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A CURE for Teaching Experimental Archaeology

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This paper explores the 'Course-based Undergraduate Research Experience' (CURE) model as an effective approach to teaching experimental archaeology. While the CURE model has been successfully used in STEM fields to enhance student engagement and produce positive long-term impacts on academic and career success, it has yet to be widely implemented into experimental archaeology curriculum - despite the inherently experiential, hands-on nature of the discipline. The results of this case study, which compare the implementation of the CURE approach versus an inquiry approach in an experimental archaeology class, illustrate how CURE engages students in an authentic research experience, which encourages deeper

conceptual understanding, skill development, and increased motivation to pursue further research opportunities. The CURE approach also provides a scalable model for faculty to integrate research into their undergraduate teaching and generate meaningful scholarly outcomes. This study highlights the potential for wider adoption of CURE-based experimental archaeology courses in undergraduate curricula.

> " This paper introduced a novel approach to teaching experimental archaeology in higher education: the CURE model. CUREs aim to immerse students in the scientific process through collaborative, project-based learning, with the dual goals of producing original research and fostering deeper student engagement.

Introduction

The inclusion of experimental archaeology coursework in undergraduate archaeology and anthropology programmes is becoming widespread as more programmes recognise the value of hands-on learning for helping students gain a deeper understanding of ancient technologies and lifeways (Clarkson and Shipton, 2015). While there are a variety of ways that experimental archaeology can be taught (e.g., Lyngstrøm, 2011; Mikešová and Maršálek, 2017; Morton and Mason, 2022), this paper will introduce the CURE (Course-based Undergraduate Research Experience to experimental archaeology with a case study. CUREs are a relatively new and promising teaching approach being used in STEM fields and have the potential to involve undergraduates in experimental archaeology research in and beyond the classroom.

A CURE is broadly defined as *"a project that engages whole classes of students in addressing a research question or problem that is of interest to the scientific community"* (CUREnet, 2018, 'What is a CURE?'). Traditional lab courses provide 'cookbook' instructions in which the topic and methods are pre-defined, and the outcome is known at the outset by the students and instructor. Inquiry lab courses involve students in scientific practice that can lead to an outcome unknown to the students; however, the focus is to challenge students, not contribute to a larger body of knowledge. What makes the CURE approach different is that it allows students to engage in genuine, meaningful research (Waterman, 2018). They actively collaborate with each other and the instructor in most or all aspects of the scientific process to generate new scientific knowledge that is unknown to both the students and instructor and is broadly relevant or important to the scientific community (Auchincloss, *et al.*, 2014).

The CURE teaching approach is on the rise in STEM fields because of its reported benefits for both students and faculty. A CURE has many of the same benefits for students as a mentored research experience, but it reaches many more students earlier in their academic career, including traditionally underrepresented students (Dorhout, 2018). CUREs are reported to increase students' science skills as well as confidence in their own ability to do science, leading to more students self-identifying as scientists (Brownell, *et al*,. 2015; Esparza, Wagler and Olimpo, 2020; Bell, Martinez-Vaz and Bell, 2025). They are more likely to take additional science classes, complete science degrees, and pursue careers in science as a result (Harrison, *et al*., 2011; Corwin, *et al*., 2018; Buchanan and Fisher, 2022; Bell, Martinez-Vaz and Bell, 2025). Offering a CURE is a natural extension of the faculty instructor's teaching because the class is based on their own research and expertise. Faculty instructors benefit from teaching a CURE because it allows them to rapidly collect and analyse large or multiple, related datasets by having a team of students working on the research, which can be used to generate new research ideas and directions, obtain grant money, publications, presentations, and otherwise enhance their career (Shortlidge, Bangera and Brownell, 2017). It also presents faculty with a low-risk avenue to pursue new ideas and pilot experiments because even if the research does not go as planned, the students still gain a valuable learning experience (CUREnet, 2018, 'CUREs for Research').

Experimental archaeologists have long recognised the importance of experiential learning. Most experimental archaeology courses already involve active, hands-on, problem-based learning in which students are presented with an archaeological problem that they attempt to solve by conducting instructor-designed experiments or by replicating published experiments (Wood, 2013; Clarkson and Shipton, 2015; Mikešová and Maršálek, 2017). Even those courses that rely on a more traditional structure of expository learning involving lectures and discussions of readings still include a hands-on learning lab component (e.g., Morton and Mason, 2022). Experimental archaeology thus lends itself well to being taught as a CURE because most faculty are already applying a hands-on learning approach that focuses on testing hypotheses in their courses, and they are already accustomed to acquiring materials and resources to make the course run. Transitioning to a CURE should therefore be an easy and natural transition for any experimental archaeologist who is interested in integrating their teaching and research goals.

This paper presents a reflective case study on implementing a CURE in an experimental archaeology course, offering a model for others considering this approach. I compare its outcomes to an inquiry-based version of the course that I taught a decade earlier. As a professor at a R2 university in the United States, which expects faculty to maintain an even distribution between high research activity and offering enriching learning experiences for students, I have found it challenging to balance my research responsibilities with a heavy teaching load. I recognised the CURE teaching approach as a potential solution for advancing my research while maintaining excellence in teaching. My personal goals for the course were to conduct and publish a large-scale study in a relatively short amount of time while at the same time creating a cohort of skilled student researchers who would continue to participate in my research programme throughout their academic careers. My specific goals for students included immersing them in the scientific method to build their confidence in scientific reasoning while providing a framework for success to eventually pursue their own independent research. In the discussion, I compare the benefits and drawbacks of teaching experimental archaeology using a CURE versus an inquiry-based approach in pursuit of these goals.

The Case Study: Producing Stone Tools Using Different Reduction Strategies-A Social Transmission Chain Experiment

Experimental Archaeology Course

The experimental archaeology course which serves as a case study for the implementation of the CURE teaching approach was taught by the author in several classroom and lab spaces at Illinois State University (ISU), a large university in central Illinois, during the Spring 2024 semester. I was awarded a CURE Fellowship from the Office of Student Research at ISU to support the creation of a new CURE, which provided the necessary funds to purchase materials for the research study that we conducted as a class and to pay summer interns. As a temporary course, it was not well advertised and only had eight students enrolled, including one graduate and seven undergraduate students. While the small class size led to more student accountability, the preferred class size would have been 10-15 students and no more than 20, which would have allowed us to conduct another experiment and have three to a group. CUREs have been used to teach even introductory classes with large enrolment, however (Genet, 2021).

As an evolutionary cognitive archaeologist, my research programme investigates the evolution of hominin cognition and the origins of cumulative culture, mainly through the replication and analysis of lithic tools. To introduce my experimental archaeology students to the research study we would be conducting throughout the semester, I presented them with the following research problem and guidance in the syllabus (Putt, 2024):

> *Humans are unique in their ability to socially transmit skills and knowledge through language, but how did this ability evolve? One prominent theory is that a hominin technological niche led to the selection for linguistic communication, which aided in the transmission of complex stone tool-making skills that could then be used for the extractive foraging of higher-quality foods (Stout and Chaminade, 2012; Morgan, et al., 2015; Stout, 2018). Our closest living relatives, the chimpanzees (Pan troglodytes), also use stone tools and other materials for extractive foraging purposes (Parker, 2015). Their hammer-and-anvil nut-cracking behavior has even been proposed to be a precursor to intentional, "intermediary" hominin stone flaking behaviors, such as bipolar and passive hammer knapping (Bril, Parry and Dietrich, 2015; Harmand, et al., 2015; Lombard, Högberg and Haidle, 2018). However, there does not appear to be selection for higher-fidelity social transmission mechanisms like language and teaching among chimpanzees (Lonsdorf, 2006; Morgan, et al., 2015). Why has chimpanzee tool use not generated selection for higher-fidelity social transmission like that observed in humans?*
>
> *To address this question, we will conduct a social transmission study to test the hypothesis that chimpanzee technologies are "sufficiently simple" to the point that language and teaching impart no*

> *added learning benefit beyond what can be achieved through more basic mechanisms like imitation and emulation (Morgan, et al., 2015, p.6). We will investigate the efficacy of five social learning mechanisms to transmit the techniques needed to make five different types of tools that can then be used successfully in an extractive foraging task across multiple transmission events along a chain of adult human participants. The social learning mechanisms include reverse engineering, imitation/emulation, basic teaching, gestural teaching, and verbal teaching. The different tool behaviors include "termite-fishing" and nut-cracking-behaviors that have been observed among wild chimpanzee populations (Goodall, 1964; Sugiyama and Koman, 1979)-passive hammer knapping, bipolar knapping-so-called intermediary stone flaking methods-and Oldowan freehand knapping-a behavior argued to be complex enough that learning is enhanced by teaching and language (Morgan, et al., 2015)*
>
> *Everyone in the class will be working collaboratively on a guided, large-scale, experimental study. We are building this study from the ground up with the goal to publish our findings in a peer-reviewed scientific journal. A realistic goal to achieve by the end of this course is to conduct and analyze the results of a pilot experiment. A paid summer internship opportunity is available to students who want to continue to work on the project after the completion of this course.*

Throughout the semester, I provided students with a guided experience through the scientific process in which I gave them the illusion of choice. Students formed partnerships at the beginning of the semester based on similar interests, with each team of two ultimately being responsible for conducting the experiment for the technology of their choosing. Each team could make decisions about their individual experiment; however, they were told that their experiment design needed to be consistent with that of the other research teams. In this way, I helped guide class discussions toward agreement that matched my expectations for a sound study design, all while giving students a sense of control over their part of the project.

The course was organized into four units. The first unit was an introduction to experimental archaeology and the period relevant to the class experiment. To ease students who were accustomed to a more traditional style of teaching into the CURE, I started the course by presenting a series of three 75-minute lectures, accompanied by assigned readings, which focused on the archaeological record of human ancestors during the Pliocene epoch and how their behaviours are informative on the evolution of modern human cognition and behaviour. During the second unit, we transitioned away from lecturing toward class discussions focused on primary literature readings that they could use to begin building the theoretical framework for their study. The third unit was dedicated to class-led workshops as we planned the details on how to carry out the experiments. In the final unit, we conducted the pilot experiments, analysed the results, and each team presented their findings to members of the department. In each unit, we dedicated time to developing important skills like scientific writing and reviewing, data analysis, research ethics, and research poster design. We also spent a day in each unit performing a small-scale experiment and writing a short report (See Figure 1). These small experiments, while prescriptive, served to introduce students to the scientific process, as well as develop, practice, and hone science skills that they would need to confidently carry out their larger experiment in the last unit.

Students were evaluated based on a series of formative and summative assessments. Formative assessments were graded based on completion, and students received extensive feedback. Examples of formative assessments included reading comprehension worksheets, discussion leadership, certification in conducting human subjects research, an experiment protocol, and pilot data. The summative assessments built upon the formative work and included a take-home exam at the end of the first unit, a theoretical framework essay and annotated bibliography at the end of the second unit, a grant proposal at the end of the third unit, and a poster presentation at the end of the fourth unit.

In terms of meeting the goal to complete a pilot experiment, each group managed to complete their experiment and analyse the data in time to present their findings at the end of the semester, though we were all getting nervous as the date for the experiment drew near and we were still waiting on approval from the Illinois State University Institutional Review Board (IRB). The approval from IRB finally came through, and we enrolled 74 participants in the study (IRB number: IRB-2024-149).

Each group discovered that their technology could not be reliably reverse engineered without any social guidance. Two of the stone knapping groups (freehand knapping and passive hammer) found that their subjects performed significantly better at completing the task when the participants learned via gestural and verbal teaching, while the chimpanzee tool group found that their participants could easily solve the task through observation alone and did not require teaching (Mossman and Kloster, 2024; Salmons and Rimer, 2024; Wiese and Roelant, 2024; see Figures 2-3 and supplementary files 1-3). Although all participants received identical instructions regardless of the experiment, the bipolar flaking group deviated from the expected pattern (Strunck and Kropp, 2024; see supplementary file 4). Upon closer inspection of the experiment videos, the class determined that this group did not follow the protocol. The experimenters provided verbal and nonverbal feedback to the human subjects in each social learning condition, resulting in their participants having equal success in all learning conditions. Although this was disappointing to the class, it served as a valuable lesson for why experiment controls are so important. After excluding the aberrant results from the bipolar knapping experiment, the class concluded that our findings supported the hypothesis that chimpanzee technology (termite fishing) is so simple that that teaching imparts no additional benefit beyond observation alone. However, we were unable to test this hypothesis with the nutcracking task, which would have been more directly relevant. The class also agreed that there were too many issues with the experiment to pursue publication.

Summer Internship as an extension of CURE

Students in the experimental archaeology course were made aware at the beginning of the semester that there would be a paid internship available to anyone who wanted to continue working on the project for five weeks during the summer. As we no longer planned to prepare a manuscript for publication, I held an informational meeting about my different research projects and invited students from the experimental archaeology class, as well as other classes, to join the internship if interested in working on any aspect of these research projects. Ultimately, three of the eight students in the experimental archaeology course agreed to participate in the internship, along with two additional students from other courses, for a total of five interns.

Interns chose a project to lead and selected one or more other projects on which they would like to collaborate. I met once a week with each student on their own, and we also met once a week as a group and with outside collaborators to hear updates and discuss (See Figure 4). Each team leader determined a specific deliverable to be completed by the end of the internship and wrote a plan to meet this goal. The three students from the experimental archaeology course chose to work on projects that were related to the study that we conducted in the spring. Their goals for the internship included writing a grant to fund a larger version of the study, prepare an IRB proposal for a related study with children, and write a grant to fund a related study on the absence of social transmission. The goals of the other two interns included learning to use new software to track the velocity of arm movements involved in stone knapping and writing a publishable paper on pre-collected data.

At the end of the five-week internship, each student was asked to write an ungraded reflection. These reflections were overwhelmingly positive and spoke directly to the core goals of the CURE: immersing students in the scientific method to build their confidence in scientific reasoning and providing a framework for pursuing independent research (See Table 1).

Goal #1: Immerse students in the scientific method to build their confidence in scientific reasoning.	Goal #2: Provide a framework for pursuing independent research.
"Grant writing is a new skill for me, and one I'm still working on, but the practice I gained from the internship really helped me develop as a writer."	*"...[T]his internship gave me the opportunity to pursue my own research, which is a prospect I had never considered... This has significantly influenced my thinking about my future and I'm considering pursuing research as a career avenue..."*
"I learned how to create a proposal for this study, and how to submit it to the IRB, which got accepted!"	*"My experience during this summer's internship gave me a fantastic insight into what specifically an Anthropologist can do and gave me first-hand experience in data collection and analysis....I would like to continue this research under the supervision of Dr. Putt, ultimately cumulating into my master's thesis."*

"...[T]his project has equipped me with valuable skills, such as professional writing capabilities, demonstrated research abilities, and experience with data analysis."	

TABLE 1. ANONYMOUS QUOTES FROM THE FIVE DIFFERENT INTERNS, ILLUSTRATING OUTCOMES OF CURE

Discussion

There has yet to be a systematic study comparing the CURE approach to an inquiry-based approach in experimental archaeology to determine whether it leads to improved student understanding of the scientific process, greater likelihood of future research involvement, and increased academic success. As I have now taught experimental archaeology using both the CURE and inquiry teaching approaches, I can offer an unstructured reflection and comparison of the two with the hope that it may help others who are currently building or restructuring their own experimental archaeology course.

When I taught it as an inquiry course in 2014, which had an enrolment of 16 students, I structured the course chronologically around major topics relevant to prehistoric and historic archaeology, which included lectures, discussions of relevant readings, and in-class "cookbook" experiments. Additionally, each student worked individually or in a small group throughout the semester on unrelated experimental projects. Most students chose their project by selecting a research question from a list of ideas that I had prepared for them. Class time was used to regularly check in with each student to provide feedback and keep them on track.

Overall, I found that both courses produced long-term student and faculty benefits. However, a greater proportion of students in the CURE had long-term productive outcomes than those in the inquiry class (75% versus 31%, respectively), and the CURE approach resulted in three measurable outcomes for faculty career enhancement in the following year, while the inquiry approach resulted in only one faculty outcome. Below, I briefly summarise these outcomes for both courses.

Because of the inquiry course, five of the students went on to present their findings at research symposia and professional conferences. I was so inspired by one of the student projects that I conducted a larger-scale version of the study and published it shortly after teaching the course (Putt, 2015). I also gained a colleague from this experience; one of the students followed me to Indiana University, where I held a postdoctoral position, and she pursued a PhD based on the research that she had begun in my class. We have continued to collaborate throughout the years, which has led to multiple co-authored publications and conference presentations.

Because of the CURE, the graduate student in the course went on to apply experimental methods to his master's thesis. One of the students who participated as an intern submitted a manuscript to a peer-reviewed journal. The CURE also inspired students to seek out additional research experience, recognize science as a possible career path, and pursue higher science degrees. For example, three students chose to extend the research experience by joining the summer internship. One of the students continued to work with me on a new research project. She funded the study with her own grant money and presented our findings at a professional conference. Two students were accepted into our accelerated master's programme to pursue careers in anthropology.

While the CURE did not meet all the personal goals I had set out for my research productivity, it did lead to some unexpected benefits that have enhanced my career. We conducted a large-scale study and collected multiple related datasets quickly. Although this work did not result in a publication, the findings are promising and could be repeated or used to write a grant proposal. More importantly, the experience led to the generation of new research ideas and research productivity. For example, many of the ideas we discussed during class inspired me to work on a novel research study involving preschool-aged children. I was awarded an external grant to do a larger study, presented on this research at a conference, and submitted a manuscript for publication. The experience also led to more student interest in my research programme, and I continue to teach and mentor many of the students from the class and internship who have not yet graduated.

Overall, the CURE was a challenging and rewarding experience for all involved. Not only did the experience meet my own goals for my students, but I also observed many of the same beneficial outcomes that have been reported for other CUREs. The CURE that I offered immersed students in the scientific process and, as a result, improved their competence and confidence at applying science skills. For example, all students in the experimental archaeology course planned and implemented their experiment and presented posters on their findings to the department (See Appendix 1-4).

I argue that both Inquiry and CURE approaches present challenges and rewards for students while also offering career-enhancing benefits for faculty, but there may be more benefits for students and faculty by using the CURE approach. If deciding between these two learning approaches, there are some additional factors to consider (See Figure 5). One may decide to teach the course as a CURE if the desired emphasis is cohesion and collaboration. A CURE is built upon a collaborative framework and requires teamwork. There is a sense of being part of something larger than oneself, leading to an appreciation of each team member for the role that they play in the larger project. Thus, everything feels more cohesive in a CURE because everything we do in the class is working toward a common goal. If looking for a way to truly integrate teaching and research, one should teach the course as a CURE. A CURE involves students in real research that has the potential to be published, exposing them to more complex ideas than would typically be present in an Inquiry course. This gives them a clearer view of the scientific process beyond simple classroom experiments and what a career in research would potentially look like. It also means that extra time devoted to the class by the instructor can be justified as time also devoted to one's research. If the emphasis of the course is methodology and scientific practice versus covering many different topics or time periods, then the CURE is the superior approach.

Conclusion

This paper introduced a novel approach to teaching experimental archaeology in higher education: the CURE model. CUREs aim to immerse students in the scientific process through collaborative, project-based learning, with the dual goals of producing original research and fostering deeper student engagement. While widely adopted in other STEM fields due to their long-term benefits, including greater student retention in science and enhanced faculty research productivity, their application to experimental archaeology had not yet been described.

To provide a model for others seeking to design or restructure their own experimental archaeology course, I detailed the structure, challenges, and outcomes of an experimental archaeology CURE that I recently taught and compared it to an earlier, inquiry-based version of the course in which students worked independently on their own experiments. Both models demonstrated the pedagogical value of embedding research in undergraduate education, but the CURE course led to more substantial contributions to faculty research and greater student engagement in science after the completion of the course, such as pursuing advanced science degrees.

These findings suggest that the CURE model offers a powerful framework for teaching experimental archaeology, one that not only transforms students into scientists but also supports faculty in integrating teaching and scholarship.

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Resources

If you are thinking about implementing the CURE approach in your classroom, check out the following resources. For general support on developing new teaching practices, including how to integrate research and teaching, visit the *Center for the Integration of Research, Teaching and Learning* (https://cirtl.net/). CUREnet (https://serc.carleton.edu/curenet/) is a network of researchers/instructors who are dedicated to the CURE practice. This resource also includes many other examples of CUREs in other disciplines.

Attachment(s)

Appendix 1: Social Transmission: Oldowan Freehand Knapping (286.21 KB)
Appendix 2: How Does Teaching Method Impact Social Transmission? (91.15 KB)
Appendix 3: Social Transmission of HumanTermite Fishing Tool-Use Behaviors (1.9 MB)
Appendix 4: Bipolar Knapping (1.18 MB)

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Gallery Image

FIG 1. EXPERIMENTAL ARCHAEOLOGY STUDENTS PERFORM A SMALL-SCALE USE-WEAR EXPERIMENT IN CLASS. PHOTO BY SHELBY S. J. PUTT.

FIG 2. EXPERIMENTAL ARCHAEOLOGY STUDENT (BACK CENTER) TAKES NOTES AS SUBJECTS (FRONT LEFT AND RIGHT) PARTICIPATE IN THE FREEHAND KNAPPING SOCIAL CHAIN EXPERIMENT. PHOTO BY SHELBY S. J. PUTT.

FIG 3. EXPERIMENTAL ARCHAEOLOGY STUDENTS (FRONT LEFT AND RIGHT) TAKE NOTES AS SUBJECTS (BACK CENTER) PARTICIPATE IN THE PASSIVE HAMMERING SOCIAL CHAIN EXPERIMENT. PHOTO BY SHELBY S. J. PUTT.

FIG 4. AN INTERN (RIGHT) LEARNS HOW TO USE TRACKER SOFTWARE FROM AN OUTSIDE COLLABORATOR (LEFT) DURING THE SUMMER INTERNSHIP. PHOTO BY SHELBY S. J. PUTT.

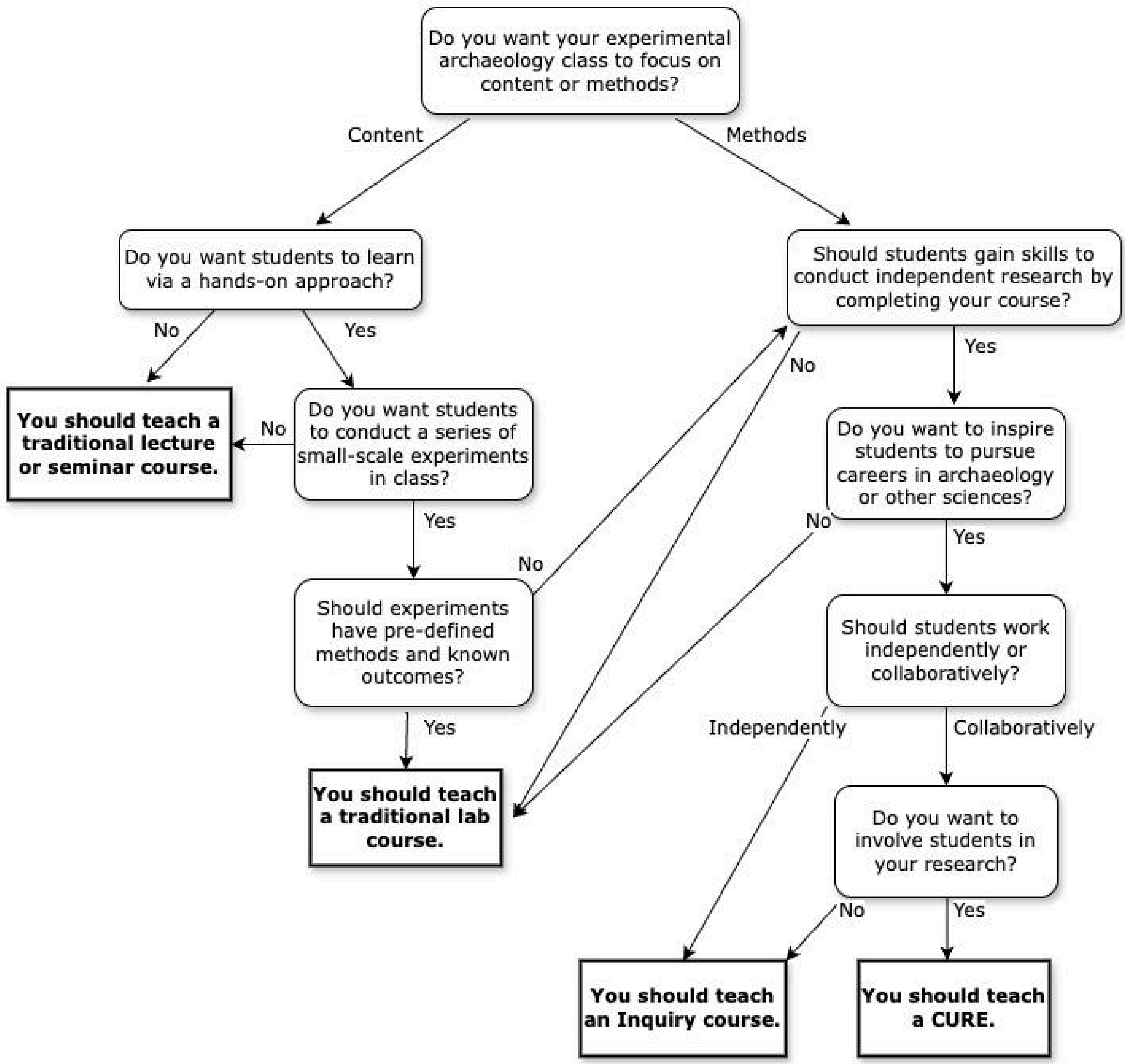

FIG 5. DECISION TREE FOR EXPERIMENTAL ARCHAEOLOGY INSTRUCTORS TO CHOOSE THE COURSE FORMAT THAT WORKS BEST FOR THE INTENT OF THE COURSE.