, as it was in the first iteration of coding. This reframing of the themes enriched our joint conceptualization of the relationships among the constructs, and the nuanced ways belonging was instantiated in the data.

Additionally our use of both qualitative discourse analysis and quantitative frequency coding was done to enhance the trustworthiness of our observations and claims. While such a blend of methods may not always be called for, in our research-practice partnership it was important for double-checking our understanding of the patterns that were emerging, especially due to our diverse professional backgrounds and training. That the patterns or correlations of themes were confirmed in the frequencies increased our confidence in our analysis. In the future, this approach would benefit from working with a larger data set to allow a finer grain analysis, including correlations of sub-codes, that might support greater insights and stronger claims.

6.2 | Theoretical approach and implications

To answer our research questions about how short-term immersive storyworlds operate to attract and engage non-science seeking public audiences in science conversations, including how they afford opportunities for participants to see science in relationship to themselves, to "belong" in and with science, we drew on Bakhtin's conceptualization of carnival as a temporal, communal experience, saturated aesthetically and emotionally, where performative role-playing allows opportunities for new stances and understanding; in this case with respect to science. A Bakhtinian lens on the power and potential of immersive storyworlds is, we argue, particularly well-suited for the improvisational, analog, and typically unique (one-time) experiences that science communication efforts often design for engaging non-science seeking public audiences. This is in large part because "living the carnival" requires people to draw on their own lived experiences, positioning these personal resources as the very means for participation.

The theoretical conjectures guiding this study, which emerged from the theory of action held by the program leaders participating in the RPP, suggested, first, that the aesthetic and emotionally saturated theatricality of the storyworld would invite and sustain (scaffold) participation of people who may not otherwise seek out science experiences. In other words, there is a commonsense (but untested) assumption that if the country fair had a lecture on insect agriculture it might have attracted a very different crowd. In this case people were attracted to the science experience by the spectacle and engaged by the grotesque humor. Second, that storyworld would operate to create a sense of belonging in a science-rich discourse space, through its proffer of many different roles or entry points, all of which depend on participants activating their own prior lived experience to generate dialogue, to react, and to contribute. Third, that the sense of belonging in that science-rich discourse space would sustain participation and lead to increased and deepening science conversations and practices. Below we review elements of the storyworld that both our quantitative and qualitative analyses suggest may be at play.

6.2.1 | Theatricality

At the Entomophatron, the storyworld provided both roles and routines that operated to initiate unexpected or even unlikely interactions. Participants, who might have at first been attracted by a popcorn maker or a crowd at a booth, found themselves some minutes later, agreeing to eat a roasted cricket, and engaged in a conversation about the human cultural practices of eating insects and sustainable agriculture. They had entered a figured world (Holland et al., 1998). The improvisational uptake or adaptation of roles, routines, and props were important for sustaining engagement and for "leaning into that which is not yet" (Atkinson, 2011). After overcoming the initial barrier of eating a cricket chip, a natural stopping point, participation in the interaction was frequently continued through the science communicator's reversion to their role as waitress and the next stage of the routine: for example, referencing the menu, wiping down the counter, or offering to move on to the "dessert" course.

As referenced by Robinson (2011), the theatricality of the experience heightened emotional engagement. Genuine surprise, disgust, or delight characterized encounters with the grotesque. Bravado and laughter were also present throughout. Humor, which was baked into the theatricality of the retro diner and the male and female waitstaff in Blondie type dresses, helped to encourage and scaffold participation—to take risks and to relieve tension, as shown in Clips 3 and 4A. In short, the theatricality of the immersive storyworld appears to stimulate curiosity and delight, and invites participation and a sense of emotional engagement that research suggests may be a powerful tool for engaging people with the subject matter, in this case with science (e.g., Iddings & McCafferty, 2007; Manyak, 2001). These data expand accounts of how humor and emotion can make science accessible and appealing, in this case demonstrating how a carnivalesque approach positions participants as active agents in producing (and not just responding to) the science experience and in sustaining the science engagement.

6.2.2 | Belonging

As the excerpts show, the science communicators at the Entomophatron were active and quick in inviting and welcoming passers-by to come to the diner, reflecting Walton and Brady's (2017) assertion that small social cues indicating that a person "fits in" must happen early to optimize

opportunities for "belonging." Waiters called out to invite passers-by (as seen in Clip 2A), they cleared the counter and handed a menu to those who sat down at the diner (as seen in Clips 1A and 6), they welcomed people by diving into positioning participants in their roles as needing to decide between Specimen A and B in the cricket chip taste test (as in Clips 2A and 6). In "living the carnival" (Vigmo & Lantz-Andersson, 2014), there were many opportunities for participants to share aspects of themselves relevant to the science communication experience—their likes and dislikes, their allergies and their understanding of sustainable agriculture, enhancing their positionality as important "to the play" (Finn, 1989). These moments of self-assertion, or bringing themselves and their lived experiences into relationship with the science and the storyworld itself, helped to build a sense of acceptance, value, and respect (Goodenow, 1993).

Almost all participants at the Entomophatron came to the country fair in social groups, and the social nature of the immersive storyworld leveraged the sense of adventure and exploration that can characterize attendance at a country fair. Participating in the storyworld within one's social groups allowed for a sense of camaraderie while taking the emotional risks of eating insects as well as engaging in public scientific dialogue. Sometimes they allowed family/friend group members to observe a trusted other eating the insects before they did. The shared "ewwws," the rolled eyes, the dares and double dares, and mild forms of peer pressure, organized around the mildly transgressive acts of ingesting insects with one another, served as social bonding agents among and between social groups at the diner counter, adding to a sense of in-group or membership within the science frame, noted as a key part of belonging (e.g., Hurtado & Carter, 1997).

This dialectic between individual and group experience, contributing to a sense of belonging within the science-rich discursive space, is an important feature of carnival, described as providing "a sense of immanence and unity" that can be emotionally expansive (Morson, 2004; Robinson, 2011). Supporting such feelings of belonging in the discourse space is critical to all science engagement, but particularly for those who may not already affiliate with and feel a sense of rightful presence within scientific contexts or discourses (Calabrese Barton & Tan, 2020; Canfield et al., 2020; Ong et al., 2018). The Guerilla Science storyworld, which did not follow a script but instead consisted of a number of routines, providing for flexibility of inputs and responses, appeared particularly suited for supporting this form of belonging in science discourse spaces. The joint production of the storyworld, created by individual improvisations and group solidarity, may be a powerful tool for creating opportunities in which participants feel solidarity and belonging in the context of science (see Varelas et al., 2021, e.g., in a school context).

6.2.3 | Sustained science conversations

Designing science engagement experiences to leverage participants' conceptual, cultural, and experiential resources has been argued as critical for broadening participation in science (Bang et al., 2013; Philip & Azevedo, 2017; Rosebery et al., 2010). Carnival celebrates diverse voices as sources of meaning (Morson, 2004). Immersive storyworlds, as shown above, can position participants as sources of expertise within the science discourse. They can also expand understanding of what counts as science. Rather than positioning it as an expensive, technology-dense and esoteric activity, the participant's body is itself the apparatus for the scientific investigation. And the stuff of the investigation is as familiar as "those things that dry up on the basement floor."

In taking on the roles of waitress and waiter the science communicators adopted everyday language and metaphors for sharing ideas and information, and for supporting participants' investigations and sense-making. For example, they frequently encouraged participants to try the insects by comparing their taste to everyday items such as ants to lemon zest or crickets to pumpkin seeds. At other times, they invoked common social constructions about what constitutes scientific forms of speech, while subtly poking fun at this stance, including by using hybridized forms of discourse that blend scientific speech with the utterances of those at the counter.

That said, we note that the content of the scientific conversations in our 31 events was somewhat limited and unvarying. While we coded many interactions as investigating or sense-making, we found no examples of critiquing—no examples where participants engaged in comparing conclusions, data points, or evidence. It may be that the science communicators were not sufficiently prepared to help participants vocalize and critique their observations and understandings; or it may be that other aspects of the experience interfered with conversations going deeper into the science. We found few examples of the waiters/waitresses probing for understanding; they were more likely to respond to questions and move on in the storyline. One early result of this RPP study was a decision by the program leaders to add more of a pedagogical focus to science communication trainings, which included developing a guide for others seeking to develop such immersive storyworlds.

6.3 | Summary

Our research set out to address the questions: How do immersive storyworlds operate to attract and engage non-science seeking public audiences in science conversations? In what ways do immersive storyworlds afford opportunities for participants to see science in relationship to themselves? By leveraging Bakhtinian conceptualizations of carnival, our analysis suggests that the Guerilla Science immersive storyworld engaged public audiences, who were not actively seeking science experiences, in scientific conversations by leveraging the aesthetically and emotionally saturated nature of the storyworld, enhancing and supporting participants' sense of belonging in that science-rich discourse space, and positioning participants' prior knowledge, interests, and embodied experiences as the means for successful participation in scientific dialogue. The improvisational nature of the experience, built on a set of roles and routines, framed by the conceit of the diner and supported by props, allowed participants to see science in relationship to themselves through their own agentive acts of roleplay, and connecting the everyday grotesque nature of the experience with the larger global and historical challenges of food sustainability. We posit that these findings suggest that the immersive storyworld may be a productive strategy for engaging participants who are not necessarily seeking out science opportunities to engage in science activities and conversation.

We also suggest that adopting expansive definitions of learning (e.g., Barron, 2006; Nasir et al., 2014) requires researchers to broaden conceptualizations of belonging. Belonging in science, as described in the data we provide here, can be seen in active engagement in the moment, where one's self is brought into dialogue with science and science is brought into dialogue with one's self. It is not so much about belonging "to science" as about having legitimacy, a rightful presence, or agency "in science"—of being accepted, valued, and respected in a social context constituted by social interactions organized around scientific phenomena. Everyday science, science in everyday life, is constituted of just such moments. As per Holland et al. (1998),

these improvisational moments can over time create a set of heuristics that are constitutive of identity, or processes of being and becoming. To understand how belonging in science develops across the lifespan we need to better account for how these unplanned and ephemeral moments, over time, can contribute to a science-engaged public, and how science communicators can develop more inclusive, compelling, and agentive opportunities for such engagement.

6.4 | Limitations and future research

This study has several limitations. Because we chose to forego gathering additional information on participants so as not to disrupt their country fair and storyworld experiences, we have no data on participants' background, including their prior experiences or interests regarding science. However, we do know that the country fair is a general audience, family/friend-oriented entertainment venue, and not a venue branded as scientific. Therefore it is perhaps less likely that participants were favorably disposed to science than they might have been at a science fair or festival (Kennedy et al., 2017). Further, as noted above, the participants at the event we documented appeared to be overwhelmingly white, thus how these approaches play out in communities of color remains the subject for a future study.

With video data as our only data source, we could not account for any cultural variations in terms of gesture or emotion. That is, we were able to code for "disgust" when people uttered "Eww" or wrinkled their noses in a common western expression of disgust. But we only coded disgust when we, from our joint perspectives of having grown up in the United States or United Kingdom, recognized it, which means that it is likely we missed some emotional expressions. We also could only code for belonging when people verbalized their thoughts on their prior experiences, opinions, or feelings of membership or camaraderie.

We note that our quantitative analysis did not prove causation, only correlations, between codes. That is, we observed that certain combinations of codes—for example, storyworld and emotion—appeared frequently together, but we did not demonstrate that the presence of one caused the other to come about. Furthermore, we did not consider the non-adjacent two-point correlations, which would have shown the occurrence of codes that were not immediately before or after each other in time, and may have revealed some deeper conversational structure such as the assertion of a storyworld at the start of an interaction leads to a discussion of science towards its end. We did however consider the correlation between codes within each given conversation. That is, how strongly the presence of, say, emotion and science correlated within a given conversation. Furthermore, because our analysis did not differentiate between utterances by waitstaff and audience members as they jointly constructed the storyworld, the waitstaff's improvisational efforts to "steer" the conversation might have influenced the results in many ways. Nevertheless, we posit that statistically confirming these correlations adds strength to the central conjectures guiding the study and underpinning the design of the program.

Finally, this article provides accounts that contribute to a theoretical basis for why and how storyworlds may be a productive form of science engagement for non-science affiliated public audiences. However, we did not compare this approach with others to see if greater engagement, richer science dialogue, or more lasting outcomes were produced in one version or another. That remains the task of future research. We hope that future studies will benefit to some degree from our work to theorize and empirically document the potential of immersive storyworlds for engaging non-science seeking publics, and more specifically how Bakhtinian

conceptions of science can be used to understand participation and belonging in shorter-term, improvisational, and fleeting science-rich interactions.

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