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Integrating concepts and techniques from ethnomethodology and sociomaterialism, this article investigates the observable material processes involving human action and place-based contexts of language use enabled by locative media. The focal pedagogical intervention utilized mobile augmented reality (AR) activities, the development of which was inspired by research on learning 'in the wild.' Applying the principle of reverse engineering, we introduce a pedagogical approach termed 'rewilding' for its emphasis on designing supportive conditions for goal-directed interaction outside of classrooms. Three instances of AR materials use are presented from an out-of-class activity associated with university-level language courses involving a quest-type AR game called *ChronoOps*. Video data of 3-player groups were transcribed using conventions from multimodal conversation analysis. The empirical investigation illustrates meaning making through visible embodied displays, the performance of new actions through incorporation of public semiotic resources, and the contributions of the material surround as actants in the flow of interaction. Analysis illustrates that mobile AR activities enable languaging events among assemblages of environments, mobile devices, and embodied experience. We conclude by outlining the affordances of mobile AR activities as one example of rewilding approaches to creating material conditions for language use and learning.

Keywords: place-based learning; rewilding; conversation analysis; sociomaterialism; embodiment; mobile augmented reality

LANGUAGE USE, SECOND LANGUAGE (L2) development, and human activity mediated by learning materials are processes situated in, catalyzed by, and productive of social and

material conditions. Humans learn as part of dynamic ecologies constituted by interaction with other people and engagement with a diversity of material and symbolic tools, artifacts, and environments. In the contemporary era, designed learning materials play a central role in human development and are intentionally created to enhance and make more efficient the learning of specific knowledge and/or processes. Institutional settings such as schools and universities, for example, offer instruction in subject matter with predefined and explicitly stated learning objectives. In instructed and noninstructed contexts alike, contemporary language learners have access to structured programs of study, textbooks and grammars, print and digital texts,

dictionaries and translation tools, tutorial websites and apps, video- and audio-based language learning content, and a wide array of tasks and activities designed to enhance and accelerate learning processes. Scholarly inquiry into language learning materials has a long history in fields such as education and applied linguistics (e.g., Garton & Graves, 2014; Guerrettaz & Johnston, 2013; Tomlinson, 2011), yet definitions and theorizations of language learning materials—and specifically, careful empirical analysis of materials use—remain underexplored in much of language education and classroom research (Guerrettaz, Engman, & Matsumoto, 2021, this issue; cf. Vygotskian sociocultural treatments, e.g., Lantolf & Poehner, 2008; van Compernolle, 2014).

In the research reported here, we investigate human action and place-based contexts of language use and learning that involve the use of locative (location-aware) mobile technologies (Frith, 2015), with an emphasis on the relationships constituting human embodiment and communicative action with and through assemblages of material and semiotic resources. Our contribution to the theme of language learning materials use emphasizes process ontology, that is, the idea that material processes themselves are the necessary focus of empirical inquiry. Taking a process ontology approach contends that process "is fundamental, and entities are derivative or based in process" (Sawyer, 2002, p. 286) and further, that "process is not only a guiding orientation but is also the fundamental nature of reality" (p. 291). An analogy from the biological sciences is the distinction between the genotype and phenotype of an organism: Genotype is the basic genetic structure of an organism, a static map of its expressive potential; phenotype is the 'observable characteristics' of an organism resulting from the history of interaction of its genotype with the environment. Two Douglas fir trees (*pseudotsuga menziesii*) with identical genotypes, for example, may mature into strikingly divergent phenotypes; one seeded in rich soil could exceed 90 meters in height while the second, growing in less hospitable conditions, may attain only a fraction of that size. Similarly, the use of identical learning materials (tasks, textbooks, assignments, technologies, syllabi) do not result in identical—or in many cases, even similar—processes or learning outcomes due the contingencies of differing material processes and conditions (Coughlan & Duff, 1994; Seedhouse, 2005; Thorne, 2003). In the empirical cases discussed here, an emphasis on material processes rather than static entities is further extended to suggest that people and the social–material world

together produce assemblages of observable "morphologies of action" (Thorne, 2016, p. 189).

This process-oriented research on materials use presents an empirical micro-interactional examination of adult English language learners playing an augmented reality (AR) place-based mobile game. Mobile AR games, tours, and community-based education projects typically involve participants ambulating through spaces such as cities and neighborhoods, museum exhibits, historical sites, natural areas, and event venues while using a location-aware (GPS-enabled) device, typically a smartphone. As participants enter (or are guided to) specific places on a digital map, they are presented with additional information such as images, video, textual information, or activity prompts that relate to those locations. The locative or place-based aspect of mobile AR technologies has recently received considerable attention for the potential educational value and capacity to hypercontextualize learning experiences (Holden et al., 2015; Thorne & Hellermann, 2017). In a parallel to commercial recreational games that have been studied as learning environments (e.g., Gee, 2007; Plass, Mayer, & Homer, 2020; Reinhardt, 2019; Thorne et al., 2012), AR games represent a shift away from models of learning based on decontextualized information delivery and toward approaches that emphasize situated problem solving and learning experiences rooted in particular places. Three instances of materials use are presented, each of which involves small groups of university students playing a mobile AR game out of doors on an urban university campus and adjoining areas.

REWILDING AS A GUIDING PEDAGOGICAL METAPHOR

The focal pedagogical intervention described here involved creating mobile AR activities, the development of which was inspired by research on learning 'in the wild' (Hellermann, Thorne, & Haley, 2019; Hutchins, 1995) and diverse cases of digitally mediated language use outside of classroom settings (Holden et al., 2015; Reinhardt, 2019; Sundqvist & Sylvén, 2016; Thorne, 2010; Thorne, Black, & Sykes, 2009; Thorne, Sauro, & Smith, 2015). Reverse engineering from studies of learning in the wild, we introduce a pedagogical approach termed 'rewilding' for its emphasis on designing supportive conditions for goal-directed interaction in spaces outside of classrooms. The development of our mobile AR activities emerged in tandem with the awareness by one of the authors of rewilding approaches to environmental

and ecological restoration. First introduced by conservation biologists (Soulé & Noss, 1998), rewilding encourages reintroducing fauna and flora to ecologies that have lost biodiversity through human habitation, cultivation, and urbanization. Applying the rewilding approach to instructed language education, the challenge becomes how to dynamically augment and integrate formal learning settings with the vibrancy of linguistically and experientially rich engagement occurring elsewhere in the social–material world. In essence, rewilding language education is a renewed call for increasing the ecological alignment of domesticated instructional spaces vis-à-vis the heterogeneity, complexity, and unpredictability of interaction in the wild (the latter defined here as extramural contexts). While not explicitly termed 'rewilding,' establishing linkages between instructed language learning settings and external communities and material environments to structure pedagogical tasks and student-initiated exploration has a substantial history, especially in digital contexts such as online gaming (Reinhardt, 2019; Thorne, 2008, 2012), in fandom participation and fan fiction authoring (Sauro & Sundmark, 2019; Sauro & Thorne, 2021), in social media and online communities (Lamy & Zourou, 2013; Thorne & Reinhardt, 2008), as well as in routine service encounters (Piirainen–Marsh & Lilja, 2019) and in the integration of world languages into academic and professional contexts (Thorne, 2013a) and community-based service learning (Dubreil & Thorne, 2017). In our research on mobile AR, the application of rewilding to instructed language learning settings is intended to introduce structured unpredictability to the language learning and use experience by having participants, in teams of three, engage in intentionally underspecified tasks that involve spatial navigation and route finding, collaborative problem solving, and discovering and learning about sustainable technologies on and around an urban university campus. Details of the mobile AR game are described in the empirical analysis section of the article, but in preface, we outline theoretical, conceptual, and methodological issues that inform our approach to learning materials and materials use.

THE USE OF MOBILE AUGMENTED REALITY IN LANGUAGE EDUCATION

One of the first applications of AR technology for language learning (L2 Spanish) was *Mentira*, a place-based mobile game set in a Spanish-speaking neighborhood in Albuquerque, New Mexico, where learners work together to solve a prohibition-era murder mystery (Holden & Sykes, 2011). University students playing the game complete a jigsaw-style set of tasks in which each player receives different roles, clues, and parts of the story, prompting collaboration with one another and with residents living in the area, to complete the task. In a study of the place-based AR game *Guardians of the Mo'o*, Zheng et al. (2018) described how "place evokes a learner's effort for making meaning and realizing values through embodied action, collaboration and coordination," and noted that "experiencing place is critical for learners to break away from institutional norms and previous thinking patterns in order to develop skilled linguistic action in actual events that lead to prospective actions" (p. 55). This is illustrated via way-finding activity, such as anchoring their next actions in what is physically present in the environment.

ChronoOps (Thorne, 2013b), a quest-driven mobile AR game used in this study, was created and located in Portland, Oregon, and is currently available in seven languages, including English. Participants play the role of an agent from the future who has time-traveled to the present moment under mysterious conditions. The game begins by describing that, in the year 2070, the planet has suffered massive environmental degradation and they (the player-agents) have been sent back in time in order to learn from the green technology projects that are in evidence on and around the university campus. Once participants arrive at a designated green technology site, they file video reports that describe the advantages and disadvantages of (and in some cases additional uses for) the green technologies at those locations (solar energy, alternative forms of transportation, captured rainwater, and free parking and charging stations for electric cars). The video reports are sent to an artificial intelligence in the year 2070 in the hopes that this information will reverse the environmental cataclysm that is this planet's future.

ChronoOps was intentionally designed as a series of open-ended and underspecified tasks with the pedagogical motivation of having players construct their actions in interaction with the game goals and content. In prior research on *ChronoOps*, Thorne et al. (2015) used ethnomethodological conversation analysis to investigate how groups of L2 English students sharing one smartphone orient to the device and the information it displays, develop practices for way-finding, and use talk to bring shared attention to features of their physical surroundings.

That research emphasized the importance of how the game moves the language experience out of the classroom and how the group dynamic around one device influences students' interactional practices. In related research, Hellermann, Thorne, and Fodor (2017) described the complex interactions associated with the literacy event of reading aloud during mobile AR game play, illustrating that collaborative practices for playing the game that involved reading emerged and consolidated over the duration of the activity. Addressing the hypercontextualization and place-based potential of AR, Thorne and Hellermann (2017) analyzed video data of *ChronoOps* game play and described how problems in understanding, as well as moving next actions forward, are often enmeshed with and supported by the immediate physical environment. Their analysis demonstrates the relevance of embodied and distributed approaches to human activity, illustrating that participants utilize gaze, gesture, vocalizations and talk, pointing, and embodied deixis, in an orderly manner, to coordinate virtual–digital (iPhone) and sensory–visual information, to navigate to next locations, and to complete the oral narration tasks comprising the game. Looking cross-linguistically, Hellermann, Thorne, et al. (2019) investigated the orientation to the built environment during the AR game process by groups from three different languages. The groups noticed and used a water fountain for the game task even though it was not explicitly part of the game design. This shows both the improvisatory nature, and further, the participant construction and use of material affordances in the environment that were emergent of the place- based aspect of the AR game.

The empirical research reported in the present article takes materials use as its central theme. The concept of rewilding, introduced previously, describes the pedagogical approach used to create the materials we analyze—in this case, a progressive series of mobile AR tasks (though as mentioned, rewilding refers more broadly to ecologically aligning instructionally situated activities with extramural contexts and practices). All data are unique to this paper and are analyzed using sequential analysis coupled with insights from 4E cognition and sociomaterialism, each of which are defined and further discussed in the next section.

ORIENTATIONS AND APPROACHES

Humans as Open Systems and 4E Cognition

A diverse array of scholarship, from dynamic systems theory to ecological and sociomaterial approaches, sees humans as relationally porous and open systems, with the implication that development arises as a function of interaction within historically formed—and dynamically changing—social, symbolic, and material ecologies (de Bot et al., 2013; Pennycook, 2018a; van Lier, 2004). This view aligns with a number of approaches that theoretically and empirically redefine cognition as embodied, embedded, enacted, extended and distributed (i.e., 4E cognition; e.g., Atkinson, 2010; Bucholtz & Hall, 2016; Clark, 2008; Hellermann, 2018; Hutchins, 1995). Extended and enacted cognition refer to approaches to understanding human action, such as thinking and communicating, as processes that are fundamentally supra-individual and that include, but are distributed beyond, neuronal activity of or symbolic representation in the brain. When viewed this way, human activity and development constitute an 'ensemble' process along a brain–body–world continuum (e.g., Spivey, 2007).

The term 'distribution' emphasizes the idea that thinking and doing involve the body and coordination between human as well as nonhuman artifacts and environments. In essence, neither the brain nor the individual are the exclusive loci of cognition; rather, the focus is on understanding the organization of assemblages, or 'cognition in the wild' (Hutchins, 1995), which presumes an ecological view of human action as organized by the interplay between persons and resources that are distributed across social and material environments. An important constraint is that the principle of distribution, applied to both cognition and communicative activity, is not meant to imply a necessary symmetry among individual humans, groups of people, artifacts, or environments (Kaptelinin & Nardi, 2006). Instead, the suggestion is that the density of activity can shift from brains to bodies and to a range of physical and representational media in the network and flow of activity (e.g., Cowley, 2009; Thibault, 2011; Thorne, 2016). The notion of distribution suggests an additional entailment, namely that of units of analysis such as 'organism–environment systems' (e.g., Järvilehto, 2009), which describe how change within an organism is accompanied by change to the environment and a reorganization of organism–environment relations. In these ways, distributed, situated, and extended approaches to cognition suggest that human action and development are fundamentally emergent of, and contingent upon, temporal, social, and material conditions, a viewpoint that is more strongly voiced in sociomaterial theorizations, discussed in the next section.

*Sociomaterial Perspectives and Sequential
Ethnomethodological Analysis*

Sociomaterial contributions to this research
include the illuminating lens afforded by taking
'matter' seriously, and in many disciplines—
including language education and applied
linguistics (e.g., Canagarajah, 2018; Fenwick,
2015; Toohey et al., 2015)—eliding a central
or sole focus on humans has opened up com-
pelling opportunities for deep engagement with
the question of what, in actual fact, it means
to be human (Pennycook, 2018a). At a general
level, sociomaterialism[1] makes visible often un-
addressed biases in the doxa (Bourdieu, 1977),
or seeming common sense validity, of human
exceptionalism, that is, the belief that humans
are of a special kind in the universe, and by exten-
sion, that human-centric interpretations of the
world are self-evident (for example, the right to
exploit the natural environment without regard
to consequence). More specifically, a number
of sociomaterial concepts have illuminated new
possibilities for interpretation and analysis. In
application to this research, these sociomaterial
concepts include entanglement, assemblages,
and emergence.

The notion of entanglement (Barad, 2007) es-
chews simple binaries and emphasizes the rela-
tional constitution of the material universe. As-
semblage (Deleuze & Guattari, 1987) constrains
the principle of entanglement by narrowing the
scope of inquiry to a heterogeneous constellation
of relations that, perhaps only for a moment or
with greater temporal durability, produce certain
actions. Emergence helps to avoid presuming a
priori states and relationships and rather refo-
cuses attention to how assemblages produce kinds
of social–material ontologies. In a critique of so-
cial science research, for example, Latour (2005)
stated that "it seems that the most important deci-
sion to make before becoming a social scientist is
to decide first which ingredients are already there
in society" (p. 28). Rather than reifying social ag-
gregates, Latour's suggestion is to trace processes
through which the social is generated, which is to
say, emphasize emergence (a chapter in Latour,
2005, is titled "No group, only group formation"
p. 27). Finally, the sociomaterial perspective has
enhanced our conceptualization of the term 'me-
diation,' with its frequent association with Vygot-
skian sociocultural theory (e.g., Cole, 1996; Vygot-
sky, 1978). Appadurai (2015) convincingly argued
that "mediation and materiality are coproduced
effects, which never exist apart from one another

(. . .) [and] are best treated as mutual conditions
of possibility and as effects of each other" (p. 233).
Framed this way, mediation is a 'mode of material-
ization,' and from the phenomenological vantage
point of human experience, the senses (seeing,
hearing, feeling, smelling) are the modes of ma-
terialization through which "matter becomes ac-
tive, vital, energetic, agentive, and effective in the
world around us" (Appadurai, 2015, p. 233).

Regarding commensurability between socio-
material approaches and sequential analysis in-
formed by ethnomethodological conversation
analysis, we note that Latour himself has re-
marked that sociomaterial approaches (actor-
network theory in his case) are "simply another
way of being faithful to the insights of eth-
nomethodology: actors know what they do and
we have to learn from them not only what they
do, but how and why they do it" (Latour, 1999,
p. 19). We find ethnomethodology to comple-
ment sociomaterial approaches because of its rad-
ically emic approach to the analysis of interac-
tion. An ethnomethodological approach seeks to
uncover the practices that members use to pro-
duce actions, not through the application of a pri-
ori theory but through careful observation and
the microinteractional description of accountable
actions that members use to produce and main-
tain intersubjectivity. Members are accountable to
one another for working toward intersubjectivity,
and accountable action can be instigated by phe-
nomena outside the minds, bodies, and voices of
the human participants (Garfinkel, Lynch, & Liv-
ingston, 1981). As described in a recent article ap-
plying a sociomaterial lens to medical education,

> Medical education is a messy tangle of social and ma-
> terial elements. These material entities include tools,
> like curriculum guides, stethoscopes, cell phones, ac-
> creditation standards, (. . .) natural elements, like
> weather systems, disease vectors, and human bod-
> ies; and checklists, internet connections, classrooms
> (. . .) and an endless array of others. (MacLeod et al.,
> 2019, p. 177)

In our research, assemblages of people, human-
created objects, and material entities are entan-
gled catalysts for communicative action (the lat-
ter our primary focus). An example from recent
research (Hellermann, Thorne, et al., 2019) in-
volved mobile AR participants reading aloud a
prompt for the task from the iPhone that asked
the group to brainstorm uses for collected rainwa-
ter. The group was walking toward a fountain and
as it came into view, one of the participants named
it as one of the uses for collected rainwater. In

this way, physicality of the water fountain—its visibility, size, and the sound of the flowing water in the fountain—prompted the noticing of the fountain by a participant, and subsequently the fountain became a resource to list and discuss as part of completing the task. Informed by a sociomaterial perspective, the excerpts and analysis that follow trace temporally sequential actions among heterogeneous assemblages of human and nonhuman actants that contribute to understanding not what things are, but what they do, and do together, in the emergent unfolding of entangled actions that comprise language learning materials use.

EMPIRICAL CASES

Our analysis of AR materials use draws on video recordings (18 hours) of small groups of students playing the quest-type AR game described previously: *ChronoOps* (Thorne, 2013b). The game was played by learners of a number of languages including English, French, German, Hungarian, Japanese, and Spanish. Video data of three-player groups were transcribed using conventions from multimodal ethnomethodological conversation analysis (Mondada, 2018; see the Appendix). The video data and transcriptions were then analyzed in group data analysis sessions. The analysis draws from multiple approaches (primarily multimodal ethnomethodological conversation analysis with concepts and terminology drawing from sociomaterial approaches) and illustrates the achievement of ongoing co-action through observable embodied displays, the performance of new actions through coordinated (re)use of public semiotic and material resources (Goodwin, 2013, 2017), and objects and the physical surround as actants in the sequential production of action (Latour, 2005).

The analytical focus of the case studies in the next section centers on the actions of the human participants—for after all, our primary concern as social scientists interested in real-time communicative practice is to investigate human languaging, and more specifically here, how people use and learn additional languages in settings that include materials designed for this purpose as well as affordances such as other people, artifacts, and proximal environments. What we discover in sequential analysis of mobile AR game play underscores the relevance of a number of principles advanced in recent sociomaterial research and philosophy—namely, that human participants, created artifacts such as mobile devices

and learning materials, and social–material context are relevant and necessary for holistically describing the observable and audible activities represented in the video recordings (Pennycook, 2018b; Toohey, 2019).

Although the instructions for how to play the game were minimal by design, there were fixed aspects of the AR activity that all participants had to engage with: Reading the game narrative and instructions for the game itself, using the GPS-enabled map to find the five technologies named in the activity, and responding to the prompts for making a report on sustainable technology at each location. Around these fixed aspects of the game, a number of contingencies arise due to the multiple routes game players may take to the different locations and the different environmental features that may become relevant material and semiotic resources participants use to complete the tasks comprising the place-based AR game. The empirical analyses that follow sequentially describe three assemblages, the nonhuman elements of which are a water fountain, a rectangular metal utility plate embedded in a sidewalk, and the sun.

Case 1: A Water Fountain Beckons

The following excerpts from Case 1 illustrate how joint attention to a contingent environmental artifact is achieved by a group. The group has completed three of the AR game tasks at specified destinations and has just arrived at what they deem to be the place to stop for the fourth destination represented by the blue circle in Figure 1.

FIGURE 1
Academic Student Recreation Center and Surroundings
[Color figure can be viewed at wileyonlinelibrary.com]

Note. The blue circle represents where the group discussed in Case 1 stops in front of a fountain, which is indicated by the dashed circle.

The fourth destination names a building, the Academic Student Recreation Center (pictured in Figure 1) and highlights the fact that the building collects rainwater on its roof. A large fountain (which the group refers to later) is marked by the dashed circle. The exact text of the task that participants read from their smartphone is as follows: "The toilets in the Academic and Student Recreation Center (ASRC) flush with rainwater collected from the roof. What are some other ways that rainwater can be used? Record your answer in the game's notebook." It should be noted that the 22 groups we have recorded doing this AR activity stopped in a number of different places on or near this plaza adjacent to the named building to complete Task 4. The place to choose to stop to complete the task is a first contingency. Some of the ways that groups thought about the use of rainwater included washing cars, watering plants, community gardens, washing windows, and producing drinking water. The uses that each group named were related to where that group decided to stop to complete this task and what structures were perceptible to that group at that time. This shows the role that place and the contingent nature of stopping at particular places played in the task-as-process. The group in this example was part of a pedagogical intervention that had expert speakers of English play the game with English language learners. Their pseudonyms are Sula, Wes, and Rex (pictured from left to right in Figure 2). For their report at Destination 4, they stop about one meter to the north of a large water fountain. The rushing and falling water in the fountain is audible in the recording.

In Excerpt 1, the group has just stopped walking when in line 3, Wes, who is holding the phone, reads aloud part of the text from the phone. During the 12-second gap (4), Sula also appears to

FIGURE 2
Sula, Wes, and Rex (From Left to Right), Participants in Excerpts 1–5 [Color figure can be viewed at wileyonlinelibrary.com]

be reading from the text. Her gaze is on the phone and her lips move. In line 5, Wes makes relevant to the group one aspect of the text just read ("water") which receives confirmatory receipt by Sula (6). However, immediately afterward, Sula and then Rex inquire about the question from the text (8–9). Wes then locates the question in the text and reads aloud: "What are some other ways that rainwater can be used?" After his reading, Sula highlights the water (as Wes had in line 5) but specifies the type of water ("rainwater," 13).

In Excerpt 2, after a 5-second gap in talk in line 14, Wes shifts his gaze away from the phone and toward the water fountain (Figures 3–4). Rex provides a minimal receipt token to either Wes's turn (11–12) or Sula's turn (13) and just after Wes proffers a nonverbal second pair part to the question prompt that he read in lines 11–12, he produces the indexical and iconic gesture in Figures 5 and 6 (15). Figure 6 shows that Rex's gaze shifts toward one end of the fountain where Wes had originated his gesture.

EXCERPT 1

```
03 Wes:    ^®the toilets from the Academic®,
   sul     ^>>gz at phone-->
04         (6.0)~(0.5)  ~(1.5)~(2.0)  ~(2.0)
   sul        -->~purses lips~      ~moves lips~
05 Wes:    ah water.
06 Sula:   ah ok.
07         (1.0)
08 Sula:   what's the question.
09 Rex:    what's the question¿
10         (.)
11 Wes:    %®what are some other ways that rainwater¿ can be
   wes     %points to words on screen as he reads-->
12         used.®%^
   wes        -->%
   sul        -->^
13 Sula:   rainwater.
```

EXCERPT 2

```
13 Sula:   rainwater.
14 (4.0)%(1.0)
   wes      %gz from phone to water feature, figs 3,4-->
```



```
15 Rex:    +^mm hm%
   rex     +withdraws gaze from phone-->
   sul       ^gz to sky, fig 5-->
   wes             ->%points across water feature, smiles, figs 5,6 -->
16         (0.6)+
   rex           -->+gz to water feature, fig 6-->
17 Sula:   [so the rain falls %on the +roof¿ and it is used
18 Wes:    [(  )
   wes                       -->%gz upward-->
   rex                              -->+
```



```
19 Sula:    ^for the %toilets +[to flush.^+
   sul      -->^rotating rh gesture, gaze to w & r----------- ^
   wes                  -->%
   rex                          + nods------------- +
```

However, at just this point, Sula shifts her gaze upward (Figure 5) and her turn at talk (17) shows she is oriented to the collection area for rainwater (the roof of the building). Her turn is an overly explicit reformulation of the prompt for the task (17, 19), which receives minimal receipt from Wes. This reformulation orients explicitly to a different source for the response to the task than that to which Wes and Rex are oriented.

In Excerpt 3, Sula continues with a reformulation of the task question itself (24) and a tag exhortation (27) after which Rex joins her in visually scanning the area.

To summarize: at the start of the group's performance of this task, all members of the group orient to the immediate environment as a resource for task completion. There are, however, different alignments with Wes and Rex oriented to the water fountain nearby; Sula, to the roof of the building. The different alignments are resolved in the following excerpts.

After the 4-second lapse in talk when the three participants make cursory looks around the area, in Excerpt 4, Rex makes a query about the water in the fountain (29) just in front of the group. Midway through his turn, he indexes the fountain

EXCERPT 3

```
19 Sula:    ^for the %toilets +[to flush.^+
20 Rex:                        [yeah
   sul      -->^rotating rh gesture, gaze to w & r---------^
   rex                            +nods-------------+
   wes                  -->%
21 Wes:    uh huh:.
22 Sula:   so:,
23         (.)
24 Sula:   ^can we use rainwater some other way?
   sul      ^gz upward then scans around the area>>
25         (.)
26 Rex:    u:[m
27 Sula:    [anything?
28         (2.0)+(2.0)      +
   rex           +gaze scans area+
```

EXCERPT 4

```
29 Rex:    from where +this water ^come?
   rex                +points to water feature, fig 7-->
   sul      >>gz scans around the area --------^gz to water feature, fig 8-->
```



```
30              ^(0.5)
   sul      -->^looks and points to water feature, fig 9-->
31 Rex:    from the +top/up^ of building?
   rex              -->+
   sul                    -->^
32         (.)
33 Rex:    or what
```

with his right hand (Figure 7) which Sula orients to by shifting her posture and gaze to the fountain (Figure 8) and then pointing to it (Figure 9). Wes also shifts his gaze to the fountain in Figure 9. When there is no response to his query, Rex adds incremental expansions to his turn: the proposal (31) and the 'or choice' tag (33).

In Excerpt 5, Sula responds to the query with some speculation and accounts (34–35; 38, 41). Rex's turn in line 42 is a suggestion that is initiated with a consequential marker *so* connecting the lack of understanding of the origin of the water in the fountain with the need to investigate. Sula gives minimal verbal receipt to the suggestion but then initiates the movement in the direction of the fountain.

Excerpts 1–5 illustrate the relevance of contingencies a group encounters during the AR activity and the work done by the group to shape and make sense of those contingencies for purposes of accomplishing the activity: making a report about uses of collected rainwater. The different orientations to the competing environmental contingencies (made public by group participants via gaze, gesture, and talk) are resolved when a verbal query is made about a fountain that had been noticed and oriented to by two group members.

FIGURE 10
Trek, Max, and Prius (From Left to Right), Participants in Excerpts 6–10 [Color figure can be viewed at wileyonlinelibrary.com]
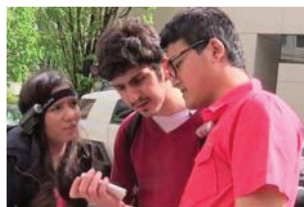
Case 2: A Metal Utility Panel Serves Language-Related Work

The second case illustrates how gesture and a contingent environmental artifact help the participants define a term from the game text. In these excerpts, a different group (from a classroom of upper intermediate English language learners, Trek, Max, and Prius (see Figure 10) has arrived at the second destination, at which they need to discuss the advantages and disadvantages of solar energy.

The following is the full task prompt as it appears in the game: "The solar panels on the roof

EXCERPT 5

```
34 Sula:  I don't know actually. I hope so, becau:se it's like
35        a decoration. [so
36 Rex:                 [yeah
37        %(1.5)%
   wes    %nods---%
38 Sula:  hopefully it is not fresh water, it might
39        [be recycled
40 Wes:   [uhh toilets
41 Sula:  water
42 Rex:   so- so we let's let's see how: it work.
43 Sula:  ok
44        ((participants begin to walk southward))
```

EXCERPT 6

```
03 Max:    ®on the roof supply almost twor- (0.5) percent of
04         this building energy.
05 Trek:   mmm[::
06 Max:        [WHAT are some of the advantages or
07         di:sadvantages (.) of using solar energy.®
08         (1.0)
09 Max:    okay, some of-
10 Trek:   [(solar panel)
11 Max:    [advantages. Its- good to environmental¿=
12 Trek:   y:es:.=
13 Max:    =>because< again (.) <do:n't emit (.) don't
14         create> co2:,
15         *(0.5)*
   pri     *nods---*
16 Max:    gas emission¿
17         (.)
18 Max:    a::::nd, (1.5) the: >but< (.) on the other hand
19         *(0.4)it [doesn't,(.) create energy, (.) for
   pri     *takes phone and looks at the screen>>
20 Prius:            [®(           )®
21 Max:    entire building¿=
```

of Lincoln Hall supply almost 3% of this building's energy. What are some of the advantages or disadvantages of using solar energy? Record your answer in the game's notebook."

The group stops outside the front of the Lincoln Hall building. As the text indicates, the solar panels are on the roof of the four-story building and are not visible from the street level. In Excerpt 6, Max is reading the task prompt aloud (3–7) and then lists some advantages (9–16). There is minimal verbal and nonverbal receipt: Trek's repetition (10) and weak agreement (12), Prius's nod (15). As Max continues with the preparation for the report by projecting a list of disadvantages of solar power (18), Prius reaches toward the phone and possession of the phone is transferred during Max's turn at talk (Tuncer & Haddington, 2020) in line 19.

Prius's acquisition of the phone forecasts an upcoming trouble source for the activity, as we see in Excerpt 7. Max continues with the list of disadvan-

tages of solar power (21, 23) which is supported by Trek's repetitions and receipt tokens, and as that sequence comes to a close, Max shifts his posture to Prius (25) and begins to reach for the phone to begin the recording of the report as he utters the transitional (Beach, 1993) item *okay* (25). At that point, Prius initiates repair (27) by requesting a definition. At the start of his repair initiation, Max stops his reaching for the phone and shifts his posture away from the phone (27), which allows Prius to then show the unfamiliar word to his peers on the phone screen.

In Excerpt 8, when there is no uptake to his repair initiation, Prius continues with the question in line 28 and the repetitions of the trouble source word in lines, 32, 34, 36 producing the trouble source with different pronunciations (Käänrä, 2017). Trek displays her understanding of Prius's request when she repeats the word (38) and begins a depiction of a generic panel. The depiction starts with Trek moving into position

EXCERPT 7

```
21 Max:    entire building¿=
22 Trek:   =y::e[s.
23 Max:         [and its expensive.
24 Trek:   its expensive.=
25 Max:    =%okay.
   max      %shifts posture to Prius, reaches for phone-->
26 Trek:   [°okay:°
27 Prius:  [%whats this uh::: (1.0) *payn? payne:ls?
   pri                             *turns phone slightly twd Max and Trek>>
   max     -->%shifts posture back>>
28 Prius:  what's the panels
```

EXCERPT 8

```
28 Prius: what's the panels
29        (0.3)
30 Max:   sorry?
31 Trek:  wh[a:t is?  ]
32 Prius:    [panels,  ]
33        (.)
34 Prius: <solar panels.>
35        (.)
36 Prius: paynels.
37 Max:   °so[mar panels?°
38 Trek:     [^paynels is *uhh::,
   tre          ^depicts panels with hands, figs 11-14>>
   pri                       *gz to Trek>>
```


fig 11   fig 12   fig 13

fig 14

(Figure 12) and then moving her hands and arms to indicate a rectangle in the air, one side of which is at the level of her face and which is made in a plane that is directed specifically at Prius and which Prius orients to (Figures 13–14).

After Trek's depiction, in Excerpt 9, Max repeats the trouble source word (40), shifts his gaze to Prius, and begins a turn that includes an agreement token, a generic categorization, and then a deictic marker (43). Trek offers a more specific description in lines 44–45, 47 ("it's the thing that holds the sun"), which is in overlap with Max. In line 46, Max adds to his deictic marker with a comparison *this size* as he identifies a rectangular metal plate on the sidewalk at his feet (Figures 15–16) and then reformulates the information given by Trek (48).

Figures 15–16 show that Max has placed his left foot on one side of the panel and moved his right foot from one corner of the panel toward the top side to emphasize the rectangular shape.

As Max produces that turn, Excerpt 10 illustrates how Prius shifts his gaze downward toward the panel on the sidewalk and utters the change of state token (49). Trek also orients to Max's depiction and steps on the panel as she utters a strong agreement and explicates further, giving the usual color of a solar panel—not the gray of the metal

EXCERPT 9

```
40 Max:   %^panels.%
   max       %gz to Prius-%
   tre         ^>>depicts panels-->
41 Prius: pa-
42 Trek:  [panel is-
43 Max:   [yea::h.% it's a kind of-^  %this-
   max           %gz down----------------------%walks, gz down-->
   tre                         -->^
44 Trek:  uh:: it's the thing that.
45        [ehh::    holds:¿  the: uh:  ]
46 Max:   [things- %this si::ze (.) you] know¿
   max           -->%steps on two corners of plate, figs 15-16 -->
```


fig 15   fig 16

```
47 Trek:  the [su:n. ]
48 Max:       [it hav]e a% ener[gy su:n.]
   max                -->%
```

EXCERPT 10

```
48 Max:       [it hav]e a ener[gy su:n.]
49 Prius:                     *[o h : : ]
   pri                        *gz downward toward panel-->
50 Max:   [   this-   this*- this ^get ]
51 Trek:  [^* >YEAH THIS (UP THE) .HH<] black (.) thing=
   tre        ^steps on panel, fig 17----------- ^
   pri            *points to panel --- *
```



```
52 Max:    =yeah,=
53 Prius: =oh: oka:y
54 Max:    %but in the roof. you know in the [roo:f?
   max     %extends arm upwards, pointing-->
55 Trek:                                     [in the-
56 Prius: roof. >I know<.
57 Trek:  [y:e:s y:es
58 Max:   [yeah %you know. [okay we need to
59 Prius:               [I know
   max          -->%
60 Max:   re[cord about this: do: you
61 Trek:     [ye:s
62 Prius: ®record your answer in: (the):: °(noteboo:k)°,®
```

panel on the sidewalk, but black. Prius also points to the panel to display his orientation to the referent being used to illustrate the trouble source word and makes another change of state token with the sequence closing marker (53).

After Max checks on Prius's understanding of the meaning of the word *panel* (54), Prius closes the sequence with an indication of a change in his epistemic state (55–56) and the group moves forward with making their report on solar panels.

The sequence of Excerpts 6–10 illustrates how when one group member displays a lack of access to a lexical item from the game text, other participants in the group can find an immediately visually perceptible feature of the built environment (in this case, a metal plate in the sidewalk on which they stand) to aid in their depiction of the trouble source lexical item (see also Eskildsen, 2019).

Case 3: Sun ≠ Rainwater: Accounting for Weather During a Report

A third example illustrates a perceptual mismatch between the instructions for the activity and the contingent environmental condition of local weather. The mismatch is accounted for during the group's report at Destination 4 show-

ing the highly improvisational nature of materials use and materials creation during these kinds of 'rewilding' tasks. In this excerpt, a third group (also from a classroom of English language learners, Sam, Rick, and Red; see Figure 18) has arrived at the same destination as the group in Case 1, in which they need to discuss other uses of rainwater.

The following is the full task prompt for Destination 4 as it appears in the game: "The toilets in the Academic and Student Recreation Center (ASRC) flush with rainwater collected from the roof. What are some other ways that rainwater can be used? Record your answer in the game's notebook." The group reads the prompt for Destination 4 and begins discussing what to include in their report as they walk to the destination. They mention several uses, including public drinking water, cleaning the streets, and watering plants on farms. When they arrive at Destination 4, they position themselves in the configuration for making a recording (Figure 18) and Rick indicates (Excerpt 11, line 9) that he will make the report. When Red asks how he will do that (12), Rick asks for the topic of the report one more time (13) and when this is clarified, he turns to the camera operator, Sam, and makes a hand gesture with his right hand to Sam (Figure 19) and then claps his hands, which is taken as a signal that he will start the report.

FIGURE 18
Sam, Rick, and Red (From Left to Right), Participants in Excerpts 11–13 [Color figure can be viewed at wileyonlinelibrary.com]

EXCERPT 11

```
 09 Ric:    okay.=I will say it
 10 Red:    okay.
 11         (0.5)
 12 Red:    but how.
 13 Ric:    what's the subject we will talk about it?
 14 Red:    uh rainwater.
 15 Ric:    rain*wa~ter.~
    ric            *gz to camera operator>>
    ric              ~gestures and claps hands, fig 19~
```



```
 16 Red:    okay
 17         ((recording commences))
```

At the start of the report, there is a misuse of a term; when that is resolved, Rick starts the report a second time (see Excerpt 12). He greets the audience and introduces the report's subject matter (20–21). At the end of his turn, Red starts a turn that is prefaced with two disjunctive discourse markers, the reduced *well* and *actually*, which is hearable, despite or because of its design, as a dispreferred action turn-shape (Pekarek Doehler & Pochon–Berger, 2011) that breaks progressivity and is interpreted as interruptive by Rick. Evidence for this is in line 22 when Rick shifts his posture toward Red and makes a two palms up gesture (Bavelas et al., 1992) "to express uncertainty" (Chu et al., 2014, p. 700) and the open-class repair initiation (24; Enfield et al., 2013).

As Red continues with his assessment of Portland weather, the alignment to this shift in topic gradually becomes shared. In line 27 of Excerpt 13, Rick begins to laugh at the narrative that

Red is presenting: a report of long-suffering rain-habituated residents enjoying the sunny weather at the time of the recording. And as Red continues his assessment, 'it rains throughout the year,' Rick collaborates to co-construct the assessment describing the current situation ("it is sunny today;" 29). Red continues building his turn with a contrastive clause (30) and raises his arms and gaze to the sky as he says "suddenly." Again, Rick makes a collaborative completion (31) to Red's turn, uttering the key point of the assessment, the punchline, the term *sunny*.

Red repeats Rick's predicate from line 31 in line 32 and they quickly close the assessment sequence in lines 33–34 and the report on other uses of rainwater started by Rick in Excerpt 12 (20–21) continues in lines 35–36.

The series of Excerpts 11–16 shows that a report on uses of collected rainwater was prompted by the game instructions and was planned. One turn

EXCERPT 12

```
20 Ric:   hello¿ we will talk about eh: (.) rainwater
21        and (.) what we can use it in.
22 Red:   we' actually *Portland it is a rainy place.=and
   ric                *gz to Red, with palms up gesture, figs 20, 21-->
```


fig 20   fig 21

```
23        r[ainy city.* it's rain all: over the:: uh
24 Ric:   [↑(huh)?
   ric              -->*gz to camera operator>>
```

EXCERPT 13

```
23 Red:   r[ainy city. it's rain all: over the:: uh
24 Ric:    [↑(huh)?
25         (.)
26 Red:   [the uh eh hih yeah. all over the
27 Ric:   [n:: heh heh heh heh heh .hhh
28 Red:   uh:: the: w- [uh yea::r uh:
29 Ric:                [it is sunny today. heh heh
30 Red:   but ^it  is     suddenly^ uh::: ^
   red           ^raises arms, gz to sky, fig 22^claps hands^
```


fig 22

```
31 Ric:   sunny.
32 Red:   sunny to[day
33 Ric:           [so:
34 Red:   so
35 Ric:   some of the uses we can like (.) give the
36        plants water from the: rain¿
```

into the planned report, however, Red makes relevant the contingent aspect of the weather, and particularly that it was a sunny day in a city that is well known for its gray skies and consistently rainy conditions. The disjunctive aspect of reporting on uses of collected rainwater while standing in bright sunshine hits him—actually as well as metaphorically—in the eye, and Red treats it as an accountable matter. Though his peer had already started the report, Red's initiation of a side sequence plays on the irony that although it is

sunny on the day of this recording, it is relevant to speak about using collected rainwater because the climate of Portland allows for that. Red's extemporaneous contribution also indexes the insider status of the participants—that they know the city and region well enough to take ownership of the task and remark on uses of rainwater under uncharacteristically blue skies—and by doing so, they perform a culturally and meteorologically framed new action built upon the publicly visible local resource of weather (Goodwin, 2013).

DISCUSSION AND CONCLUSION

The empirical cases of materials use described here illustrate that communicative action is multimodal, embodied, and embedded in material environments that catalyze action among a heterogeneous array of humans and nonhumans. The use of a mobile phone for the place-based AR game provided a framework for cooperative action among the participants and with their environment. Sequential–temporal analysis showed how human actions such as gaze, pointing, reading aloud, bodily deixis, and audible communication are used in an orderly manner to achieve and maintain intersubjectivity; and importantly, that such human actions, enmeshed with nonhuman contributions (a fountain, a metal panel, the sun) together produce the social (Latour, 2005). Even while maintaining a focus on human agents, shifting to the sociomaterial unit of analysis—the assemblage (Deleuze, 1988; Fox & Alldred, 2015)—affords helpful perspectives on our three empirical cases. Tracing from the human participants' actions, the assemblages include (a) a group standing where their sightlines present a water fountain leading them to investigate how the fountain works and its source of water, (b) a member of the second group encounters a trouble source word while standing near a metal utility panel embedded in the sidewalk and its rectangular shape and size is used to describe and define the trouble source word, and (c) while making a report about uses for captured rainwater as they face direct midday sun, a member of the third group produces an extemporaneous side sequence—namely, that Portland is a rainy place—to account for the irony of squinting into bright sunshine while discussing rainwater. From the vantage point of relational sociomaterial ontology, each case shows how emergent assemblages divergently accomplish what are, ostensibly, the same (Cases 1 and 3) or a similar task (Case 2).

And we should not be surprised by this. All learning, and indeed all activity, in the phenomenal universe, is entangled in the process ontology of unfolding activity across temporal scales. As Tomasello (2000) has described it, "all linguistic knowledge . . . derives in the first instance from the comprehension and production of specific utterances on specific occasions of use" (pp. 237–238), where each 'occasion of use' is situated in, and potentially catalyzed by, a particular social–material context (see also Eskildsen, 2015). In essence, everything happens in a place and at a time, while each place and

moment is sequentially nestled against immediate temporal and material neighbors and also entangled with more distal flows of space, time, experience, and memory. As such, when language learning materials are considered genotypically, as stand-alone entities—blueprints for action—or treated as isolated objects decontextualized from their mediational role in human activities, the result is an impoverished and potentially inaccurate representation of the phenotypic dynamic comprising situated brain–body–world activity.

As described in the introductory article to this special issue (Guerrettaz et al., 2021), definitions and theorizations of language learning materials and materials use remain underexplored in the majority of language education and classroom research. The analyses presented here attempt to provide a fine-grained process-focused account of emergent heterogeneous assemblages that illustrate the surprising and creative morphologies of action that emerged in mobile AR game play. Theoretically and pedagogically, this research illustrates the significance of embodied, extended, and ecological views of cognition and learning as 'material processes,' and in particular, it outlines the affordances of mobile AR as one example (among many) of rewilding approaches to creating situated and affordance-rich conditions for action and language learning.

The biologist Lewontin (1974) described the goal of population genetics as mapping between two spaces, from a genotype space, representing the expressive potential of genetic material, to the phenotype space, the observable characteristics of that genetic materiality *in situ*, when entangled in assemblies of myriad other entities and emergent dynamics in the process ontology of change over time. The development and use of language learning materials run parallel. We design for the desired phenotype space but can never fully predict, or sometimes even imagine, what will happen there (and perhaps this is the art and alchemy of pedagogical innovation). It is for this reason that detailed, microinteractional, moment-by-moment investigations into materials use are so critically important: They offer insight into the ways that learning materials, as purpose-designed constituents of broader human and nonhuman assemblages, potentially enhance (or have some other effect on) the developmental trajectories of the people who use them (for research specifically describing language use and learning in mobile AR, see Sydorenko et al., 2019, for a discussion of language-related episodes; and Sydorenko et al., 2021, for analysis of directive language use).

In closing, we share a few less formal comments on our design and research experience with mobile place-based learning materials. Humans remain the analytic focus of this work due to our primary concern with language development and the building of social and material infrastructures for learning (Wagner, 2015). The rewilding approach informing our development of mobile AR materials was guided by the notion of 'structured unpredictability,' a game design principle used to enhance engagement by providing adequate-but-limited explicit guidance (structure) so that players evolve their own practices for setting and accomplishing objectives in environments involving some degree of probabilistic, unexpected, or stochastic variability (unpredictability). In essence, when creating rewilding opportunities for language learners, the suggestion is to provide pedagogically informed resources and guidance, but not too much.

The mobile device, AR game, human participants, and features of the material surroundings form material assemblages of humans + artifacts + environment(s), together yielding "the raw materials out of which signs grow, and from which language emerges" (van Lier, 2004, p. 63). In the analyses, these assemblages were shown to produce entangled morphologies of action that were spontaneously emergent and that incorporated elements that extended beyond the learning materials in each instance of materials use. During the iterative process of creating this modest mobile AR game for language learners, analyzing player actions to get a sense of the phenotype of the game-in-use, and then modifying the game for clarity and flow, two recurrent catchphrases were frequently repeated among the researchers. The first was, "simple game mechanics yield complex human behaviors." This phrase arose because we initially fretted about the simplicity of the game, which—while based on a narrative role-playing scenario—was essentially comprised of a serial set of location-specific oral narration tasks based on linguistically uncomplicated prompts (the latter so that language learners at many levels could participate). We were surprised and intrigued by the complexity of observable player behaviors and the emergent assemblages that formed among people, objects, and the built and natural environment. As Sacks (1984) remarked, "from close looking at the world we can find things that we cannot, by imagination, assert were there" (p. 25). For readers interested in language learning materials, iterative design, and pedagogical innovation more broadly, we leave you with the second catch-phrase, which was, "what would something better look like?"

NOTE

[1] Sociomaterialism is the term used in this special issue. See also the terms *posthumanism*, *new materialism*, *actor-network theory*, and *object-oriented ontology*, which this brief treatment will not tease apart.

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APPENDIX

Transcription Key

Conventions are from Schegloff (2000) and Mondada (2018)
Nonverbal Behavior

®	Reading.
* *	Descriptions of embodied movements are delimited between
+ +	two identical symbols (one symbol per participant's line of action)
ˆ ˆ	and are synchronized with corresponding stretches of talk/lapses of time.
~ ~	
% %	
*—>	The action described continues across subsequent lines
–>*	until the same symbol is reached.
>>	The action described begins before the excerpt's beginning.
>>	The action described continues after the excerpt's end.
——	Full extension of the movement is reached and maintained.
ava	Participant doing the embodied action is identified.
[ ]	Overlapping or simultaneous talk.
=	"Latched utterances" no break or pause between utterances.
(0.5)	Numbers in parentheses indicate silence, represented in tenths of a second.
(.)	A dot in parentheses indicates a "micropause."
.	Period indicates a falling intonation contour, not necessarily the end of a sentence.
?	Question mark indicates rising intonation.
,	A comma indicates "continuing" intonation.
¿	An inverted question mark is used to indicate a rise greater than a comma but less than a question mark.
::	Colons are used to indicate the prolongation or stretching of the sound just preceding them. The more colons, the longer the stretching.
-	A hyphen after a word or part of a word indicates a cut-off or self-interruption.
word	Underlining is used to indicate some form of stress or emphasis, either by increased loudness or higher pitch. The more underlining, the greater the emphasis.
WOrd	Especially loud talk may be indicated by upper case; again, the louder, the more letters in upper case. And in extreme cases, upper case may be underlined.
°	The degree sign indicates that the talk following it was markedly quiet or soft.
↑↓	The up and down arrows mark sharper rises or falls in pitch.
> <	The combination of "more than" and "less than" symbols indicates that the talk between them is compressed or rushed.
< >	Used in the reverse order, they can indicate that a stretch of talk is markedly slowed or drawn out.
hhh	Outbreath.
.hh	Inbreath.
(( ))	Descriptions of events: ((cough)), ((sniff)), ((telephone rings)), ((footsteps)) (word). All or part of an utterance is in parentheses indicates transcriber uncertainty.
#	Creaky voice.

SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of the article.