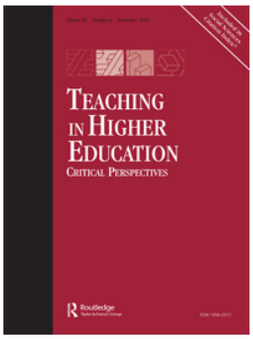

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Epistemic cultures in undergraduate education

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ABSTRACT

In this study, we introduce undergraduate research as a powerful, knowledge-rich experience that may counteract instrumental approaches to teaching and learning. We conceptualise undergraduate research experiences as *socialisation into epistemic cultures*. This paper challenges conceptions of undergraduate learning by suggesting that students can be experientially inducted into ways in which knowledge is produced in a given field. We draw on Knorr Cetina's work on epistemic cultures to demonstrate how students become a part of the 'machineries of knowledge production' as they participate in undergraduate research. We illustrate and develop this conceptualisation with an ethnographic research project in archaeology education. This empirical case exhibits how students internalise, reject and renegotiate the epistemic cultures of archaeology – and how these processes of learning and knowing are thoroughly relational, embodied and affective. Our study emphasises the significant potential of 'other' kinds of learning experiences in shaping students as epistemic subjects.

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Epistemology; epistemic culture; epistemic agency; sociology of higher education; archaeology

Setting the scene: a mystery in an Armenian highland

On a warm May afternoon, Juuso (the first author) arrived in Urtsadzor, Armenia, to conduct an ethnographic project about student learning at an archaeological field project. The trip included students directly participating in archaeological research. This seemed like a fantastic opportunity to uncover how students develop their 'epistemic agency': whether they saw themselves as meaningful contributors to the creation of knowledge. For a short time, Juuso became a part of a group of around 25 undergraduate students from Hong Kong. Together with the students, Juuso dug and processed archaeological data from 6am until 3pm, from Monday to Friday, in the scorching heat of an arid Armenian highland.

After long days at the site, Juuso spent his afternoons unpacking what he had observed about student learning. The project, he realised, provided students an experience of operating as parts of the machineries of knowledge construction. Namely, students not only

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gained relevant experiences of doing research but were embedded in intricate socio-material assemblages of knowledge production, consisting of rules and procedures, clearly defined roles, advanced technologies (such as drones and laboratory equipment) and less advanced but not less essential technologies (such as plastic buckets and toothbrushes).

Participating in archaeological research made Juuso feel proud. He felt a sense of societal responsibility every time he dug out a piece of bone, tried to distinguish pottery pieces from a rock, and scraped off dust to reach deeper layers of a trench. All these actions contributed to archaeological knowledge production, no matter how small or insignificant.

Yet, Juuso's ideas of 'students being parts of machineries of knowledge production' were met with some suspicion by students themselves.

One day, Juuso took a walk with some students. As the conversations turned to their experiences of the project so far, the chirpy mood changed. These students shared that they felt a little disappointed. Juuso was surprised because he had enjoyed his time a lot, and his encounters with the students had been overwhelmingly positive. The students recited various issues: the hours were long, they were not accustomed to local food, they were homesick … However, the students also felt 'they have not actually learned anything'.[1] One of the students opined: 'We are not here to gather any new knowledge. We're just digging. It doesn't really require that much skill.'

What was even more surprising was that the students hoped we could have more lectures – lectures! In the outdoors! Some suggested the instructor could give us quizzes. According to the students, these more traditional approaches to teaching would confirm what they had learned, and perhaps make 'learning' more tangible.

After this conversation, Juuso became sensitive to students' concerns about *not learning* in the project. What exactly was going on?

Introduction: how could undergraduate research foster transformational relationships with knowledge?

The story above illustrates the disparities in how undergraduate education aims to develop students' transformational relationships with knowledge. What is clear from the story is that such 'transformations' may not always occur, or they might not be recognised by students.

How could students be supported to build relationships with knowledge in transformative ways? One common answer relates to knowledge-rich curricula, or 'knowledge-rich degrees', that ask students to 'engage with the world from the perspective of a particular body of knowledge' (Ashwin 2024, 1; see also Annala 2022; Anderson and Hounsell 2007; Barnett and Coate 2004). As Hauke (2019) explains, such approaches to the curriculum reach beyond considering knowledge as an entity that can be 'transferred' and 'learned'. Undergraduate studies can be seen as providing an entry point to disciplinary cultures of knowledge production (Jensen, Nerland, and Enqvist-Jensen 2015). As students start engaging with disciplinary knowledge practices, 'knowledge (…) can change their sense of who they are and, critically, the meaning of being at university' (Ashwin, Abbas, and McLean 2016, 963). Knowledge-rich curricula may cultivate students as epistemic agents who not only 'learn' and 'know' but actively shape the cultures

and structures of knowledge around them (Nieminen, Haataja, and Cobb 2024; Nieminen and Ketonen 2024).

However, in practice, knowledge-richness is often restricted to 'special experiences' such as placements and dissertations (see e.g. Ashwin, Abbas, and McLean 2017). Such was the case with our mystery story above. In the present study we focus on *undergraduate research* as a high-impact practice that provides a compelling venue for 'knowledge-richness' as it asks students not only to analyse but *produce* knowledge (Manathunga et al. 2012). We refer to undergraduate research as 'opportunities for learners to work on scientific research with practising scientists', often in laboratories and field sites (Sadler & McKinney 2010, p. 43). Namely, students not only complete predetermined assignments but engage in authentic fieldwork as a functional, autonomic part of a research team, receiving a view of how science is 'really' done (Sadler & McKinney, 2010, p. 43).

While undergraduate research projects have been studied extensively (Ahmad and Al-Thani 2022; Linn et al. 2015; Palmer et al. 2015), there is a need to explore their 'complex and intangible benefits' for students beyond immediate learning outcomes (Haeger et al. 2020, 66). This is precisely what our study focuses on, as we theorise and illustrate whether and how undergraduate research experiences may socialise students into the epistemic cultures of their respective discipline. In theory, undergraduate research seems like a perfect candidate for promoting students' transformational relationships with knowledge, as in these experiences, students are supported to understand the underlying organising principles of different forms of knowledge in their respective field and their associated knowledge practices. In practice, as our mystery story above shows, transformations of both students and knowledge do not occur automatically, not even when students are explicitly asked to take part in scholarly knowledge construction.

To understand the nuances of how students engage with knowledge in undergraduate research, we position these experiences within the broader global contexts of higher education that are increasingly evaluated by economic rationales and employability agendas rather than by knowledge (Annala 2022; Ashwin, Abbas, and McLean 2016; Rosenblad and Wheelahan 2025). Universities are commonly portrayed by critics as shifting away from a core mission of knowledge production, and the mission of engaging students with bodies of knowledge, as their mission is framed in economic and instrumental ways. The question is, then, how undergraduate education may promote students' transformational relations with knowledge in such contexts?

Research objective and significance

This study conceptualises undergraduate research experiences as a powerful (yet imperfect) way of socialising students into the epistemic cultures of their disciplines. This idea is illustrated with ethnographic material deriving from a project in archaeology education, part of which we have introduced in the vignette above. We explore the 'black box' of students engaging with knowledge construction and analyse whether and how these moments of engagement are transformative.

This paper challenges conceptions of undergraduate learning by suggesting that students can be experientially inducted into ways in which knowledge is produced. This study supplements earlier work on undergraduate education as a venue to promote

students' transformative relations with knowledge (e.g. Ashwin 2024; Barnett and Coate 2004). We bring conceptual and methodological depth to this area of research by drawing on Knorr Cetina's work on epistemic cultures and by using ethnographic methods to capture student engagements with such cultures. This research project was also rather intercultural, providing an intriguing context to study the cultural aspects of knowledge production. Moreover, the project had an orientation towards societal responsibility as it aimed to foster cultural heritage. We anticipated that this could help the students feel ethical responsibility. While epistemic cultures have been studied prevalently in science (Knorr Cetina 1999), it is important to understand them in the humanities and social sciences due to their specific knowledge structures (Luckett and Hunma 2014).

Theoretical background: epistemic cultures and agency

We rely on Knorr Cetina's (1999) concept of *epistemic cultures*, which she presents as structural features of knowledge societies, to theorise how undergraduate research could engage students with knowledge production. Epistemic cultures are 'those amalgams of arrangements and mechanisms (…) which, in a given field, make up how we know what we know' (Knorr Cetina 1999, 1). More precisely, we draw on the following definition:

> The notion of epistemic culture is designed to capture [the] interiorised processes of knowledge creation. It refers to those sets of practices, arrangements and mechanisms bound together by necessity, affinity and historical coincidence which, in a given area of professional expertise, make up how we know what we know. Epistemic cultures are cultures of creating and warranting knowledge (Knorr Cetina 2007, 363).

Whereas Knorr Cetina's work has unfolded epistemic cultures in science contexts, we apply this knowledge in the context of undergraduate education. Undergraduate students are only occasionally given opportunities to engage with the machineries of knowledge production that Knorr Cetina writes about. Typically, such experiences are restricted to undergraduate research projects, dissertations and placements. We portray undergraduate research as a powerful means for students to 'enter a specialised knowledge domain … by taking part in the knowledge practices characteristic of their area of expertise' (Jensen, Nerland, and Enqvist-Jensen 2015, 126). While it is typical to think that taking part in knowledge construction should be reserved for those who already possess a significant amount of knowledge, we explore undergraduate research as 'an entry point into the epistemic culture of a profession' (Sellberg and Solberg 2024, 77).

The analytical lens of epistemic cultures allows us to understand the social, material and embodied settings, interactions and practices through which students are socialised into such cultures. By examining epistemic cultures, we thus shift our gaze to the spaces, artefacts, objects and tools that are at play in the knowledge production processes of archaeology.

In addition to its focus on epistemology, epistemic culture calls attention to its latter part: culture. Knorr Cetina (1999) used this concept to bring questions about culture into the centre of conversations about knowledge production. Whereas research has typically been seen as a rational and technical process, epistemic cultures provide a lens to understand the social and cultural aspects of how knowledge is produced (Knorr Cetina 2007).

The level of analysis is very particular here, as epistemic cultures grasp a level of practice rather than the level of symbols and meanings (Knorr Cetina and Reichmann 2015, 873). This means that analysing epistemic cultures should target particular observable practices in knowledge settings and how they unfold in socio-material assemblages.

By participating in these machineries of knowledge production, students are shaped as *epistemic subjects* by the practices, spaces, tools and objects of knowing (Nieminen, Haataja, and Cobb 2024; Nieminen and Ketonen 2024). Following the formulation of Zehner and Durán Del Fierro (2024), the machineries of knowledge production could be portrayed as 'infrastructures of becoming' (2) that can be characterised as socio-material spaces of subject formation (see also Malazita and Resetar 2019). Asking students to take part in epistemic cultures is then seen as a thoroughly ethical practice, as students must position themselves not only to knowledge and knowing but to the broader socio-political networks of knowledge production. For example, students might take part in conversations about the politics of science and the potential power imbalances and ethical dimensions related to scholarly activities (Malazita and Resetar 2019).

Project description and materials: ethnographic methods with socio-material sensitivities

Describing the project

The study was conducted as a part of the Ararat Plain Southeast Archaeological Project[2] (APSAP), in which students participated in a research project in Urtsadzor and Vedi, Armenia, as a part of an accredited course at the University of Hong Kong (Cobb, Cobb, and Azizbekyan 2022; Cobb et al. 2024). The second author managed the project. There were approximately 25 undergraduate students, five postgraduate student tutors, and volunteers or collaborators from Hong Kong and Armenia. The student participants mainly majored in arts and humanities.

Perhaps the best way to describe how the project looked in practice is to explain a typical day in Armenia. Every weekday, all participants engaged in data collection, preservation and storage. Each day was divided into two parts. The first part lasted roughly from 5:30am until 12:30pm, including transportation to and from the site. The early time is explained by the hot climate. Around half of the participants jumped into cars in the morning and drove to the *digging site*, while the other half stayed at a *laboratory* to collect data about objects. By 12:30pm and up to 3pm, all participants worked together in the laboratory.

The digging site had three *trenches* where the excavation occurred, each measuring precisely 10 by 10 metres. The most excavated trench can be seen in Figure 1. Each trench had an assigned postgraduate student responsible for managing students' work there. For around six hours a day, with breaks, a group of 4–5 students was assigned to each trench to dig. Digging was done with various tools one can find in a garden: shovels, trowels and buckets.

What exactly were we digging? The rule was: anything related to the *humans* who lived in this area. Most commonly, this meant pottery pieces among stone walls. We found plenty of bone fragments likely belonging to animals, and some worked stones. Each one of these artefacts was stored and digitised. The dirt from the trench was placed in a bucket and sieved to ensure all the relevant artefacts were identified.

Figure 1. The most-excavated trench, on top of of the archaeological site.

As we were digging, every artefact we found was stored in a plastic bag with a label for the *context* of this object. 'Context' means the specific place where the object was dug from, three-dimensionally. Every day, the contexts dug that day were digitised, meaning that the trench can be digitally reconstructed later. In other words, a geolocated 3D model was captured at the trench using photographs and differential global navigation satellite systems (dGNSS), like the Global Positioning System (GPS).

The other part of the project was spent in the laboratory. Half of the group worked there in the morning, and everyone gathered to work on the laboratory activities in the afternoon (12:30-3pm). The project was managed from this laboratory, which sat in a private home located at the edge of Urtsadzor. This building held all the project's material datasets – basically, everything that was dug out from the ground.

The data was processed in the laboratory. There were two essential tasks. The pottery pieces and other artefacts were washed. This was done using brushes of various sizes, such as toothbrushes. Figure 2 illustrates one pottery washing station. All the materials were individually photographed and weighed for digitisation. Pottery pieces were also captured with photogrammetry to later produce 3D models of the artefacts.

The project involved a few 'formal' moments of teaching. Peter held an introductory lecture about the project, but besides that, 'teaching' occurred via an apprenticeship model in the field. In the second week, all students participated in a pottery workshop facilitated by locals.

Figure 2. A pottery washing station.

Before arriving in Armenia, the students completed some coursework to ensure they shared essential foundations about the project. Students met on the university campus to learn about the trip, including from prior summer undergraduate attendees. Next, they had a live online training session to learn how to create 3D models from 2D photographs. After this training, each student had two assignments to create their own 3D models of any two outdoor spaces. They were provided detailed feedback on their modelling process and results after each submission, to help them improve. Students were also invited to a public education event where they could virtually visit the site in Armenia through a virtual reality (VR) experience. Using the communal learning platform Perusall, students watched and discussed a two hour lecture about archaeology and the project. Before and during their time in Armenia, they also used that platform to read and discuss a series of short articles about both archaeological practice and the ancient past of the region.

Data generation and analysis

Before the project, we obtained ethics approval from our university (HKU EA210522). The participants were asked for consent to participate, and we avoided capturing data of those who wished not to participate.

This study draws on short-term ethnographic research methods (Pink and Morgan 2013). Ethnographies have been used to understand how humans enact and reproduce

cultures, making it an adequate method to explore epistemic cultures (Knorr Cetina 1999). The ethnographic fieldwork lasted for two weeks. Many ethnographic projects are defined by long-term engagement with participants. In contrast, short-term ethnographies involve 'intensive excursions into [participants'] lives', using 'interventional as well as observational methods to create contexts through which to delve into questions that will reveal what matters to those people in the context of what the researcher is seeking to find out' (Pink and Morgan 2013, 352). Indeed, the two-week period Juuso spent in Armenia was physically and mentally intensive. In intensive, short-term ethnographies, the ethnographer 'implicate[s] her or himself at the center of the action, right from the start, and engages participants in the project with this intention clearly stated' (Pink and Morgan 2013, 355).

The first author spent two weeks at the site and participated in all the activities with the students. He recorded his experiences continuously; however, his primary purpose was to be helpful to the project. When he had the time (and available hands), he recorded situations by writing fieldnotes, following the guidelines by Emerson, Fretz, and Shaw (2011). The fieldnotes were written and audio-recorded digitally on the phone. Each day, he reviewed the data material and recorded reflections (approximately 30 min) of what he learned about epistemic cultures. Based on these reflections, he wrote final memos (Emerson, Fretz, and Shaw 2011). He also took pictures (approximately 70–100 per day) and videos (approximately 8–10 per day, differing between 1-20 min). He recorded several informal conversations with the students, tutors and teachers. Nine students were interviewed 'formally', meaning that time and place were arranged for this outside working hours, and four students were interviewed about their longer-term memories of the project two months later.

This ethnographic data was analysed using Knorr Cetina's concept of epistemic cultures. The first author led the data analysis, with the second author providing further interpretations and counterpoints through a dialogical process. Following Knorr Cetina (1999, 2001, 2007), we focused on the level of practice, paying attention to whether and how these practices transformed students. The process followed the three stages outlined by Reeves et al. (2013): description, analysis and interpretation. All stages were socio-material in nature: they aimed to untangle the material infrastructures of knowledge production (Roehl 2012). First, the datasets were described by recounting what happened, when and how. This stage remained at the level of objects, artefacts and practices, by locating them in the various sites of the project. Next, the data was analysed inductively by 'examining relationships, factors and linkages across the data points' (Reeves et al. 2013, 1370). We paid closer attention to what the human and non-human agents and materials *did* in the project; what their boundaries and relations were, and how they affected each other. Finally, we weaved the material nodes and relations into three complete sets of stories. Due to the word limit, we have constructed these stories around our interpretation of what happened. However, we also provide various descriptions of our data to allow the reader to contest these interpretations.

Limitations and ethical issues

Several limitations and ethical issues should be mentioned. The short timeframe of two weeks is an obvious limitation. This choice was made due to ethical considerations. We

did not want the educational project to be intrusive for students; after all, the project was already an emotional experience for them. This study relied on extensive immersion, meaning that the first person mediates the knowledge production of this study with his history, background, culture, and language. We have aimed to protect the anonymity of the participants by not reporting the exact year of this project and by restricting information about the students.

Findings: epistemic cultures in the field

Here, we introduce an imperfect set of stories that, woven together, aim to illustrate *how students were socialised into the epistemic cultures of archaeology*, or why these processes were left undone. These stories pay particular attention to non-human agents, spaces, objects and materials taking part in knowledge production. Some materials, such as trenches, buckets, sieves and tutors play roles in multiple stories; some deserve their spotlight in one of them. Each story emphasises how these machineries shaped students as epistemic agents.

The first story brings the reader directly to the archaeological site. In fact, it starts from our very first day in the project, in the Armenian highland where the excavation took place.

'What do you see?' human observation and interpretation in archaeological knowledge construction

It is the first day at the digging site. After taking a walk around the area and introducing the three trenches, students are given a spontaneous 'miniature lecture' by Peter (wearing a pink shirt in Figure 3). We are facing the Vedi Valley.

Peter: What do you see? (points to the valley) Archaeology is all about observations.

(silence for a while)

Peter: What do you see? Don't be shy …

(a long silence, the students stare at their feet … until finally, one speaks out)

Student: (points at a pile of rocks in the valley) These rocks …

Peter: Yes! Thank you. I have no idea how the rocks ended up here. It looks like they are piled up. Now, look at everything from a different angle. See if your perception changes.

(students walk around and have a look at the rocks)

Peter: What might this formation be?

(silence)

Peter: Humans like to put rocks in a line. This is what we call a wall.

(*fieldnotes*)

The excerpt above is an adequate way to start unpacking our findings. This moment, where Peter constantly asked students to *see*, demonstrates the knowledge structures

Figure 3. What do you see?

of archaeology that were made visible throughout the project. Archaeology belongs to the humanities and social sciences, meaning that many parts of the knowledge production process depend on human observation and interpretation. As the excerpt above shows, the students were asked to participate in knowledge production processes that differed quite a bit from those that occur in the scientific venues of, say, biochemistry laboratories or at Large Hadron Colliders (as in Knorr Cetina 1999). Asking students to 'see' made it clear from day one that students' own, active observations and sensemaking processes were to play a crucial role within the knowledge production processes of archaeology. Following Knorr Cetina (2001), human observations and further interpretation became a part of the machineries of knowledge construction of archaeology. In this section, we unpack how human observation and interpretation interact with the non-human objects in knowledge production, and what students made of such situations.

From the early moments of the project, Peter socialised the students into making observations. Human observations – on many scales, differing from vast landscapes to tiny pieces of pottery – were a central epistemic practice that students started practising from the moment they entered the site. Observations could be seen as epistemic practices that 'bring together the world of non-human objects with human contexts and processes' (Knorr Cetina 2007, 365) by initiating and sustaining the various networks of knowledge practices and objects that produce knowledge. In the excerpt above, Peter is showing the students how archaeologists initiate a knowledge production process by 'seeing': by bringing into focus particular material elements in the environment that might require

different angles and viewpoints, but also common sense, as in the humorous case of how 'humans like to put rocks in a line'.

So, to produce knowledge in archaeology, the students had to learn how to see. The apprenticeship model of the project was a key epistemic practice through which students learned to make proper observations and, as such, operate as active human agents within the epistemic cultures of archaeology. Sometimes, the model manifested through spontaneous 'miniature lectures' as in the excerpt above. These were not planned situations but occurred when one of the participants noted something worth discussing. These moments made the 'rules of the game' visible: 'Archaeology is all about observations.' The students were not asked to make observations in the traditional sense of 'professional vision', as outlined by scholars such as Goodwin (1994) (who also worked with archaeologists!) as 'organized ways of seeing' (606). Rather, they were asked to bring relevant materials and objects into the focus of inquiry, but more than that, observation initiated a complex coordination of epistemic practices and objects (following Knorr Cetina 1999, 242). Later on, an archaeologist would utilise shovels, dGNSS devices, drones, and computers, but all that started from a human observation: seeing.

Throughout the project, students were constantly asked to observe and to combine the various 'data points' they observed by using archaeological theory. Such moments emphasised the role of humans as the active interpreters of data. This is exemplified by a scene in which a tutor, who is Armenian, wanted students to make active observations at one of the trenches. In this situation, the students had to decide where to dig next, and the students were waiting for the tutor to provide the answer, which the tutor preferred not to do himself. The tutor prompted students to come up with *their* stories:

> You are the ones who must produce the stories. Take a look at this trench. Try to understand it. Try to produce stories based on what you see. Connect some parts of the trench to the parts not excavated yet. Draw some connections. (…) You can think of the trench as a book. It has its own language. And now you have to read it. (…) Try to approach it from different ways, from different angles. (*recorded video*)

However, not all stories were considered equally legitimate. Instead, observations must have been tied to evidence and existing knowledge in meaningful ways; the stories had to *act* meaningfully within the machineries of knowledge production. Later on, if the observation led to digging, and if digging led to artefacts, the archaeological knowledge production turned the initial story into 'knowledge'. Human observations played an essential role in this machinery, but they were insufficient in producing knowledge. However, as an interdisciplinary field, archaeology relies on knowledge and methods not only from the humanities but also from science. This means that by being socialised into the epistemic cultures, students had to learn which form of knowledge was needed in which situation. Human interpretation existed alongside knowledge from fields such as computer science, history, geology and mathematics. In some situations, only 'pure facts' mattered, such as when discussing the chemical composition of pottery. However, in other situations, students' own observations were encouraged and validated, such as in the first excerpt, where a student notices a pile of rocks – a simple epistemic act that is validated in the situation ('Yes! Thank you.').

Navigating this epistemic plurality was not always easy. The students struggled with understanding when 'common sense' or 'lived experience' was considered valid in the knowledge production processes of archaeology. What role should these play within the rigorous processes of scholarly knowledge production? For example, when was it possible to validly state that a pile of rocks is a wall since 'humans like to put rocks in a line'? After all, some tasks were akin to house chores or gardening. In Figure 4 below, two students are digging a layer of the trench together with a hired labourer who did not share their academic background, namely, studying or having studied humanities in university. However, the Armenians from the region brought their own unique knowledge to the project, from having lived in the landscape and having used local materials like clay for pottery, as well as from pre-existing familiarity with local archaeological remains. From the students' point of view, collaborating with the Armenians while taking part in the physical duties in the project was not always seen as 'knowledge work', particularly since there was no shared language but communication with the Armenians happened mostly through gestures.

Yet it was through these mundane practices – such as by learning which trowel to use with what kind of soil – that students developed their active role in initiating and sustaining the knowledge production processes of archaeology. Perhaps the most adequate example of this is the *sieve* through which dirt from the trench was sifted (see Figure 5). Sieving was done by two people, of whom one was responsible for shaking the sieve, while the other carefully judged each artefact remaining in the sieve. Was it a

Figure 4. Where is knowledge?

Figure 5. Juuso and two students at the sieve.

rock or a pottery piece? This was where active human interpretation was needed. Here, human agents were needed not only to *see*, but also to *touch*, such as by feeling the weight and surface of an artefact.

Initially, the students felt inexperienced about making such judgments. On one occasion, two students were washing pottery and raised concerns about the 'unscientific' interpretations (recorded conversation). These students were worried about 'the lack of science in determining whether the pieces are parts of pottery or not', instead focusing only on 'the eyes of experts'. Yet, throughout the project, students were mentored to differentiate between pottery and rocks. The first author experienced the same: first feeling nervous about making archaeological judgments and then *feeling* whether the decision was right, based on embodied judgments of artefacts.

Through the apprenticeship model, students were shown how to organise various human and non-human agents to produce knowledge in scientifically rigorous ways. These networks of human and non-human agents had to be sustained through the chain of initiating an excavation, conducting the excavation, and interpreting the data that was produced throughout the process. The students learned how a human agent was needed to organise the materials in ways that eventually produce meaningful knowledge. But what agents, materials and objects to coordinate, and in which way? Many data collection procedures in the project relied on 'scientific' technology, such as drones and chemistry equipment. However, to *work*, such technologies had to be used in coordination with toothbrushes, plastic buckets, and dust masks. Let us provide an example

of this, related to using a dGNSS satellite positioning device, an expensive piece of digital equipment used to map the exact coordinates along each edge of the quadrilateral trenches. One student held this device, while another used a dGNSS application on the phone to record the coordinates. However, the large dGNSS machine had to be placed at an *exact* point on the ground. To do this, an old, rusty nail was attached to the bottom of the dGNSS device. The dGNSS device and the rusty nail were equally important and symmetrical in the knowledge production process.

The example of the dGNSS device combined with a rusty nail is an example of how archaeological knowledge production combined scholarly procedures and protocols with creativity and 'common sense'. Human creativity, in particular, was identified as a crucial part of epistemic cultures, given the practical limitations of excavating in Armenia. For example, at one point, we needed an object in the laboratory to provide a white background to the photos we took of our artefacts. Peter found the right shade of white as he *noticed* certain plastic kitchen cutting boards in a local supermarket. These cutting boards found their way to the laboratory, right next to the expensive camera equipment. They became an equal part of the archaeological machinery of knowledge construction, allowing the students to take high-quality photos, so that they could record colour, shape, and decoration of the artefacts. Here, it was Peter's observation in the supermarket that ensured rigour in the knowledge construction process.

As the students practised making active human observations and interpretations, they had to learn how to operate with *epistemic humility*: ' … positioning oneself and one's knowledge at the borders of uncertainty' where 'one's knowledge might be limited or flawed' (Zehner and Durán Del Fierro 2024, 11). This was necessarily the case in an interdisciplinary context where no one could know *everything*. Epistemic humility was constantly modelled through the apprenticeship model. We illustrate this with the following excerpt. Here, Peter is holding another miniature lecture demonstrating how archaeologists make informed, knowledge-laden decisions. The excerpt illustrates how, in certain situations, objective data is required, in this case in the form of carbon samples, and how such objectivity co-existed with human interpretation. During this situation, everyone is gathered to hear about a wall of the trench that is about to be removed:

> **Peter:** So we're gonna remove the whole thing. It's gonna be hard-packed. People walked on it for ages, fired and put stones on it. There was all this kind of activity. Then you remove it all, and there's gonna be this soft layer, certainly from the Iron Age. But I don't quite understand this hard-pack layer … *I have no idea what it is.* It somehow separates the early medieval layer above and the Iron Age below. *I'm not sure what it is.* (directs the talk from the whole group to one of the tutors) Take a carbon sample from the fire pit to ensure we get the exact date. Although I bet it's going to be 800 BC …
>
> (*video recording*)

'I have this feeling … ' untangling the relational dimensions of knowledge production

As with any culture, the enactment of epistemic cultures is thoroughly relational, embodied and affective. In archaeology, it is not only tools and objects that constitute the machineries of knowledge production, but emotions and bodies, with all their strengths

and limitations, that were part of these machineries. To learn archaeology required one to make use of their whole self; to know archaeology was a thoroughly embodied practice. As Knorr Cetina (2001) phrased it, epistemic practices have a relational undergirding. Yet drawing on Knorr Cetina (2001) means that we do not consider relationality in humanistic terms, but instead overcome the subject-object separation by exploring how various knowledge objects and tools, ranging from shovels to dGNSS devices to human bodies, were active in co-constructing affects. These affects, then, took part in the process of knowledge production. We are thus concerned with relationality that does not centre the human but the material.

Students came to notice that it was not possible to produce archaeological knowledge without putting one's whole body to use. As noted, visual observations started an archaeological discovery ('What do you see?'). However, this was only the beginning. After the first few days, Juuso noted that producing knowledge by digging in the heat was like going to the gym for six hours – at 6am, no less! Working in the trench was hard work. Many times, students were exhausted during the lunch break, so they just chewed their lavash bread and eggs in silence. The sun was scorching. Dust was everywhere, and wearing a dust mask made breathing challenging. The buckets full of dirt were heavy, as were the stones we removed from the trenches. And all this time, it was necessary to stay aware of scorpions and snakes.

Embodiment had an epistemic role. Being physically present and being aware of one's spatial surroundings were essential for producing archaeological knowledge, particularly since we were ultimately studying the embodied experiences of past humans in the same spaces. One's relation to the trench mediated the observations one could make. This was seen when Peter asked a student to 'touch the trench' to understand where, and why, it would be plausible to dig: 'Put your hand on it.'

Moving around the trench was an epistemic practice in itself. One day, students had to decide where to dig next – a typical dilemma at the trench. As students brainstormed about this, their tutor said: 'Ok, everyone, let's move to this side … move over here. You can't *see* this from here.' (*recorded video; our emphasis*) As the tutor kept on explaining details about the past and asking for our input, the students physically circled around the trench. Finally, everyone ended up inside the trench, with the tutor saying: 'It's easier when you're inside. You may want to touch it.'. Likewise, gestures, such as pointing towards certain elements of the trench, held the epistemic function of shifting human observations and focus.

While many physical actions at the trench required strength and stamina, the work was always delicate. At the trench, one needed to be careful not to accidentally fall or step somewhere that might damage the site. As an ethnographer, Juuso had to face the limitations of his body in the project:

> At the trench today, Peter called for help by asking: 'Who is a delicate person [when digging]?' His example was that it could be someone good at making pottery. No one said anything, and I was so nervous I'd be picked … I'm too clumsy for this job! As careful as I try to be, I can't help my clumsiness. (*fieldnotes*)

This 'nervousness' brings us to the affective, emotional side of archaeological knowledge production. Many times, Peter was modelling the *feeling* that was an essential part of archaeological inquiry. Through a 'feeling', one determines whether an artefact is a rock or a precious piece of pottery, or which context to open. In one particular

example, a group at the most-excavated trench had to determine whether we should remove a massive stone wall that we had excavated. While the students operated through a 'student mode' (the ethnographer included) by drawing on scholarly arguments, Peter drew on his 'hunch':

> **Peter:** Should we get rid of wall 30 [the context number]?
>
> (We discuss in a small group. Many of us come up with opinions, backed up with theories and scholarly arguments. But the final decision is made by Peter.)
>
> **Peter:** This whole time I've been digging, I've had this feeling that there's nothing else there. So let's just get rid of it!
>
> (*fieldnotes*)

In our project, students learned by *living through the life cycle of knowledge*. For example, the life cycle of a pottery piece (that started thousands of years ago when someone produced the artefact) was initiated from an observation: by seeing where to dig. The piece then found its way to the sieve and then (if the observer has developed their interpretation skills well enough) to a plastic bag. It was then brought to the laboratory, where it is washed twice and let dry in the sun, after which it is photographed, digitised and stored. The students took part in each stage with their whole bodies.

At the end of the second week, we participated in a pottery workshop led by local Armenians (see Figure 6). The workshop started with a lecture by our team member from museology, who shared information about, for example, the chemical and geological composition of typical clay in this area. After this, we produced our own clay by using the same techniques that were originally used while producing the pottery we were now digging. Finally, we constructed our own pieces of pottery, providing us with an embodied experience of the anatomy of pottery; what kind of a piece might originally belong to a rim, bottom or handle of a vessel. This activity brought us one step closer to the professional interpretation of experts, such as Peter, who could tell immediately where a pottery piece might be located on a vessel – just by looking at it.

Emotions held many epistemic functions in the project. While it is impossible to disentangle all the roles emotions play in the knowledge production processes, we illustrate two emotions that caught the interest of the ethnographer: *boredom* and *anxiety*.

To start from boredom, we must travel from the trench into the laboratory. Every day, some participants stayed at the laboratory to digitise the data and to wash the pottery pieces that were dug during the previous days. These days consisted of nine hours of washing and photo-taking (see Figure 7 for a photo of the latter). Many considered these processes repetitive and less interesting than digging. Indeed, the project illustrates that seemingly noble academic goals such as 'knowledge production' might ultimately feel rather mundane. While boredom is, of course, just one of the many emotions taking place in the project, it is an intriguing example since it carries an important epistemic function. Only through boredom, *things get done*; science gets made. Any scholar knows this, and the students felt it too. Knorr Cetina (2001) knew this, too, and claimed that 'knowledge-centered work shifts back and forth between the performance of 'packaged' routine procedures and differentiated practice' (187) (see also Knorr Cetina 1999).

Figure 6. Pottery workshop.

In one case, Juuso was washing pottery with a group of students when they started to share stories about their boredom. One of them noted that 'they are doing something very repetitive every day', with another chiming in: 'It makes you feel like a robot. Are we really learning something? Is it inspiring?' (*recorded conversation*) These students, at this moment, connected knowledge production with inspiration. In the project, they understood that the feeling of inspiration does not find its way to all parts of knowledge production. The students actively re-constructed two different epistemic cultures: the inspiring yet tough one at the trench and the relaxed yet less interesting one at the laboratory.

The other notable emotion was anxiety. Archaeology is a destructive science that destroys the research object it seeks to understand. When the trench has been excavated, that action cannot be undone. This means that there is the perception that making a 'wrong' decision would have consequences for generating knowledge. The students noted their anxiety about making mistakes, compounded by the destructive nature of archaeology. Once, a student accidentally bumped into a wall of a trench, knocking over part of it. This was witnessed by the instructor. After this accident, the students

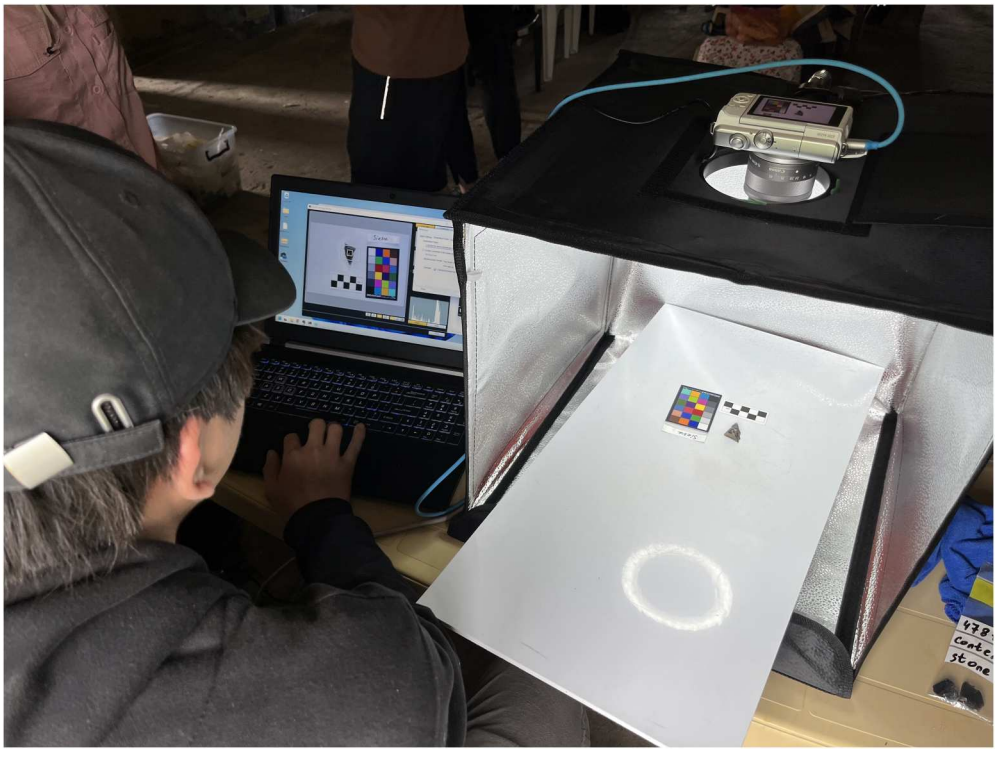

Figure 7. Photographing a shard of obsidian.

learned to be more careful by placing 'anxiety' into the affective-material machineries of knowledge production: doing archaeology meant being emotionally invested in not making mistakes. And here, such a moment of learning and knowledge production was only possible because of the generative effects of the wall that was knocked over.

These two examples of boredom and anxiety afforded the students an important yet 'strange' learning opportunity about the role of such emotions within epistemic cultures. The boredom and monotony of the labour in scientific knowledge production are rarely mentioned as explicit learning objectives within the undergraduate curriculum, following from the fact that the curriculum represents a recontextualised version of scholarly fields of knowledge (Barnett and Coate 2004). Yet in this project, students had to face those deeply embodied emotions that are not only typical parts of knowledge production, but that also have a generative role within the routine procedures of science (Knorr Cetina 2001). This was welcomed rather differently by different students, perhaps explaining some of the varying experiences they had about engaging with knowledge. It is important to note that preparations can be made for such embodied emotional responses both before and during the scientific experience.

'Could we have more lectures?' renegotiating the cultures of education

The final section focuses on the cultural aspects of epistemic cultures. Whereas in 'typical' university courses it was the teacher who determined what was learned, how, when, and

why, this project provided students with much more agency over their own learning. The project was built on an apprenticeship model: students were supposed to learn by observing the experts around them, by participating in the same scholarly practices as them, and by engaging in conversations with them. However, there was a cultural disparity between how the project was organised and how students navigated it, explored here through the voices of students. This section necessarily reaches beyond Knorr Cetina's work on epistemic cultures that has focused on practising scientists, not students 'in the making of' scientists.

Some students hoped for a more 'school-like' experience. Some wished to have quizzes and lectures to gain some basic knowledge about archaeology: the instructor 'could do some more lectures to try to explain what we are doing.' (*on-site interview*) The students felt there should have been a clearer, structured model of teaching: 'We don't have basic information about what we are doing.' (*on-site interview*) Such wishes may have stemmed from a particular view of knowledge as something that can be 'had', transferred and tested, so they did not feel that they 'possessed' the scientific foundation of facts, theories and procedures to be able to function in the project.

However, such relatively static views of knowledge did not easily fit the epistemic cultures of archaeology, given how central observations and active questioning were for such cultures. These practices were parts of the same machinery of knowledge production as any other tools, technologies and objects. More precisely, it was observing and questioning that initiated scientific discoveries. Through these human-initiated practices, certain areas, objects and artefacts were subjected to further knowledge production processes. In the project, asking students to socialise themselves into this culture of questioning, observing and initiating was constantly present. The very first excerpt in our findings is an apt example of this ('What do you see?').

However, some students were slow to adjust to taking part in such cultures. There was a discrepancy between how the students saw the roles in 'traditional' university education. It was seen as the role of professors to teach, whereas the job of students was to learn, write essays, complete tests, and not to ask questions. The irony was that in many situations, students' hesitancy to engage with the experiential teaching model meant that they also did not gain access to the scientific foundations the course aimed to provide. This was evident when students refused to ask for help or feedback due to feeling that they lacked knowledge about the topic at hand; and yet, by disengaging from feedback-seeking, students missed important opportunities to learn about those facts, theories and concepts they felt they did not yet master.

In one particularly interesting group interview, students were debating whose responsibility it is to ensure that *learning happens*. In this excerpt, a student recalls how a tutor engaged in a conversation with students while washing pottery:

> One day [a tutor] accompanied us when we were washing the pottery. (…) The tutor said 'washing pottery is really fun' and we were like whaaaat? No, not really. And he was like, why? You can see the different colors, shapes and spots on the pottery! We said that because you are an expert in this area, you think that it's fun. And he said, well, then you should ask questions about the pottery. (…) And so we asked questions. Why this color? Why this shape? And he explained it to us. We felt like, yeah, it's getting more interesting after we have this information. (…) [The tutor] said that well, you should ask questions if you don't know something. But we don't have any place to start to ask these questions

> because we don't have basic information about these pottery parts. We felt that it's [the teachers'] responsibility to give us more information, like actively, rather than just waiting for us to ask questions.
>
> (*post-course interview*)

The students were often hesitant to ask questions and 'lose face' in front of more knowledgeable others. This can be seen in how the student above recalls situations in which questions can only be asked once students *possess* a certain amount of 'basic information'. Where could such views originate from? One way to approach this question is to focus on the educational histories of the students. Without essentialism or drawing on unhelpful stereotypes, it is simply notable that this project was led by an American professor in Armenia, with most students being from Hong Kong and mainland China. The students themselves commonly made sense of the cultural disparities through their 'Chineseness' – or, more precisely, this is how they narrated these situations in English to Juuso. One participant noted that 'in China and in Asia, we are really afraid of making mistakes' (*on-site interview*). Another student felt like being asked to break those norms they had always followed in education:

> Asian students seldom raise questions in the class because of our, I don't know, shy characteristics … Sometimes I feel like the questions by students are really dumb. (*post-course interviews*)

Unsurprisingly, some cultural misunderstandings occurred in such a intercultural project. While this may sound obvious, we emphasise the epistemic aspect of such misunderstandings. The epistemic cultures of archaeology asked students to participate in new 'rules of the game' (see Luckett and Hunma 2014). No matter where cultural disparities and even clashes originated from – which is something our study cannot satisfactorily answer – they were clearly there, and they left some students feeling their needs were not met. Because of the lack of lectures, tests, quizzes and tutorials, some students felt their knowledge was never visibly tested or validated. The rigid and static view of knowledge as something to be 'transferred' from teachers to students, as it typically occurred in undergraduate education, according to the students, simply relied on different sets of rules, as this project did. It was evident that with some students, participating in the epistemic cultures of archaeology did not automatically shift such static views.

That said, there were many situations in which students overcame their barriers and asked their questions and concerns, leading to meaningful moments of learning and discovery. Many students felt like the process allowed them to see themselves as epistemic agents who could meaningfully contribute to knowledge production:

> This week, I learned a lot of things! (…) The supervisors have prior knowledge about archaeology. But we are still learning, we are learning from Day 1. They are really trying to teach us something … It's like a self-learning process. You have to discover something yourself. Fortunately, we have to ask. It's the opportunity that pushes us to ask because we really don't have any previous experience … And then if we don't ask, we're going to miss one of the artefacts. This is how the learning environment is different from the classroom. (…) This is the enforcement that makes us ask more questions. And I really appreciate it. (*on-site interview*)

In some cases, the students were 'activated' by bringing structures from typical classrooms to the field. For example, in one case, Peter arrived at a trench we were digging at and asked us to determine where the next context should be opened, namely, where we should dig next. He then gave us roughly an hour to think about our responses, asking everyone (Juuso included) to share their theories and arguments individually. This *worked*, given how deeply the students engaged in the process. Later on, Peter joked: 'It's quiz time!' As light-hearted as this joke was, it illustrated the power of integrating traditional structures of teaching into epistemic cultures while socialising students into these cultures.

Conclusion: the transformational potential of 'other' experiences

In this study, we have theorised undergraduate research projects as an entry point to epistemic cultures. Our short-term ethnographic project has shown that as students take part in the epistemic cultures in archaeology, they 1) must learn to act as active human initiators and coordinators of knowledge production, 2) engage in knowledge practices in ways that are thoroughly relational, embodied and affective, and 3) must navigate the shifting epistemic norms between 'typical' coursework and 'strange' research projects. All these processes illustrate how students are shaped and shape themselves as epistemic subjects, namely, *knowers*.

The key outcome of this archaeology project for students was to have 'other' sorts of experiences. The students were recognised as epistemic subjects, rather than as 'students', and as such, the project might have enabled not just experiential forms of *learning*, but new ways of *being*. What students learned about being part of the machinery of archaeological knowledge production might be helpful for them in their future studies with their tests, quizzes, and essays. Placements, undergraduate research projects and dissertations have enormous potential in making use of their 'otherness' in how they orient students to knowledge production and thus introduce students to epistemic cultures (Ashwin, Abbas, and McLean 2017; Manathunga et al. 2012; Nieminen, Haataja, and Cobb 2024).

However, our study does not glorify such experiences. Let us return to the mystery we started our article with. How is it possible that the intention of the project and the student experiences differed, at least with some students? Perhaps taking part in the machineries of knowledge production was not something undergraduate education typically frames as 'learning'. It might be that students could not recognise the learning benefits of participating in epistemic cultures. After all, 'learning' is typically portrayed as something individualistic rather than networked; quantifiable rather than messy; analytical rather than embodied. As undergraduate education steers away from knowledge and knowing in many national contexts, 'other' experiences might widen students' conceptions of 'learning' – yet this is not something to take for granted. We thus call for further research to grasp how students internalise, reject and renegotiate epistemic cultures.

Notes

1. The direct quotations are based on recorded and transcribed conversations.
2. A collaboration with the Institute of Archaeology and Ethnography, National Academy of Sciences, Republic of Armenia.

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