Teaching and Learning Anthropology Journal
Vol. 6, No. 2 (2024), pp. 37-62

ARTICLE

ChicanXperimental Archaeology: Addressing Chicanx Student Equity Gaps and Bolstering Identity Construction by Producing and Testing Experimental Ovens

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Abstract

Conceptual artist Rafa Esparza argues that adobe bricks are loaded with meaning and represent ethnic Mexican heritage and communion with land through Chicanx ritual labor. Our ethnographic experiences in northern New Mexico and our pedagogical and research work in experimental archaeology in California confirm Esparza's assertion. Among traditional Chicanx villages in New Mexico, adobe construction serves to reinforce community relations. Among Chicanx college students, constructing experimental earthen ovens in the California laboratory creates new student communities and validates familial and social memories of adobe making in ancestral homelands. Bringing together initially separate research threads, we consider adobe's culturally sustaining capacity and its potential in scientific archaeological research as inextricable facets of the same research-teaching system we now call ChicanXperimental archaeology. This article plants three interrelated seeds in that vein, offering starting points for: (1) a culturally sustaining college teaching model centered on adobe making; (2) a replicable experimental adobe oven construction and testing model with field-applicable results; and (3) project expansion to California elementary school classrooms with the same pedagogical and scientific goals in mind. We invite our readers, especially archaeologists and K-12 teachers, to explore and experiment alongside us, providing an experimental oven blueprint and suggestions as to prospects and best practices for both sides of this project.

ISSN: 2641-4260

Keywords: *Adobe; archaeological pedagogy; California, Chicano/a/x; citizen science; community-based participatory research; experimental archaeology; Latino/a/x; horno; New Mexico; querencia*

Introduction: Mud Bricks as Instruments of Representation and as Instruments of Science

The manufacture of earthen bricks and the construction and maintenance of adobe architecture has drawn innumerable Chicanx (ethnic Mexican) communities in the American West to coalesce in construction practice and extended sociality since the colonial era. Those practices persist in many of the towns and villages of northern New Mexico, where the repair and re-plastering of communal adobe structures often constitute major annual events, attracting kin from dozens or even hundreds of miles away. We build on the work of our colleagues and analyze our own ethnographic practice to argue that communal adobe work is a ritual of dedication and demarcation, connecting and reconnecting aspects of the local landscape or built environment to the families and communities historically associated with them. However, our experimental construction of Mexican-style earthen ovens (*hornos*) began apart from that work. We aimed initially to offer college students the opportunity to gain rare experience cracking the code of a traditional technology's potential archaeological signature. Those students came to discover alongside us that, despite the ubiquity of *hornos* in historical accountings of everyday life in the American West during the Mexican and Colonial Periods, no archaeologist really knows what the buried ruin of an adobe oven "looks like." Those disparate lines of inquiry – the study of community and adobe materiality and experimental deduction of *horno* archaeological signatures – came into close orbit as increasing numbers of Chicanx student participants in our California laboratory reported meaningful cultural connections to adobe making and varying senses of community connection constructed in the process. We never anticipated either phenomenon, but we now see the two as inextricable facets of the same greater project we have come to call ChicanXperimental archaeology.

We turn to conceptual artist Rafa Esparza for guidance here. Esparza (2017) argues that adobe bricks are "loaded" in terms of Chicanx meaning, that "they signify brownness, the land, and labor." For the Los Angeles-based artist, earthen art practice catalyzes recall of his father's adobe construction work and of social memory, holding "adobe brickmaking as a collaborative process" (Esparza 2017). We bring Esparza's statements to bear as virtual operating hypotheses, seeing it mirrored numerous times among Chicanx student participants. We discuss the sociality of New Mexican adobe construction practices here in that vein, comparing their community building results to those of our experimental adobe making in the classroom and laboratory. We review the work of our scientific archaeological study here as well, suggesting that culturally sustaining pedagogy and good science are not mutually exclusive. Archaeologists of the American West have variously argued that archaeological *hornos* represent Chicanx, Mexican, or Spanish identities and practices (Brinkman 2019, 53; Carillo 1990; Eiselt and Darling 2017, 203), but have never established guidelines by which to distinguish *horno* walls from architectural adobe in the field. Our tests are designed based on ethnographic preference for maximized heat retention and with the aim of producing suggestions as to what related mud-matrix additives, if any, may have been employed by *horno* makers of the past. We find that mud brick ovens containing gravel do a better job of retaining heat than those without.

Our ovens are not difficult to produce or test. Our student-powered research model works well due to the simplicity of our plan and the only moderately demanding nature of indoor adobe work at the micro scale. We believe that the work may be carried out just as effectively upon expansion as a citizen science model and are currently working with San Francisco Bay Area elementary schools to develop programs at schools with large Chicanx and Latinx populations. Though the pandemic has slowed our pace there, we anticipate that the datasets produced by "kid scientists" will come to refine our current research questions substantially. Through classroom-based adobe manufacture and construction, Chicanx elementary students will work like their college counterparts to deconstruct the stigma associated with mud technology on this side of the U.S.-Mexican border. We have identified significant overlap between California's fourth-grade content requirements and project interests, making those classrooms ideal hosting spaces. We offer an *horno* construction blueprint here to give potential research partners a sense for required knowledge and resources, inviting experimental replication and similar modes of community building.

This paper plants a seed for Chicanx student success at the college level alongside companion seeds tied to our experimental results and the promise of our related elementary school outreach efforts. We hope to draw archaeologists and elementary school teachers into our research orbit by doing so. Despite numerous efforts in recent years by archaeologists to fashion archaeological research methods into high impact and culturally sustaining pedagogies (Dean 2019; Garcia 2021; Kemmerlin 2022; Kolpan and Passalacqua 2022; Laluk et al. 2022), reporting on related archaeological research results almost never accompanies arguments for transforming practices in the laboratory and field. Based on our lived experiences as primarily BIPOC faculty and students in archaeology, we feel strongly that many teaching archaeologists – including some supportive of disciplinary social justice efforts – do not act on suggestions presented in the literature of archaeological pedagogy for fear of stalling their own research agendas. We address that inclination here by weaving an instructive pedagogical narrative together with promising preliminary research results and a discussion of our plans to distribute the research effort outward toward elementary schools. In that way, this paper plants a fourth seed as well, providing a manuscript model as contribution to the conversation on the research-teaching nexus (Copeland 2016). We invite our readers to emulate and improve upon any aspect of our efforts.

Adobe Construction and Chicanx Placemaking in Northern New Mexico

As a construction material, adobe tends to resist efforts at modernization in methods of manufacture, assembly, maintenance, and long-term preservation (Braun 2017; Degirmenci 2008; Geylani 2018, 291; Russell 2015, 66). The technology has seen only limited strides in terms of automation, and that only over recent decades to a generally quiet reception (Ayyappan et al. 2018; Buxton et al. 2016; Russell 2015). Adobe manufacture demands substantial human labor and has historically relied on groups sharing some degree of familial affinity that hold some cultural aim beyond completion of the finished product. One of us, Albert Gonzalez, has served as a volunteer at the annual community re-plastering of the centuries-old San Francisco de Asís Mission Church in Ranchos de Taos, New Mexico, a half dozen times over the last sixteen years, spurring this program of research and teaching. Known locally as *el enjarre*, the summer re-plastering and repair of the San Francisco church is a major local event, drawing numerous families, hundreds of their relations, hundreds more visitors from various points in the state, and even tourists from out of state and beyond (Birdsong 2017, 251; Kamins 1999). The thousands of adobe bricks that make up the church walls were encased in concrete during the mid-twentieth century to minimize maintenance, but the effort resulted in cracking and partial wall collapse due to differential expansion between the two material types upon repeated absorptions of groundwater (Hamard 2013, 110; Hooker and Santistevan 1996; Huddleston 2015; Kamins 1999). The Ranchos de Taos community reinstated the tradition of *el enjarre* in 1979 following the catastrophic collapse of key portions of the church's walls. The collapse drew them to realize that technology cannot rival tradition and human devotion when it comes to earthen architecture. Recounting the renewal of the old tradition, Msgr. Jerome Martinez y Alire noted that the act of reconstruction drew memories of "ancestors [coming] together as a community" to repair and maintain their sacred architecture. The work reminded parishioners and residents of the importance of community rituals of renewal and reconnection – of the need, as Father Jerome put it, to "[re-link] themselves, one to the other" (Kamins 1999).

Gonzalez's prior ethnographic work in the vicinity of Ranchos de Taos has led him to connect with various households of the plaza surrounding the San Francisco church (Gonzalez 2007). It was his work among elders in the parish that led to his involvement at the plastering event. In addition to serving as a ritual of community renewal, the enjarre serves as a privileged introduction point for vetted outsiders, exposing them to local culture bearers and introducing them to New Mexican Catholicism. A good deal of ethnographic work has been carried out in northern New Mexico with the aim of understanding past and present community-building and identity-linked aspects of acequia irrigation culture in the region (Rivera et al. 2014; Rodriguez 2008; Sunseri 2018), but very little work aims to understand the same aspects of adobe construction. Urban planner Estacia Huddleston's work (2015, 24) is instructive here, arguing that adobe making in northern New Mexican context is place making full on and a demarcation of querencia, a beloved community space or landmark. Querencia placemaking is accomplished and continually renewed by community engagement in group modes of creative agency, such as in acequia construction and maintenance and in the ritual of the enjarre (Huddleston 2015, vi). We suggest here that it is possible to respectfully bring the enjarre into the classroom, moving Chicanx, Latinx, and other undergraduate students to evaluate adobe technologies in a way that reveals its subtle complexities and produces student participant engagement and group cohesion.

Querencia in the College Classroom: Adobe Making as High Impact Practice

Gonzalez is a faculty member at California State University, East Bay (CSU-East Bay), a member campus of the California State University (CSU) system. The CSU Office of the Chancellor launched an initiative in January 2016 designed to increase graduation rates while eliminating achievement and equity gaps, in particular between underrepresented minority students (URM), including Black and Latinx students, and their white and Asian counterparts (CSU 2018a; CSU 2018b). That suite of goals is referred to in the higher education literature simply as *student success*. The CSU has adopted a toolkit for the facilitation of student success, including the propagation of literature and faculty training connected to the use of High Impact Practices (HIPs), a group of pedagogical techniques found to correlate in practice with student success at a number of institutions (Kilgo et al. 2014; Kuh 2008). HIPs include undergraduate participation in original research, service and community-based learning, diversity and global learning, collaborative student work, and first year experiences; such practices result in greater relative investment on the part of students to their coursework, classmates, and in their own education (Kuh 2008). Though not often touched on in print, archaeologists have not entirely avoided the topic. Most who are involved in the conversation extoll the virtues of field schools for serving as a one-stop shop for HIPs, arguing that many of those practices come built into the structure of field programs to begin with, justifying their relatively high cost (Connell 2012; Dean 2019; King 2019; Smith 2017, 5–6). However, no studies we are aware of suggest the incorporation of experimental archaeology in the undergraduate classroom. As Laura Heath-Stout and Elizabeth Hannigan recently noted (2020), the expense of field schools makes them difficult for many URM students to afford and their typically distant locations and gargantuan time commitments serve to further draw down hope for hands-on experience on the part of URM students, in particular those who identify as Chicanx. Gonzalez follows Heath-Stout and Hannigan's mandate here, offering accessible laboratory experience to Chicanx and other college students as an entrée to our campus-based spring field methods course.

Gonzalez founded the Pacific Earthen Architecture Research Laboratory (PEARL) at CSU-East Bay in 2018. The PEARL is an adobe makerspace designed to encourage student investment in course material by connecting them to original research projects involving the construction of scaled-down experimental replicas, including New Mexican-style *hornos*, among other structural types. It serves as a base for an otherwise largely distributed operation, with anthropology majors training in adobe experimentation in preparation for assignments among other students in lower division and general education (GE) anthropology courses, and eventually K-12 institutions, to teach adobe making and related experimentation. In this way, we transport *el enjarre* over northern New Mexico's Sangre de Cristo Mountains to Chicanx and other students in California, offering a small dimension of *querencia* and perhaps a reminder to some Chicanx students of their own family pasts in mud. A number of the CSU-East Bay students, staff, and faculty who have taken part in adobe manufacture and experimentation with the PEARL have openly noted the familiarity of the enterprise and its materials. Adobe making and *horno* construction have served in many cases to spur recall on the part of Chicanx and Latinx participants of the landscapes, built environments, and communal traditions of their ancestral homelands, constituting a form of heritage practice pedagogy (Paris and Alim 2014). That said, we do not claim to present a fully replicable college teaching model here. Instead, we enthusiastically share our initial impressions, planting seeds for future studies of adobe making as culturally sustaining pedagogy.

Querencia in the College Classroom: Adobe Making as Culturally Sustaining Pedagogy

Experimental adobe oven work at the PEARL takes place in four student-engaged phases: (1) the harvesting of earth by campus excavation or by purchase, jobs usually carried out by supervised lab interns; (2) adobe manufacture, the construction of hundreds of mini-bricks by novice student participants in GE or introductory classrooms guided by faculty or experienced lab interns; (3) the construction of miniature experimental oven replicas in the PEARL facility by lab interns and upper division anthropology students; and (4) testing for relative thermal mass, a task typically carried out only by supervised PEARL interns under controlled conditions. This study largely focuses on phases two and three, adobe brick manufacture and oven assembly, either of which may be carried out under varying classroom conditions. Gonzalez has employed multiple pedagogical approaches in this vein, organizing activities and assessment by class size and by proportional balance of student majors. Hundreds of CSU East Bay students have now worked to either produce bricks or construct ovens for this project in numerous curricular contexts. That includes students from large lower division introductory archaeology and four-field anthropology GE courses (substantial subsets of the 65-120 typically enrolled), a medium-sized upper division GE archaeology course, ANTH 321: Archaeology of the Americas (enrollment up to 35), and a small hands-on anthropology seminar, ANTH 320: Archaeological Science (enrollment typically under 25). While most oven construction is carried out by students in ANTH 320 and ANTH 321 working under Gonzalez and lab interns, brick manufacture is typically executed by students in the two lower division GE courses under Gonzalez's guidance. Mud bricks sufficient to produce one or more replica ovens are easily manufactured by 30 or more novices in around two hours, including training and cleanup time.

The original instructional purpose for inclusion of these activities in Gonzalez's courses was to expose students to methods of experimental archaeology in the context of the historical American West. For that reason, Gonzalez has not required any form of technical preparation by students in advance of mud brick manufacture or oven assembly. He has, however, assigned Joseph Gallegos's (2017) "Chicos del Horno: A Local, Slow, and Deep Food" in ANTH 321 to help students understand adobe oven use and social significance among Chicanx and Indigenous populations. Formal assessment takes place intermittently after initial instruction, including on-the-fly verbal evaluations of teamwork and manufacturing quality. Students are not encouraged to take any particular cultural tack on the exercise or to expect any specific results in terms of classroom sociality. Gonzalez encourages but does not require students to reach out after class, at office hours, or by email if they feel compelled to comment on the process. Over a dozen mostly Chicanx students have reached out to discuss their personal and familial ties to adobe making over the last several years and many more have left activity-specific comments in their course evaluations. We do not offer any systematic study of those comments here. Instead, we relay a small subset of student anecdotes and oral histories, with consent to share those as well as student names, suggesting that patterns may emerge upon further analysis.

CSU-East Bay student and PEARL intern Krystal (personal communication 2020), whose family stems from the city of Ameca in Jalisco, Mexico, reports that work in our lab space brought her "back to her culture." Her daily physical negotiations with the lab's earthen materials resulted in the resurfacing of personal memories of Amecan adobes and the relations that dwell within them. As she recalls, those mud-brick homes owned by "established families" are well kept and tend to be accompanied by well-constructed earthen *hornos*, akin in shape and size to those of northern New Mexico, while the cement-patched walls of expedient earthen architecture seemed to her, on the other hand, to reflect want. The mud invited her memory, affording reflection on the material in part by its undemanding character. Student participant Vanessa (personal communication 2020) recounts in-class conversations where she and other Chicanx students compared the process of adobe making to the production of tamales in their own family households. Like tamal making, the manufacture of adobe bricks may be carried out by a single individual, but typically is not. *Tamaladas*, as Vanessa notes, are family affairs where a continuous stream of *chisme* (gossip) flows over *masa* (maize dough) and other ingredients as various hands work to combine them.

The physical proximity of student adobe makers and the continuous and relatively undemanding physicality of the process works alongside the required time commitment to produce a sort of classroom *tamalada*. Chicanx personal and social memory flows too, entangled as much in mud as in *chisme*. The work drew Vanessa's mind to stories of the ranch in Michoacán where her grandfather worked making adobes long before her family's migration to the United States. She was grateful for the opportunity to experience a new "connection to [her] abuelo – another way to remember him" (Vanessa, personal communication 2020). Somewhere between *enjarre*, *tamalada*, and conventional lab work, the PEARL's adobe making projects produce a sense of personal investment on the part of many Chicanx students by reaffirming and destigmatizing their material connections to Mexico, past and present. The PEARL's adobe making activities in this way constitute rituals of personal renewal and reconnection to a greater whole. The process is an adobe-mediated exploration of personal identity and community, an imported *enjarre*. Operating for four years now, the PEARL has hired a number of interns and taken in numerous volunteers who, like Krystal, have served as "adobe ambassadors" after their training. Our adobe ambassadors have over that time worked with hundreds of CSU-East Bay students like Vanessa, many of whom are also of Chicanx heritage, facilitating their connection to the research, exploration of identity, and investment in their own education.

Among many of the Chicanx students who hold some direct memory of adobe making or adobe-constructed environments, connections to module material appear to develop quickly, revitalizing Chicanx identities in classroom context. In our experience, Chicanx and other Latinx students whose families have passed down indirect or historical memories of adobe making also tend to leave the module feeling their histories are validated. More than one such student has commented that the work destigmatizes what they prior considered an embarrassing aspect of their family, regional, or national heritage. Looking back unsystematically on our informal conversations with student participants, comments made by those with no prior direct or indirect exposure to adobe or knowledge of adobe making traditions are similar in that they tend to express surprise at the technology's sophistication. Though we did not design the module to achieve this end, group work in adobe making clearly influences Chicanx identity formation for some students (Verduzco Reyes 2017) and holds promise as a powerful culturally sustaining pedagogical practice. It reminds Chicanx students that their histories matter and reinforces the idea that their ancestral knowledge is as sophisticated as any other they may encounter in the college classroom (Garcia 2021).

Informal student feedback having revealed the project's social justice promise, we may now approach things more deliberately, addressing Django Paris and H. Samy Alim's (2014) "loving critiques" of culturally sustaining pedagogies, two of which are especially pressing here. Those include questions of aims and outcomes, in response to which we argue the value of supporting Chicanx identity in a college context where most are first-generation and Pell Grant students with a high statistical likelihood of dropping out (Verduzco Reyes 2017). Paris and Alim also ask culturally sustaining educators to evaluate whether their efforts privilege static heritage practices over understanding how minoritized youth rework their own identities and cultural performances (Waitoller and King Thorius 2016). Setbacks and failures in culturally sustaining pedagogies abound (Puzio et al. 2017) and archaeologists are in an especially precarious position here by the nature of our work. Even as experimental archaeologists, we rely on a static material past to carry out our research, but most of our Chicanx students do not live that reality outside of our classrooms. Gonzalez has worked recently to address this by encouraging students to carry out experimentation tailored to their own interests, including by modes relevant to contemporary green engineering and architectural concerns. That expands the scope of the traditional aspect of this research, but Gonzalez is already working with partners at CSU East Bay's School of Engineering to evaluate the potential for scientifically multi-dimensional adobe oven research. The experimentation's prospects are only made more expansive by consideration of Paris and Alim's critiques, though much more planning, modeling, and interdepartmental discussion must take place before our research team is prepared to offer a teaching model full on. For the moment, we offer only this sketch and invite archaeologist educators to explore and experiment alongside us.

Where Did All the Hornos Go? Our Archaeological Question

Hornos are beehive shaped mud-brick ovens of the sort utilized by the sedentary inhabitants of the American Southwest and Far West after European contact. They represent a shared tradition across the American West, and still dot the historical neighborhoods of contemporary northern New Mexico and populate many historical parks in California as working replicas. Like their architectural counterparts, *hornos* require regular maintenance and may in some neighborhoods be found crumbling away due to accident, neglect, or the action of animals (Gallegos 2017, 155). Since the 1990s, New Mexicanist historical archaeologists have variously argued that archaeological *hornos* represent, alongside a suite of other markers, ethnic Mexican habitation (Carillo 1990), a late Spanish colonial presence (Eiselt and Darling 2017, 203), or Spanish culinary practice more generally (Brinkman 2019, 53). Kelly Jenks (2017, 226) cautions, however, that archaeological features typically associated with Indo-Hispano and *vecino* identities have been the subject of far fewer studies than the New Mexican historical communities that surround them. Some laboratory-based tests exist by which to identify archaeological *hornos*, including inductively coupled plasma-atomic emission spectroscopy (Middleton and Price 1996), but those tend to be oppressively expensive. Moreover, such tests are generally of no use in the field, where macro-level evidence often decides the interpretive fates of archaeological sites, especially in cultural resource management (CRM). Adobe *hornos* range in size but may be very large, close to two meters in height in some cases as well as in base diameter, with walls that often incorporate unmodified architectural adobes. Few guidelines exist by which to distinguish *horno* walls from the adobe walls of architectural features by field archaeologists, and related research reports are effectively non-existent outside of gray literature. The need to draw the distinction in the field is especially pressing in CRM contexts, where excavation units tend to be small and related decisions are made based on the character of features as they are uncovered in excavation.

We may never know how many *horno* walls have been conflated with adobe architectural features in the Southwest and Far West as a result. If we are to take the presence of adobe *hornos* in either region as indicative of the presence of any particular ethnic population, then we ought to possess a toolkit that will allow us to recognize one when we see it. Archaeologists in New Mexico and California typically reinvent the wheel in *horno* identification by site, but most cite some combination of feature circularity, burned adobe, charcoal and ash, rock lined floors or foundations, and the presence of some horizontal aperture as evidence of function (Burghardt 2014, 60; Dorsey 2012, 54–55; Phillips 1988, 128; Van Wormer and Walter 2012, 118). In cases where excavation may follow such features to their termination, those properties might alone serve as a good basis upon which to make the call. Archaeologists are not often so lucky, however, especially in CRM and in the earliest phases of the academic archaeological process. We aim to develop some remedy by exploring evidence-based modes of macro-level identification of adobe ovens in the field. We propose to do so by the production and experimental heat testing of miniature adobe ovens made in the historically popular beehive *horno* style that has dominated earthen oven construction in the Southwest and Far West since the colonial era. We aim, as suggested in earlier sections, to engage college and K-12 teachers and students in the process, building preliminary testing ovens and templates at the CSU-East Bay PEARL laboratory to distribute the search for an experimental answer to our archaeological question.

Querencia Science: The Experimental Answer

Ethnographic evidence indicates that Southwestern Chicanx *horno* users are either *horno* makers or articulate technological needs to makers (Gallegos 2017; Rodriguez 2016). While it is impossible to upstream that assertion very deeply into the past without risk of interpretive error, we have no historical or archaeological reason to doubt that such was the case. In addition to assuming communication between *horno* users and makers, our experimental design considers the need for maintenance of consistent cooking temperatures. Bread baking, for example, requires gradual heat dissipation for at least one hour per batch, turkey roasting requires similarly slow heat loss for up to three hours, and the same goes for traditional corn roasting, where ears may stay in as long as twelve hours (Gallegos 2017). We suggest here that the constitution of adobe employed in historical *hornos* may thus not always have mirrored that of its architectural counterparts, as the aims of architectural adobe construction tend to be very different from those of oven construction. Historical *horno* makers probably preferred adding materials to adobe that slow the rate at which heat escapes from *hornos*. Architectural adobe additives[1] such as straw, rock, manure, ash, cactus mucilage, and animal blood, among numerous other types, serve various purposes, including maximizing mechanical strength, minimizing seismic susceptibility, and maintaining low thermal conductivity. The thermal conductivity of a material is the rate at which heat flows through it and the quality of construction materials is judged by contemporary engineers based in part on that metric, depending on material use. In house architecture, for example, low conductivity materials tend to be preferred over those of high conductivity for maintenance of warm internal temperatures during cold seasons and of cool temperatures during hot ones (Bahobail 2012; Dao 2018;

[1] We follow the adobe engineering literature, using the term "additive" rather than the archaeological term "temper," to encourage the utilization of the methods presented here in the green engineering academic community.

Russell 2015, 23). The engineering literature is bursting at the seams with comparative analyses of adobe conductivity by additive type and amount due to a renewed interest in sustainable construction methods (Abanto et al. 2017; Bahobail 2012; Calatan et al. 2015; Dao 2018; Revuelta-Acosta et al. 2010; Russell 2015).

Interest in the relationship between adobe additives and thermal conductivity in archaeology and preservation has not kept pace, but the conversation is gaining traction, however slowly (Forget and Shahack-Gross 2016; Martinez-Camacho 2008). As far as we are aware, no archaeological studies have explored the thermal conductivity of historical, contemporary, or experimental adobe ovens to pin down related concepts of optimal construction. The PEARL recently initiated a program of adobe construction and testing that aims to do exactly that by experimentation with laboratory-manufactured adobe ovens. Those tests involve oven heating by a built-in portable propane stove, followed by a period of electronically tracked cooling by digital thermometer. Alongside numerous college students, we constructed three propane-powered experimental *hornos* in the beehive style using adobe mini bricks (Figures 1 and 2). Our experiment teams, composed largely of Chicanx PEARL interns, excavated the earthen material used in *horno* construction on campus, all of it from the same clay loam deposit. The interns helped to determine the experiment parameters, exploring relevant ethnographic, archaeological, and engineering literature. They settled on construction of three ovens, with one containing straw (SO), another containing pea gravel (GO), and the other unamended (UO), with no integrated additives. We provide additional details as to adobe manufacture, construction, and additive properties in a section below entitled "The Blueprint: Building Community One Brick at a Time."

In ethnographic use, adobe *hornos* are typically loaded with wood fuel through a front facing aperture. The wood is burned to embers and ash behind a wood or stone shield that largely seals the aperture. The burning wood heats the oven floor and walls by contact and the oven interior and roof by convection. Wood smoke escapes through an exhaust port usually located at the rear of the *horno* near the top. Once an appropriate temperature is achieved, judged either by thermometer or by user experience in traditional cooking practices, ash, embers, and charcoal are usually removed unless a recipe calls for their continued presence. The user then seals the exhaust and again covers the front-facing aperture, in both cases using one of various techniques (Gallegos 2017, 153). PEARL construction teams embed two ultra-portable butane camp stoves at the interior base of each experimental oven, allowing for reliably gradual and generally even heating while preventing any buildup of ash and charcoal. The experimental *horno* aperture is sealed by a wooden door during the initial heating period, mirroring traditional heating methods. Temperature recording begins within two minutes after the oven base reaches 215° C (419° F), during which the gas stove is cut off and aperture and exhaust are both sealed. The experiment team seals the exhaust with a form fitting earthen stopper and loosely covers the aperture using a custom-built wooden door, complete with aluminum heat shield. Thermocouple probes placed in bores located at various points across the oven surface record temperature at fifteen second intervals over the course of an hour's cooling. The resultant dataset allows for the comparison of cooling rates across oven types.

Figure 1. PEARL experimental *hornos* (bottom) and mini-bricks (middle right) in storage. Photograph by Albert Gonzalez.

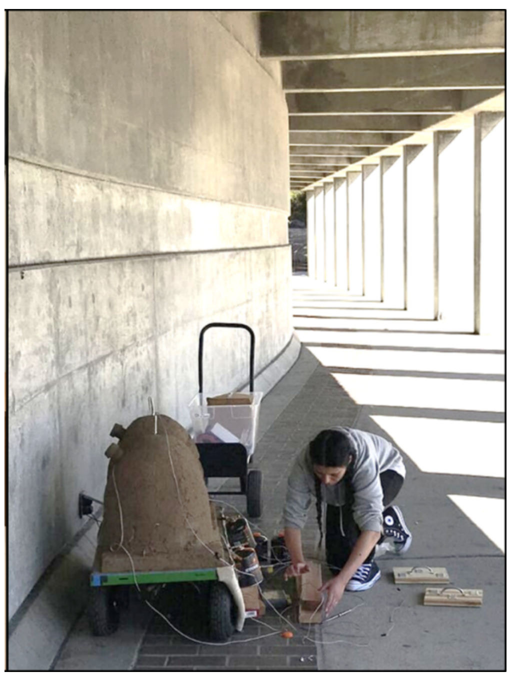


Figure 2. Heat testing of experimental *hornos* carried out by co-author Marina Day Hernandez. Photograph by Albert Gonzalez.

Toward an Archaeological Signature: Discussion of Horno Test Results

PEARL interns carried out seven complete oven experiments in all, an impressive number for a single semester considering the Facilities and Risk Management permissions required for outdoor experimentation at CSU-East Bay and the logistics involved in trucking the ovens across campus for use. They initiated heating and cooling cycles for GO twice, UO three times, and SO twice, in all cases without incident (Figure 3). This analysis averages the temperature recordings taken during experimentation by oven type, comparing the heat retention performance of the three ovens against one another. In just under an hour (all ovens were tracked for 59 minutes and 15 seconds), GO went from 215° C to 101.4° C, representing a difference of 113.6°. From the same starting point and over the same amount of time, UO cooled to 92.7° C and SO to 81° C, falling in temperature by 122.3° and 134°, respectively. Our gravel oven (GO) appears to retain heat most efficiently of the three, as determined by Tukey HSD test where $p < .05$ in comparison both to UO and SO (Figure 3). This suggests that gravel additive may appear in association with archaeological *horno* remains more often than such remains may be found with no additive or with incorporated straw. GO's unamended counterpart trails it by a negative temperature difference at end of recorded cooling phase of 8.7°. The difference in cooling rates between gravel and straw ovens is even greater at a 20° difference at the end of the recorded cooling phase, making it possible that *horno* making traditions, as they are represented by archaeological signature, may have leaned historically toward gravel additive over straw. We cannot discount the potential archaeological implications of the difference between unamended and straw oven types in this vein either, as their final temperatures varied by 11.7°. The unamended oven remained warmer than the straw oven, indicating that archaeological *horno* remains are more likely to reflect an absence of additives over the purposeful incorporation of straw.

Temperature change tends to follow a similar pattern across all oven types in our tests, characterized by exceedingly rapid cool down during the first fifteen minutes after oven shutoff followed by a decline in the rate of cooling (Figure 4). The initial drops are precipitous, as GO temperature falls an average of 4.3° per minute over that time, UO by 4.9° per minute, and SO by 5.9° per minute. All oven types cool much more slowly during the last three-quarters of the recorded period than the first, however. The relative speed of cooling shifts between ovens during the later periods as well. SO goes from cooling off most quickly among the three to cooling off most slowly while GO transitions from the slowest cooling oven to maintaining a comparatively brisk pace of heat loss. UO holds a comparative pace all the while. By the final quarter of the recorded period, the gravel-embedded oven loses 0.8° per minute, the unamended *horno* loses 0.6° per minute, and the oven containing straw additive loses heat at a rate of 0.5° per minute. The change is a curious one, to say the least.

The shift in relative cooling rates between quarters two and four in the cooling process impacts our archaeological conclusions to some degree. In locations where *horno* makers and users found gravel more difficult to come by than fuel, for example, their potential employment of greater relative volumes of fuel wood or charcoal may have served to produce much higher initial temperatures and, despite the drop predicted here, a similar net effect in terms of heat efficiency. We plan to test for the possibility in the future by heating our ovens to increasingly higher temperatures and by recording for longer periods to develop a better sense for the settling of cool down rates. A number of other factors warrant caution in our interpretation of the data produced by PEARL *horno* tests, including the need for testing of additional additive types such as animal blood, manure, or cactus mucilage, with earthen materials of varying particle size proportions, with varying exhaust stoppers and doorway seal types, and of heating with varying food mass types present. We expect, however, that our interpretations will change over time as we work to distribute experimentation, farming replication, and the construction of new mini *hornos* out to Bay Area elementary schools and other interested institutions.

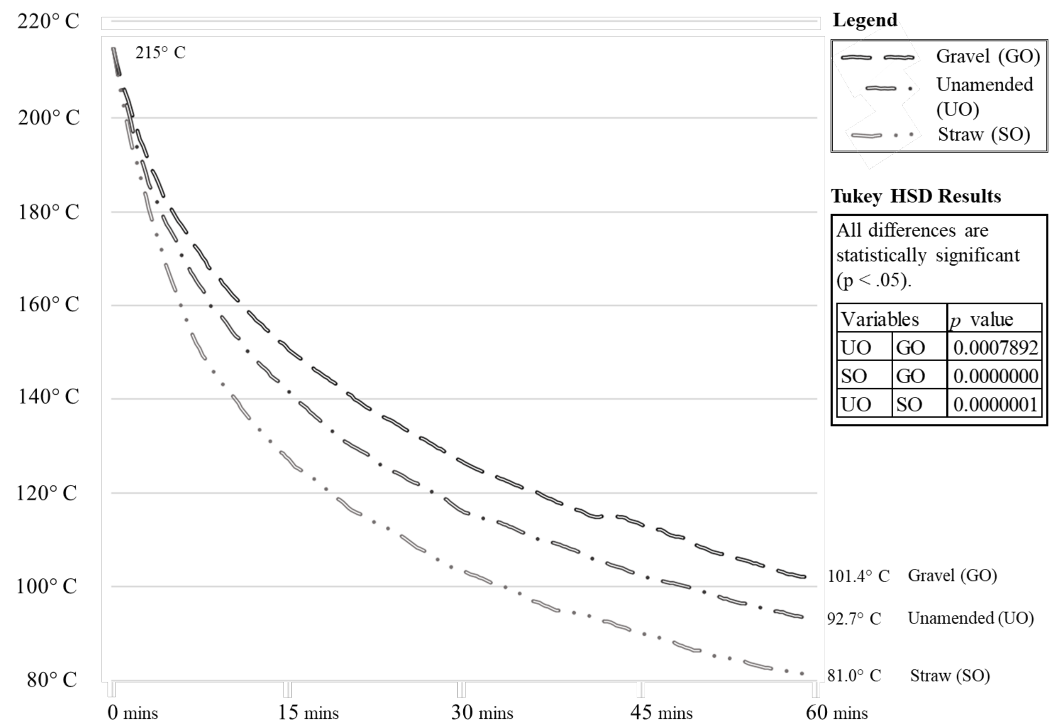
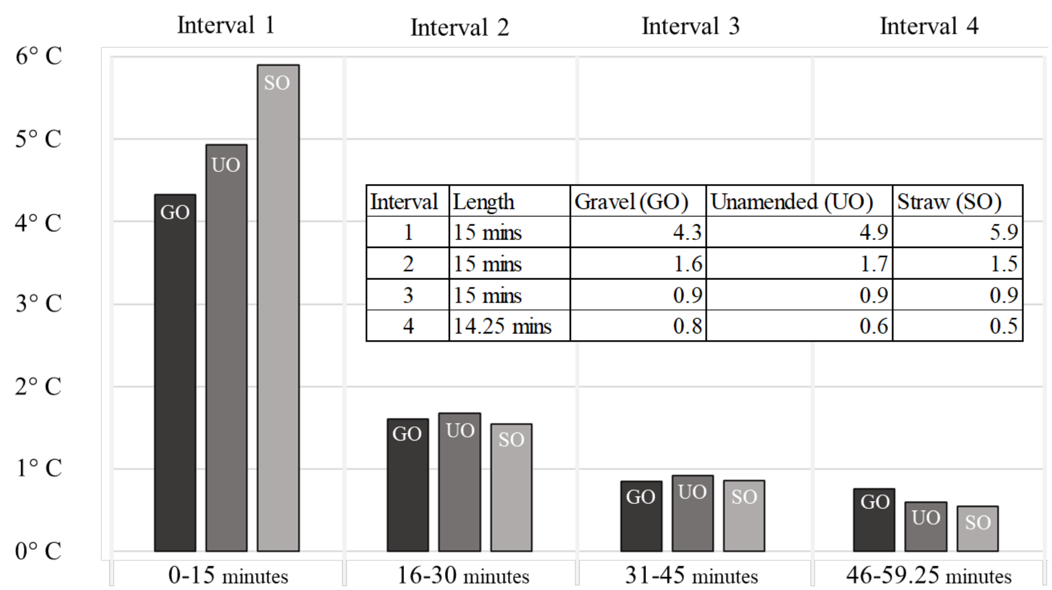


Figure 3. Temperature decrease after oven shutoff by oven type (gravel, unamended, straw).



Interval	Length	Gravel (GO)	Unamended (UO)	Straw (SO)
1	15 mins	4.3	4.9	5.9
2	15 mins	1.6	1.7	1.5
3	15 mins	0.9	0.9	0.9
4	14.25 mins	0.8	0.6	0.5

Figure 4. Comparative cooling rates for experimental *hornos* by cooling interval.

Distributed ChicanXperimentation: Querencia in the Elementary Classroom

The PEARL team is currently working to develop long-term relationships with teachers in elementary schools across the San Francisco Bay Area so that we may expand our investigation parameters. We also aim to inculcate a similar sense for Chicanx social memory and community among K-12 teachers and students as currently exists among our Chicanx college student participants. The Bay Area's various county health department distancing mandates made this imperative very difficult to fulfill for nearly two years during the COVID-19 pandemic, during which time we could not train teachers in groups, send PEARL interns to elementary schools for site visits, or even expect the kind of close physical proximity that brick manufacture and construction require. Making up for lost time, we are working with CSU-East Bay's Department of Teacher Education to train new teachers to incorporate the project in their classrooms with the assistance of PEARL interns. Current collaborative efforts reveal that most *horno* making and testing steps are easily accomplishable by children at or over the age of eight years with limited teacher and adult-volunteer intervention after initial training. That point is proven yearly by the extremely broad age group participation that characterizes northern New Mexican *enjarre* events. We aim to produce a robust citizen-science program over the next several years that serves as a vehicle for Chicanx engagement in STEM education at various levels. We have identified grade four as an ideal starting point because of overlap in the aims of the California Department of Education's (CDE) content standards in history and social science for that year with our research and community service interests. The CDE requires that fourth graders develop an understanding of the cultural and economic life of the state's various historical populations between pre-Columbian and Mexican Rancho periods (CDE 2000, 12–13). The priorities of the CDE's fourth grade Next Generation Science Standards overlap neatly with our interests here as well, as California fourth graders are expected to gain exposure to the scientific concepts of energy, matter, and energy transfer (California Department of Education 2013, 11).

Despite the persistence of California's centuries-old adobe making tradition into the present, the project will represent the point of first encounter with adobe materials for most participating California fourth graders. By exposing fourth graders to the engineering realities of adobe making and by connecting the topic to California Chicanx histories, we help to de-stigmatize an otherwise seemingly "primitive" technology, empowering Chicanx students in particular. The connection made by the project to Mexican and Borderlands history expands the *enjarre* model that much further, branching impact from the college classroom to its elementary correlate. The project also affords the field of experimental archaeology the opportunity to lay its own unique claim on the citizen-science revolution, adding a cultural element to related community building while exploring its own scientific effectiveness in the hands of "kid-scientists" (Miczajka 2015). Scholars of elementary classroom citizen science tend to place a high premium on the development of "science identity" among marginalized student populations, challenging their practitioners to devise modes by which to make science culturally relevant and even sustaining (Bonney et al. 2016, 13; Committee on Science Learning 2007, 201; Jordan et al. 2015, 209–210). We suggest that bringing practices of *querencia* placemaking such as adobe making and construction into the elementary classroom will go far toward resolving the dilemma as it pertains to many Chicanx students. Ethnic community building is, furthermore, a largely unexplored outcome of citizen science practices. The Ten Principles of Citizen Science, an oft-cited document produced by the European Citizen Science Association (ECSA) is quiet as to the potential for culturally sustaining and community building outcomes that may result from citizen science efforts (Hecker et al. 2018, 28–40). Even the movement for the transition from contributory citizen science to community science, one characterized by the co-creation of knowledge between scientists and community members, has produced relatively few related suggestions, leaving a yawning space for our exploration (Wandersman 2003, 231; Wiggins and Crowston 2011, 2). In order to facilitate that mode of exploration and experimentation, we offer an overview of the blueprint for the construction of our experimental ovens below and a brief primer as to methods. We embed this blueprint here with two aims in mind: (1) to facilitate and advance the emergence of our own future K-12 partnerships, where it may serve to guide the technical side of those partnerships in action, and (2) to encourage readers, their institutions, and their students to improve our research by building their own experimental ovens and choosing unique parameters in consultation with our team.

The Blueprint: Building Community One Brick at a Time

For participants in the Bay Area, our blueprint (Figure 5) for experimental oven construction requires purchase of only a few cheap and readily available commercial components, as the PEARL may supply pre-made bricks or earth from our campus borrow pit. Depending on the additive option chosen by participant educators and their students, those components may include organic wheat straw, unpigmented natural aquarium gravel of any brand packaged by the Estes Company, sealed food containers capable of producing adobe bricks of 8 cm x 11 cm x 4 cm dimensions, a 3500-watt gas fueled backpackers' stove with heat proof hose, and an empty 12-ounce Red Bull soft drink can. The sealed food containers may be purchased from the discount chain retailer Daiso, of which there are sixteen locations in the San Francisco Bay Area. The aquarium gravel we use is widely available, as the Estes Company currently holds a 90% market share (Rick Dunnahoo, personal communication 2020). Their subangular gravel is composed of felsic rock, largely quartz and orthoclase feldspar, and is not well sorted, ranging between 2 mm and 1 cm in diameter. The PEARL will provide Bay Area teachers and other nearby participants with earth harvested and screened on the CSU-East Bay campus if they prefer to mix their own bricks. Otherwise, the laboratory keeps pre-made bricks ready for distribution at no cost to the participant. The earth used in constructing our ovens is of the following rough particle size proportions: 75% sand, 5% silt, and 20% clay. A garden cart, rolling cart, or end table of proper dimensions (Figure 5) may be employed as platform upon which to construct an oven, with platform height depending upon on the size of the citizen scientists. Our current adobe recipe represents an arbitrary starting point, including 235 g of fully dry earth, 95 mL water, and either 3 g wheat straw or 17.5 g of gravel per wet brick. Three limiting factors governed recipe development: (1) ethnoarchaeological observation, which varies a good deal by tradition, (2) limitations of the PEARL storage space, as larger scale construction is not feasible, and (3) our intent to make replication affordable for any K-12 or other institution interested, with or without our assistance. As long as the project is funded by CSU-East Bay, materials and student personnel will be provided to participating Bay Area institutions at no cost in order to facilitate experimentation.

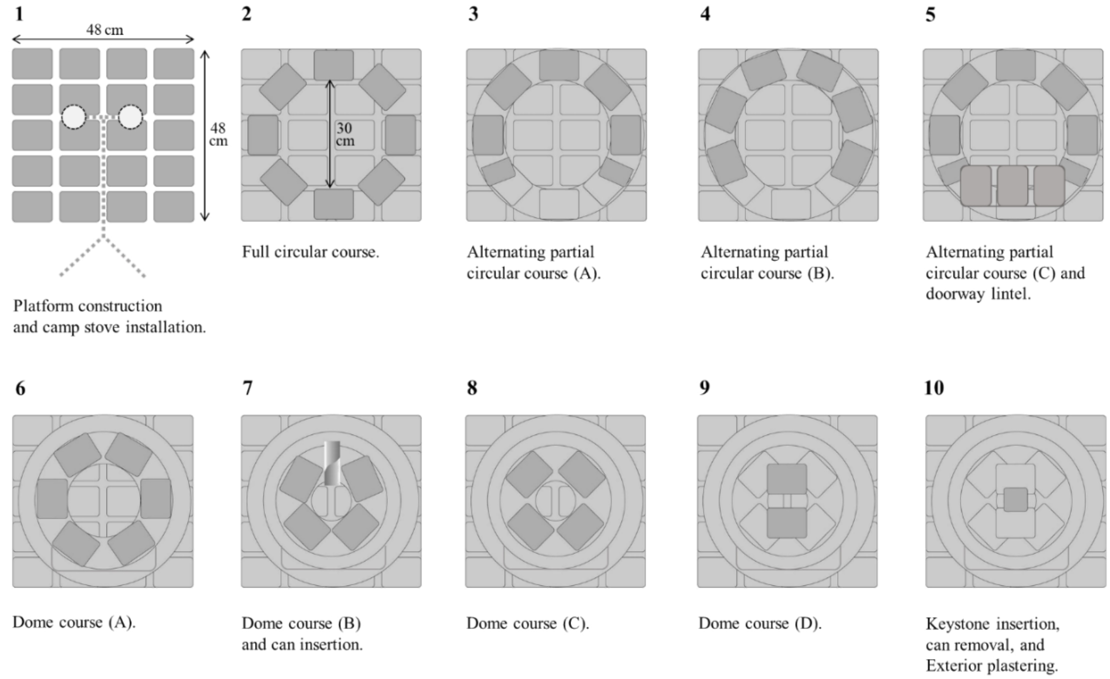


Figure 5. PEARL Experimental *horno* blueprint.

Mini-brick manufacture is a simple process requiring very few tools. Those include buckets, large wooden stirring spoons, sharp fabric scissors, Daiso food containers without their accompanying seals, and a temporary flat surface such as carboard or plywood. That is in addition to the required earth, aquarium gravel, and organic wheat straw. We dry our construction sediment before mixing, spreading it evenly over our flat surface in amounts matching the number of mini-bricks we expect to produce in a particular batch. We allow the material to dry for four days and gently rake it once per day during that time. Students cut straw additive using scissors in pieces less than 3 cm in length to guarantee fit within our very small bricks. Aquarium gravel is not treated. Each bucket is filled with earth and additives to roughly two-thirds of bucket height, containing materials in an amount that is calculated based on the per-brick recipe presented above. We pour the dirt in first, followed by additive, and apply water one to two cups at a time, stirring with each hydration until the mixture is at roughly the consistency of toothpaste. Earth does not always dry evenly across batches, so buckets are hydrated only until the desired consistency is achieved. Students scoop the mixed material out from their buckets into Daiso food containers one spoonful at a time to about 5 mm from the container's rim. We store the wet mini-bricks indoors at the PEARL, allowing them to dry for four days while running a dehumidifier in the space 24 hours a day. Without a dehumidifier the drying process may take as long as ten days and the risk of mold growth increases. Some batches require one to two more days to dry, even with a dehumidifier running.

After the mini-bricks have dried, the construction of the oven's foundation, walls, and dome begins. That process is carried out in multiple courses, with approximately 1 cm of mortar between each, following the steps below (Figure 5):

- Step 1 – we assemble a roughly square foundation course where two camp stoves are embedded using mud to affix their feet to the foundation;
- Step 2 – we lay one fully circular mini-brick course at about 42 cm in exterior diameter;
- Steps 3 to 5 – we put down three stretcher bond courses with ends terminating to form the oven aperture (including expedient use of two bricks cut in half lengthwise), afterwards we apply a pre-made 3-brick lintel above the opening and let the structure sit overnight to dry;
- Steps 6 to 9 – we lay four progressively narrow dome courses varying in diameter and number from one to the next with an empty 8.4 fl oz Red Bull can placed between bricks on the oven's back end to produce a hollow section of the wall which serves as an exhaust port;
- Step 10 – we modify a brick to resemble a trapezoidal prism and place it in the resulting space for use as the dome's keystone.

We then apply two even coats of mud plaster over the oven's exterior, adding an average of 1.5 cm of mass over the oven and platform using a 4.5-inch plasterer's trowel, and allow the finished product to dry indoors at the PEARL for at least three days while running a dehumidifier 24 hours a day. Cracks always form but the majority are unthreatening in both structural and experimental terms. We do, however, fill cracks at or over 5 mm in width before first use. We typically custom craft a simple wooden door for each oven with a metal handle, stapling heavy aluminum foil to its backside as a heat shield, to loosely seal the opening. The seal should be imperfect, allowing a small amount of air in, as is the case for full size *hornos*. We use heavy duty garden carts as construction platforms for their portability and load-bearing capacity, but cheaper four-wheeled alternatives such as furniture movers are easily located via online retailers. Alternately, experimental participants outside of CSU-East Bay may choose to dry their ovens in place. The PEARL team is currently working to produce a kid-friendly photo instructional and video tutorial for use by participating Bay Area elementary school teachers and the adobe ambassadors assigned to them. In the meantime, we have carried out some on-campus trainings with teachers in training in the CSU-East Bay Teacher Education program and invite community members, outside teachers, and researchers to join us.

Conclusion: Building Multiple ChicanXperimental Templates

This article plants seeds, looking ahead to the fruits of our three aligned adobe making efforts: a culturally sustaining college teaching model, field application of ChicanXperimental archaeological findings, and expansion of our experimental parameters by elementary age citizen scientists and their teachers. What we know in this moment, however, is that adobe draws people together in negotiation with it as a construction material, facilitating communication and the building of common identity between participants. Among northern New Mexican populations, practices like the *enjarre* capitalize on the community-building consequence of adobe making, in some cases drawing hundreds of people from among extended kin networks to carry out much needed maintenance on community architectural treasures. The PEARL facility at CSU-East Bay works to explore adobe's community building potential among Chicanx students in college and K-12 classrooms, achieving scientific goals with strong potential for practical application in the process. As we see it, the three facets of our project are inextricable for two reasons: (1) for the strong cultural connections between the people whose historical tools we replicate and the students carrying out the experimental replication, and (2) for the instructive example we set in dovetailing our pedagogical findings and our archaeological research results in the same manuscript. Our informal conversations and correspondence with college students involved in the project strongly support the former assertion. Our experimental archaeological research findings, revealing that gravel-amended material outperforms straw and unamended counterparts in thermal mass testing, make clear that culturally sustaining pedagogy and archaeological science are not mutually exclusive things. Though the pandemic put our plans for outreach to elementary school teachers on hold, the PEARL is again fully staffed and back in the business of experimental oven manufacture. We are currently working with two Bay Area elementary schools to pilot the program in the fall of 2024 and look forward to reporting both pedagogical and archaeological results. We hope that this work spurs academic archaeologists, elementary school teachers, and others to explore the various ChicanXperimental templates we've outlined here, inspiring them to work toward answering similar archaeological research questions, to tap Chicanx cultural assets in nurturing related student identities, and to draw culturally sustaining pedagogies into closer alignment with scientific archaeological objectives. There should be a higher premium placed among archaeologists on producing the next generation of Chicanx college graduates. This paper provides several replicable starting points for that journey, most of which are easily employed by non-specialists interested in closing equity gaps and bolstering Chicanx identities.

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