A Pedagogical Trebuchet: A Case Study in Experimental History and History Pedagogy

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A COMMON PROBLEM history teachers face regardless of their field of specialization is how to help students find answers to the most difficult historical questions, those for which the sources are unavailable or inaccessible, and teach them to do so in a methodologically valid manner. The case study presented here shows how a project in experimental history applied to a medieval trebuchet was used to solve just such problems by encouraging historical thinking, hypothesis testing of a historical problem, and reinforcing traditional primary source research.[1] Follow-up of this first project by several others in experimental history has shown good results in student-centered historical pedagogy as well as teaching historical research methods, exploring difficult topics, and inspiring students. My experience has shown that the experimental history project discussed here is an approach applicable within any historical specialization where there are gaps in the primary sources.

1.1: A Pedagogical Dilemma

Recent films including *Robin Hood*, *Arn*, *Kingdom of Heaven*, *Timeline*, *King Arthur*, and *The Lord of the Rings* trilogy, with their stirring images of knights, castles, and sword-won battles, have fired the imagination of a new generation of students. Although various aspects of warfare receive attention in these films, one particular device that has become extremely popular as a flashy prop is the trebuchet, a type of catapult. Similarly, popular culture phenomena including the “Punkin Chunkin” contest in Delaware that features trebuchets in addition to the more common pumpkin cannons catch the attention of the public and students. Inspired by these and other representations, undergraduates have frequently come to me in the past seeking to investigate these and similar siege engines. The problems they often run into are typical of historical investigation, but can be overcome with perseverance and imagination.

We faced a number of external problems typical of most history departments in public universities and liberal arts colleges. For example, there is no historian of medieval Europe in our department; most of our students do not take any foreign languages; and finally, because of long-term budgetary constraints at the state level, our library collection in medieval history is extremely weak in monographs, journals, and electronic resources. As with most historical problems, even when a student follows common methods and locates accessible sources, there are still many aspects of the topic that can remain beyond the reach of the texts (omissions) or the students’ skills (foreign languages). More commonly, however, the problem is a gap in the primary sources. Such lacunae are increasingly common as students move back in time through history, especially in the medieval and ancient periods.

1.2: Experimental History

In some cases, these gaps can be filled with hypothesis-testing if there is enough source material. Students can consider a problem, formulate a hypothesis, and then test it in the extant source documents. The difficulty in many cases is not formulating hypotheses, but testing them with the limited evidence from even more limited primary sources.

When traditional historical methodology does not answer our needs or those of our students, it is time to seek out something different. As more commonly recognized in the sciences, there are some problems that can only be fully explored and illuminated by experiment. There is no reason why historians cannot use certain kinds of experimentation to test hypotheses.

After finding that students repeatedly ran into a variety of difficulties in primary source research on medieval military history, I prepared an independent study project for three students who were also enrolled in a class devoted to ancient and medieval military history. The students would investigate a medieval siege engine, formulate hypotheses on specific aspects of the device, and conduct a hands-on experiment to test their research hypotheses. This testing would require they engage in a bit of imaginative research—constructing and firing a scale trebuchet to experiment and investigate how the device was built and used.

Since such historical experiments risk being dismissed as uncontrolled reenactment, we needed to find a theoretical framework into which our project would fit and which would provide intellectual rigor.[2] Although historical reenactment can be informative and entertaining, it was not sufficient for this project. Reenactment is often devoid of the kinds of specific guidelines that permit effective hypothesis testing. It is anchored more in the experience of the participants than anything else. Thus, the outcome of reenactment tends to privilege emotional response above all else, reinforcing its focus on traits of the historical record—such as personal experience—that we cannot recover. That is not to write off reenactment as valueless for history. The bottom-up nature of historical investigation found in reenactments appeals to a number of public constituencies. It also has an undeniable appeal for popular media. When undertaken with care and attention, as it can be, it may inform aspects of historical investigation.[3] Despite these positives, reenactment as a methodology was not suitable for our research.

Although trebuchets are often used in the hard sciences to demonstrate all manner of vectors, calculations, and mechanics, we were not interested in the implications of our project for physics or engineering.[4] Our goal was to understand the history of the trebuchet and explore methodology. The hard sciences are not, however, the only source which provides a conceptual framework for building and testing historical devices. The field of experimental archaeology is explicitly interested in projects such as ours.

Calling something "experimental archaeology" sounds sexy and excites students, but using a label does not make it so, and we should ask whether it provides a conceptual grounding for reconstructions of past aspects such as the one we had selected. Although it had been around for a while, experimental archaeology emerged as a recognized and defined methodology in the 1960s and has continued to undergo examination and refinement. Recent definition of experimental archaeology has broadened its conception: "contemporary experimental archaeology is built around the experiment as a means of discovery and answering a specific question by empirical trial or testing a specific hypothesis...it is a structured method for empirically testing our beliefs about and discovering the past material world and human activities through experiments."[5] This definition is general enough to include an array of projects, but its strictures of specificity and structure exclude many varieties of historical investigation.

John Coles, one of the first archaeologists to write about experimental archaeology in systematic terms, recognized that there must be a hierarchy of project types, which he put in three levels or rubrics. Our project falls closest to Coles' lowest rubric of *simulation*, in which the researcher builds a duplicate of an original artifact with no concern for using original technology or materials, nor any expectation of testing past production processes. The object is built to show what an original artifact or structure may have looked like. Our project exceeded Coles' *simulation* rubric, however, because it was used and tested, although our decision to avoid period raw materials and methods meant our project also did not fit into any of the higher rubrics. Coles further observed that, while some scholars might dismiss it entirely, *simulation* has educational value and public appeal.[6] Education still remains an important component of experimental archaeology according to the many discussions of it since Cole defined the methodology.[7]

Our project met another requirement of experimental archaeology by using structured experiments to generate and test specific hypotheses.[8] Without this fundamental prerequisite, a project devolves into an exercise in reenactment. While experimental archaeology provides a conceptual framework, the formal connection between our project and the field is superficial, since our project in no way informs archaeological investigation. Therefore, we cannot call this project experimental archaeology. Instead, we call our methodology Experimental History.[9]

2.1: Phase I—Planning and Assignments

Having found a theoretical framework, I set up an independent study in the spring semester for the students (hereafter called "investigators"), all of whom were second- and third-year history majors, with Steven Catania as primary investigator. The ultimate goal of the one-semester process was for the investigators to conduct the experiment together and each write a research report, but since it coincided with a class on military history in which they were enrolled, I also required the investigators to share their findings with the military history class and gave the students in the class the chance to help with the experiment and write a short paper (2-4 pages) on their experience in the context of the class. In this way, a maximum number of students benefited from the experiment and the investigators had a chance to make oral presentations as well as reports.

One way in which we all encourage our students to think critically, regardless of our specialization, is by teaching them to follow good research habits like testing their assumptions about history as well as the world around them. In the process of interviewing the would-be investigators, I found that they had a variety of assumptions about trebuchet crews, instructions, skill, and building materials, so I had them choose among these issues and formulate hypotheses to test and research. In this way, the assignment began with identifying and testing assumptions and formulating hypotheses. Because they were going to build an actual trebuchet, they invested this initial step with more importance than students often do, as if the pragmatic requirements of the experiment made following correct research procedures more tangible. Making assumptions into their topics reinforced critical thinking habits and also made organization easier.

Once we identified their assumptions, they formulated hypotheses that would guide their experiment and research. The three original hypotheses they sought to test were that 1) a trebuchet could be built by a crew of non-specialists following an accepted instruction manual, 2) a trebuchet crew did not have to be a specialized unit to be effective—it could be made up of a mix of experienced and mostly inexperienced members put together ad hoc for each round of siege, and 3) that the trebuchet could be built of wood robbed out of buildings or harvested on site for the purpose instead of special components made in advance and transported to the site. The students would work as a team to build the trebuchet, but once the trebuchet was built, each would work on testing his and her own specific problem. Armed thus with topics, we set to planning the first phase—building a trebuchet.

The experiment, although large, was manageable because I organized it along the lines of any research paper project. There were regular deadlines that started out two weeks apart and became weekly after six weeks. Once everyone had sorted out the project and their hypotheses in week one, they had to initiate research on the bibliography, including both primary and secondary sources. In addition to researching their topics, they had to research how to build a trebuchet. Since the weather in Illinois in the early spring semester is not conducive to work outdoors, bibliographic research, note-taking, and planning consumed the first two deadlines. The third deadline they met required them to create a materials list for the experiment, find the raw materials and begin securing them, create several drafts of a blueprint, and begin working on the structure. All later weekly deadlines followed this pattern of combining stages in research and writing with building and then later firing the trebuchet.

After some trial and error with designs and manuals, the team of history students realized they lacked the basic technical knowledge to guide the building and design process. This first problem in the larger experiment suggested to the investigators that the assumption about being able to build from a manual without expertise was flawed and needed adjustment. Clearly, a manual alone was not sufficient. This finding seemed to be confirmed by their initial look at the sources. The investigators then began the search among colleagues for specialists to assist with constructing the siege engine. In this way, they brought in an engineering major and a physics major. Neither of these students had ever built anything like a working scale trebuchet, but both had the technical expertise to move the building phase along. We arranged for them to get independent study credit for their work on the project and they kept journals. Together, they worked on the plans and a parts list for the project. While this recruitment process was occurring, the team continued reviewing primary documents and soon concluded that what we had found in trying to design a trebuchet was confirmed in the surviving sources. During the eleventh and twelfth centuries, there were specialist engineers for hire who would travel around Europe and the Latin East directing siege engine construction by skilled craftspersons (e.g., carpenters and blacksmiths) and unskilled laborers.[10] Thus, the first finding in the sources confirmed what the experiment had already suggested. This result demonstrated to the students the potential effectiveness of our experiment. The remaining hypotheses still needed further testing—that a trebuchet could be built of wood robbed out of buildings or harvested on site for the purpose rather than carried around piecemeal, and that a crew of non-specialists (such as soldiers gathered ad hoc) when directed by or working with an experienced core crew could fire a trebuchet effectively.

The multi-disciplinary team of investigators concluded that the project was practicable, but due to limitations on funding, materials, and storage space, as well as safety concerns, a one-third- or one-half-scale trebuchet would be sufficient. This experimental device would still be a large engine measuring 10' wide by 15' long with a height of 10', and the throwing arm would add an additional 15' to the height when vertical. The frame and throwing arm would be fabricated of wood purchased for the project and with found parts including a steel axle, lifting weights, and tractor weights as counterweights. The reason the investigators went with finished timber and various found parts was a combination of wanting to test the thesis about random wooden parts, availability of funding for supplies, and time constraints. The use of the steel axle was a safety issue given the available time. All parts were readily available in the local area. The investigators also concluded that in the interests of time and cost, it would be necessary to use modern tools, including power tools. None of the investigators had the requisite hand carpentry skills to have fashioned the materials, nor did we have the time to learn those skills. Since the experiment did not actually have to be built with original technology to be effective, the modern parts and tools did not have a deleterious impact on the experiment. This phase was helpful to the long-term planning because it suggested costs and crew requirements while forcing Steven to dispatch with any attempt at full historical recreation in scale and building method. It also suggested that some of our preliminary assumptions were flawed.

Much as was the case in the Middle Ages, building a trebuchet, even a one-third-scale model, is a resource-expensive undertaking in terms of money, time, and effort. Building with a mixture of "found" materials and ready-made parts reduced our expenses, as did borrowing tools. The original investigators and fellow students they recruited completed all the work. Finally, in a fortuitous turn, as the building phase began, the college initiated a grant program to fund promising undergraduate research. The grants were small ($375), but sufficient to get things started. The effort required to bring these resources together gave the students direct insight into the importance of organized leadership and skilled workers in the fashioning of parts for a siege engine.

Gathering a crew to assemble and fire the trebuchet provided an opportunity to test another hypothesis—the efficacy of crews with mixed experience levels. We assembled the crew by drawing on the concurrent large class in military history. The requirement for crew participation was that all candidates did so voluntarily and at their own risk. Students who participated actively (the investigators kept attendance) and wrote a paper on their experience received credit in the military history class. In this way, the experiment—which would have been practical for a small class, but not for my large enrollment survey—could still contribute directly to the pedagogy of the large class. Since the class is not exclusive to majors, this recruitment method resulted in a diverse crew drawn from every college in the university and over twelve different majors, with history predominant. The original investigators coalesced into a team of specialists because of their knowledge and the amount of time they worked together, while the rest of the crew was "casual" in that they joined in at random. Additional crewmembers were interested to varying degrees in aspects of the project, but brought no particular knowledge sets or experience with trebuchets or other siege engines. The casual aspect of most of the crew made delegation more difficult, but contributed directly to testing the hypotheses about crew make-up and effectiveness. We had assembled as mixed a crew in terms of experience and skill as could be hoped for in an experiment such as ours.

2.2: Phase II—Building and Firing

Since construction and experimentation necessarily took place in one semester, there was constant pressure to meet deadlines. The timeline originally established had to be adjusted for the weather when a particularly cold spring semester delayed outdoor building activities until late March. Investigators could focus primarily on source research in January through March, but they still needed the experiment to complete their research and present results in late April. Once the weather permitted, they had to fit the building and testing into a six-week window, thus providing additional pressure on the materials, crew, and deadline. They may not have been under fire literally, but this compressed timeline created a stressful environment with a sense of urgency and an edge that would have been lacking from a more relaxed pace in consistently reasonable weather.

The regular deadlines ensured that work proceeded at a steady, productive pace toward the final deadlines and kept everyone focused. Multiple design issues came up and required quick adjustments. In order to overcome the vagaries of outdoor storage, the design team built the frame out of treated 4” x 4” timbers. They created the first-generation throwing arm by gluing and fastening several 2” x 6” boards together and then installed the composite piece on the frame with an axle shaft from a truck in a manner that made it removable for safe storage. When the wood frame could not handle the strain of the throwing arm, they solved the problem by adding cross-supports, but later stress on the frame led to these having to be removed, repositioned, and the entire device reassembled with stronger bracing. Calculating the correct design of the throwing arm and the dynamics of the frame was handled by the physicist and engineer members of the core crew, thus again demonstrating the need for interdisciplinary approaches to the project and reinforcing the importance of having skilled specialists in the medieval period.

The counterweight turned out to provide some of the most dangerous problems, but these too were eventually overcome. An early counterweight made of a sand-filled barrel intended to swing on rigid bars from the throwing arm nearly destroyed the superstructure when the bars broke under the stress of firing. Another early counterweight test with loose weights nearly caused critical failure of the throwing arm. Through testing, the team solved the problem by attaching chains to the throwing arm and threading weights (“found” barbell and tractor weights) on a bar hanging from the chains. By increasing the weight with each test-firing, we were eventually able to employ safely 800 pounds of counterweight. The solution to these problems took several days and was finally reached only through the observations and cooperation of the team as a whole, not just the core crew. This building phase suggested that a crew made up of experienced operators and inexperienced members could build a trebuchet using some found timbers. Some parts, however, could have been so specialized or specific to trebuchet design that once they had been made, it would have been ridiculous to not reuse them.

Having resolved these difficulties, the investigators moved to testing and tweaking the trebuchet in preparation for the next stage of the experiment—live firing drills. Only through actual firing could we fully test the hypotheses regarding the found parts and the crew. During this adjustment phase, we tested everything to make sure all mechanical components worked smoothly. Additionally, they explored the use of various projectiles, including melons, coconuts, and gallon jugs of water. The designers tested many of their calculations. As the faculty mentor, responsible for safety as well as mentoring the research, I often was present to observe the experiment and assist as necessary.

Firing the trebuchet was not the same as building it, so this phase was also a means for crewmembers to figure out the most efficient and safest means of operation. Since there are no manuals on how to fire a trebuchet, the core crew of investigators worked through a procedure for loading and firing. Then they had to train everyone else on how best to participate. After more testing, they decided that the loading of the projectiles and firing would be handled exclusively by specialists, while casual members of the team assisted in spotting down range, setting up the throwing arm, and transport. Since we could not control the weather, some of the testing and tweaking occurred in less than ideal conditions (rain and low light), but this simply provided a few more variables for the experiment. Crew efficiency rose considerably through the testing. Eventually, the time between firings decreased from the initial pace of once every five minutes to the final pace of once every ninety seconds. The building phase from design to finished testing lasted twelve weeks.

The timeline for research and writing did not end when the planning and manufacture began. After assembling the bibliography and initiating research in the first two deadlines and planning the experiment in the third, the investigators needed in the fourth deadline (week seven) to start work on their historiography and outline. Since they started with a hypothesis, formulating the thesis would be easy, but it was dependent on progress in the experiment. Both a subject outline and then a sentence outline were the next two deadlines. In week ten, the investigators needed to submit their first draft introductory paragraph and final bibliographies, with these polished for the following week. The rough drafts of their papers were due in week thirteen, preceding their public presentations by one week. The final paper was due in week sixteen. Throughout these steps, I met with the students regularly to check on progress, discuss previous work, and advise them.

As part of the experiment, the investigators with some of the casual crew drawn from the class fired the trebuchet for the campus community in April. This demonstration provided a chance to test their skills under the pressure of an audience. I integrated this display into the military history class to give the students a chance to see a device in action. Several other students who had taken on outside projects for credit also displayed the results of their projects. In the interest of safety, we demonstrated the trebuchet in an athletic field surrounded by a fence and backstop hammer-throw netting. As often happens in such situations, the added pressure of a potential audience put additional stress on the crew. Initially, a flaw in the sling design resulted in two shots flying out backwards, behind the trebuchet, but no harm was done. They created a new sling immediately from available materials, including burlap, rope, and fishing line as thread, and the rest of the demonstration went off without further incident. Steven and the team demonstrated that a combined crew of specialists and non-specialists could fire a trebuchet made out of some "found" and some pre-finished materials and that it could be fired quickly, safely, and accurately. Indeed, the trebuchet worked so well, it reinforced in a practical sense class lectures on the range, accuracy, and potential speed of these devices and why they were worth the expenditure in wartime. Although it was a success, the wear and tear on the trebuchet was sufficient to limit our firing, after which we had to return it to storage.

3.1: Outcomes—Experiment Results

The results of our experiment met and exceeded expectations both experimentally and pedagogically on several levels. The student investigators set out to test three primary hypotheses. In the process of design, assembling, training, and firing, they were able to test the hypotheses, revise them, and retest until they had a successful experiment. It is important to remember that at the start of the project, there were few medieval resources available on campus and the students had difficulty finding sufficient primary sources in translation. This situation necessitated the use of experimental history via the construction and use of a trebuchet in order to answer a number of questions and suggest directions for our further inquiry.

Despite the presence of published instructions for building a trebuchet, the students found in the experiment that it was unlikely that an inexperienced crew could have built a trebuchet without specialized assistance from other participants familiar with mathematics, construction techniques, and materials. Not only were our experts necessary to get the engine built, but the experiment demonstrated that specialists were vital in making the calculations necessary for aiming and firing the engine with the consistency for which it was justly famous. The trial and error that would have been necessary for non-specialists to build and consistently aim a trebuchet was not a luxury any leader could afford during a siege. This result showed that the hypothesis had been flawed and the experiment was yielding results later confirmed in primary source reading—there were specialist engineers, both in armies and as "independent contractors." Testing our hypothesis on design was a good beginning since it demonstrated the value of our process and established a pattern for the rest of the experiment.

The actual building of a trebuchet was a significant element of the experiment, the results of which led to a number of observations, some of which we were not testing or expecting. The original hypothesis was that militaries could build trebuchets out of whatever found materials were available on site, especially the wood, rather than transporting the engines ready-made across the countryside. Of course, once timber would have been prepared for the construction of an engine, then it would have been preferable to transport as much of that as possible, but leaders could not always count on being able to do so. Our own experiment suggested that a trebuchet could be built with mostly "found" parts and thus confirmed the basis of the hypothesis. There were some parts, however, such as rope and pulleys, which we could not have substituted with found objects. Also, since we used metal fasteners instead of trying to duplicate any of the original construction methods, such as mortise and tenon joinery, it reinforced the necessity of having access to skilled craftspersons (carpenters and blacksmiths). The experiment suggested that there were some structural parts that were probably transported rather than constructed on site due to the cost or time involved in their completion. Investigation of the primary sources later confirmed this pattern in some cases.

Both the building and firing phases of the experiment permitted us to test the remaining hypothesis, that a crew of non-specialists (such as soldiers gathered ad hoc) when directed by and working with a specialist or a core of specialists could fire a trebuchet effectively. Even before building was underway, we had already found that some specialization was necessary among the builders. The use of a diverse crew with differing backgrounds, skill levels, and commitment showed that casual crewmembers could work out well for most tasks. Indeed, the casual nature of most of the crew was necessary since it was difficult enough to coordinate the activities of the investigators. Despite these hurdles, some casual team members did develop limited experience during the test firing that contributed to efficient operations. Over time, the team members developed a division of labor in which the specialists handled the design, aiming, and high-risk elements of the firing, while casual crew could assist in everything else, especially construction and maneuvering. This result mirrored actual wartime practice, since there would have been a need to replace casualties among existing trebuchet crewmembers with inexperienced crewmembers who were available.

One development that we saw among the mixed crew that helped them succeed, but for which we did not test, was unit cohesion. Unit cohesion is that bonding force which can develop in a group and hold it together as well as help it to succeed. It has been most thoroughly studied in the military, but has also been shown to develop among non-military small groups. The investigators were not testing for the emergence of unit cohesion, but they were aware from my research presented in class that it might emerge and that it would help. The experiment confirmed that cohesion did arise, not only among the specialists where we might expect it, but also among the whole mixed crew, both specialist and casual members. Indeed, during construction and then especially in the firing trials, observant students could see unit cohesion emerging among a crew that included some entirely inexperienced members. Research by military sociologists has suggested that such unit cohesion can emerge from the social ties or group pride among team members (social cohesion) or from the group's shared commitment to a particular task (task cohesion).[11] Our experiment suggests that since the bond in our mixed crew developed despite extremely weak interpersonal bonds among some members, no previous experience working together, and no visible "group pride," it was task cohesion which developed and contributed to the crew's success. This cohesion contributed to the increasing effectiveness we observed in reload times. Unit cohesion was a finding that confirmed a mixed team of experienced and inexperienced siege engine operators could have bonded quickly enough over the task to operate the trebuchet effectively.

Going into the project, the students believed that it was their accuracy and power that made trebuchets so effective in sieges, but during the experiment, we were able to validate this assumption. It was the accuracy of the trebuchet that allowed it to remain an important part of warfare well into the age of gunpowder weapons.[12] In the case of our model, we were able to demonstrate consistent accuracy using different projectiles including tires, filled milk cartons, melons, coconuts, and of course, pumpkins. The consistent accuracy was another demonstration not only of the importance of skilled specialists, but also of unit cohesion in reaching maximum distance and accuracy.[13]

At the same time, the qualities that made our experimental siege engine so effective also demonstrated why it was replaced by gunpowder weapons. The trebuchet was an expensive piece of equipment to build and maintain, but it was even more expensive to fire. Both trebuchets and cannons required skilled specialists to direct their building. Such skills came at a price that leaders had no choice but to pay if they wanted effective weapons. If all expenses had been equal, the trebuchet may well have lasted longer in war since it enjoyed greater accuracy and range than early cannons. In the case of the trebuchet, however, we also observed first-hand the required participation of specialists to ensure effective aiming and the large crew needed to reload and fire the trebuchet each time.[14] The costs of a specialist and large crew were not shared by early cannons, however, which could employ a smaller crew and did not require specialist engineers to aim. It is not surprising, then, that military leaders seeking a cheaper way to wage war gravitated to the cannon.

3.2: Outcomes—Pedagogical

Our experiment had important, positive outcomes connected directly with historical pedagogy. In terms of student-centered learning, several history majors already interested in the topic, but unsure how to proceed in a dearth of sources, were able to investigate aspects of a difficult topic as part of an independent research project grounded in good historical methodology. The use of experimental history to fill in the "unknowable" and gaps in sources demonstrated another way of exploring such topics. The methodologies applied here could be used for selected topics in any field of historical specialization, as they are used now in a variety of archaeological specializations.

In terms of this particular project, the student investigators completed their projects on time and presented their research to their peers in the military history class. Their examination of extant sources turned up many interesting details, a number of which were corroborated by the experiment. The investigators had a chance to use experimentation to supplement the sources and, in the case of questions about crews and specialists, fill in source gaps that would otherwise have remained blank spaces in the historical record. In addition to benefitting from oral presentations, the investigators modeled good historical methodology for other students. Students participating in the project received academic credit for their work and considerable praise (if not envy) from their peers.

In terms of the classroom, students and I were able to use this independent study to explore experimental history as a methodology and see how it is different from historical reenactment. In this way, the students were engaged in a collaborative exploration of new methodologies, an opportunity that undergraduates do not often have at smaller state universities. Additionally, I drew upon the experiments and the independent student presentations for an already existing class on military history, thus maximizing the pedagogical impact of the experiment. Their peers in the class not only benefited from the tactile demonstration, but had a chance to participate in the research and see how experiment can be employed effectively in historical research.

The project on which we have focused here was not the only example of experimental history I have used with students in independent studies and in classes. This project was so successful that we repeated the trebuchet experiment two more times in subsequent semesters and were able to reconfirm all the previous results despite changes in personnel. Based on other students' interests, I have since then directed experimental history projects on a variety of military topics including training in the first-century Roman army, training in Alexander's Macedonian phalanx, the influence of Hoplite tactics on Roman legions, and the building and firing of a Roman ballista. In each instance, I have found that a similar mixed timeline of research and writing with planning and building combined with oral presentations in other classes has worked well and should be applicable to other kinds of projects too.

Another benefit of the project was that it supported a field of history in need of attention at our university. We were able to increase interest in medieval history despite having no medieval historian in the department at the time. This interest translated into successful student demand for a course in medieval history. That demand also contributed to our successful efforts in favor of a new hire in European history. The project resulted in some additional funds for purchasing books on medieval history for the university library. The research project paid huge dividends for a field that previously had little support.

The project also demonstrated the value of humanities-based undergraduate research. Not long after we had initiated this project, our university began actively encouraging undergraduate research. This initiative was warmly received in the sciences where there was an already established tradition of undergraduate research, but it was slow to gain acceptance in the humanities. There was resistance from some people who rejected undergraduate research in the humanities as not practicable because of the training necessary in some fields, or because there was no tradition for its use and success. By teaching how to apply scientific method in the history classroom, engaging students in their own methodologically sound projects, and engaging the university and the general public in education, this project demonstrated for everyone that research in the humanities by undergraduates has genuine value for students and departments outside the hard sciences.

An additional outcome pedagogically was the way in which the trebuchet research excited students about history and historical methodology. As noted above, the project attracted student volunteers from every college in the university and more than a dozen different majors. Admittedly, it was the chance to earn additional credit as well as involvement with a flashy medieval weapon that attracted many of these students, men and women. Not all of them were drawn to the process by the chance to "bring history to life." I found that enrollments in my history classes increased twenty percent during these projects and, in the case of this first project, three participants changed their major to history or added it as a double major. We also saw an increase of more than ten fold in undergraduate research projects within the department. The trebuchet created an energy that excited students and faculty, most of whom were not even involved in the project.

4: Conclusions

Our lengthy research project that began with questions about medieval warfare yielded far more than we anticipated. Initially unable to locate sources, students formulated hypotheses to test until they could locate primary sources (if ever). The experiments were a wild success. Recall that the goals of the experiments were to test hypotheses, suggest areas for further analysis, and demonstrate effective methodology, not show off a historical device or confirm long-held assumptions. Our experiments achieved these goals by confirming one hypothesis, adjusting and retesting other hypotheses, and using experimental history effectively in combination with traditional primary source research. These results alone make this project a resounding success, but the other outcomes were no less important.

More than just exploring history, students saw how important historical methodology is for analyzing data and patterns, reading sources carefully, and writing effectively. We harp on these issues regularly in our classes, but in this case, students had a chance to see practical results blossom before their eyes. Had our methodology been flawed in any of these respects, we would never have launched the project, won funding, garnered positive attention, and seen it through to a successful conclusion. Students built on what we did and started other projects in which they had to employ these methodologies successfully. Many more students also appreciated how interconnected different fields of history were and remain. For example, some students who were attracted to military history and had previously rejected other approaches now better understood why they had to grapple with economic, intellectual, cultural, and transnational history—history as a whole—to understand the emergence and success of this siege engine. In terms of pedagogy, the project had a huge impact well beyond its center of gravity.

The trebuchet, which has become a useful tool in physics, mathematics, and engineering classrooms, continues to have applicability in the history classroom. Our project shows how an exploration of this siege engine can yield results at many levels. We have also shown how experimental history can be a useful tool in the classroom. More than bringing history to life, as it is sometimes characterized, experimental history properly understood and carried out can illuminate and support a variety of historical methodologies.

Notes

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2. Stephen Saraydar, *Replicating the Past* (Long Grove, IL: Waveland Press, 2008), 19-27; Izumi Shimada, "Experimental Archaeology," in *Handbook of Archaeological Methods*, ed. Herbert D. G. Maschner and Christopher Chippindale (New York: AltaMira Press, 2005), 608. On reenactment as uncontrolled and unscientific, see W. B. Griffiths, "Reenactment as Research: Towards a set of Guidelines for Reenactors and Academics," *Journal of Roman Military Equipment Studies* 11 (2000): 135-136; V. Agnew, "Introduction: What is Reenactment?" *Criticism* 46, no. 3 (June 2004): 327-330; Alexander Cook, "The Use and Abuse of Historical Reenactment: Thoughts on Recent Trends in Public History," *Criticism* 46, no. 3 (June 2004): 487-488.

3. Agnew, 327-332 and Griffiths, 136-137 discuss some problems and positives associated with reenactment and include citations for other works. Agnew points out (p. 329) that there has been insufficient work done on reenactment as a historical methodology, an issue that becomes clear in other articles in the volume (*Criticism* 46, no. 3), none of which show awareness of Griffiths' article and associated work. The historical situation has not changed since these articles came out.

4. Building a trebuchet might seem a natural part of history pedagogy, but in truth, it has become in recent years a staple tool of pedagogy in other fields. A survey of recent publications shows that its classroom use is located exclusively in the pedagogies of physics, mathematics, and engineering.

5. Shimada, 615, with bibliography for past discussions. This definition remains appropriate, see Saraydar, 17.

6. John Coles, *Experimental Archaeology* (New York: Academic Press, 1979), 36-43. His middle level of experimentation requires the use of appropriate technology and raw materials to test production processes, while his highest level was to test the function of artifacts made with original technology and materials. These higher levels exceeded our goals and would have taken longer to complete than the time available. Contra Coles, see James Mathieu, "Introduction," in *Experimental Archaeology: Replicating Past Objects, Behaviors, and Processes*, ed. James R. Mathieu, *BAR International Series*, vol. 1035 (Oxford, U.K.: Archaeopress, 2002), 2, 5-7.

7. Shimada, 614; Mary Crothers, "Experimental Archaeology within the Heritage Industry," in *Experiencing Archaeology by Experiment*, ed. P. Cunningham, J. Heeb, and R. Paardekooper (Oxford, U.K.: Oxbow, 2008), 37-46.

8. Coles, 36 and Mathieu, 2. Mathieu, 2 and Saraydar, 17-19 also assert that for it to be experimental archaeology, the experiment must serve archaeology, a distinction not made by Coles.

9. The term "experimental history" has been in circulation for a while, but has lacked consistent definition. We maintain that the only important difference between it and experimental archaeology is that the former serves history while the latter serves archaeology. There have been a variety of experimental history projects undertaken, the largest of which was the Trireme Project, on which, see John S. Morrison, John Coates and N. B. Rankov, *The Athenian Trireme. The History and Reconstruction of an Ancient Greek Warship*, second ed. (Cambridge, U.K.: Cambridge University Press, 2000). For

other projects, see Griffiths, 135-136, and his bibliography.

10. Villard de Honnecourt, *Facsimile of the Sketch-Book of Wilars de Honecourt, An Architect of the Thirteenth Century*, with comments and descriptions by J. B. A. Lassus and J. Quicherat, trans. and ed. R. Willis (London, U.K.: 1859); Galbert of Bruges, *The Murder of Charles the Good*, trans. James Bruce Ross (London, U.K.: Columbia University Press, 1953); John Froissart, *The Chronicles of Froissart*, trans. John Bourchier, ed. G. C. Macaulay (New York: The Macmillan Company, 1904). For recent discussions of this phenomenon, see A. Z. Freeman, "Wall-breakers and River-bridgers: Military Engineers in the Scottish Wars of Edward I," *The Journal of British Studies* 10, no. 2 (1971): 5; John France, *Victory in the East: A Military History of the First Crusade* (Cambridge, U.K.: Cambridge University Press, 1994), 162, 165, and 368; Michael Prestwich, *Armies and Warfare in the Middle Ages: The English Experience* (New Haven, CT: Yale University Press, 1996), 286; Paul Chevedden, "The Invention of the Counter-Weight Trebuchet: A Study in Cultural Diffusion," *Dumbarton Oaks Papers* 54 (2000): 92; and Roni Ellenblum, *Crusader Castles and Modern Histories* (Cambridge, U.K: Cambridge University Press, 2007), 195-197. For modern plans, see especially Bernard F. Barcio, Ralph Payne-Gallwey, and Ron L. Toms, *Catapult Design, Construction and Competition and the Projectile Hurling Engines of the Ancients* (San Antonio, TX: RLT Industries, 2006).

11. Brian Mullen and Carolyn Copper, "The Relation between Group Cohesiveness and Performance: An Integration," *Psychology Bulletin* 115, no. 2 (March 1994): 211-214. A recent, directly related study from the Strategic Studies Institute has resulted in an extremely interesting and informative exchange on unit cohesion in the journal *Armed Forces & Society*, see Leonard Wong et al., *Why They Fight: Combat Motivation in the Iraq War* (Carlisle, PA: Strategic Studies Institute, 2003); Anthony King, "The Word of Command: Communication and Cohesion in the Military," *Armed Forces & Society* 32, no. 4 (July 2006): 493-512; Robert J. MacCoun, Elizabeth Kier, and Aaron Belkin, "Does Social Cohesion Determine Motivation in Combat?: An Old Question with an Old Answer," *Armed Forces & Society* 32, no. 4 (July 2006): 646-654; Thomas A. Kolditz, "Research in *In Extremis* Settings: Expanding the Critique of *Why They Fight*," *Armed Forces & Society* 32, no. 4 (July 2006): 655-658; Leonard Wong, "Combat Motivation in Today's Soldiers: U.S. Army War College Strategic Studies Institute," *Armed Forces & Society* 32, no. 4 (July 2006): 659-663; Guy L. Siebold, "The Essence of Military Group Cohesion," *Armed Forces & Society* 33, no. 2 (January 2007): 286-295; and Anthony King, "The Existence of Group Cohesion in the Armed Forces: A Response to Guy Siebold," *Armed Forces & Society* 33, no. 4 (July 2007): 638-645.

12. Bradbury, 254-255 and 267-268 discusses the necessity of engineers in achieving the accuracy for which trebuchets were known. In fact, even after the proven effectiveness of cannons and gunpowder, trebuchets still proved their worth in unique situations. Such a scenario arose in 1789, when British soldiers used a trebuchet to bombard Spanish troops positioned in a gorge that made them immune to cannon fire; see Peter Vemming Hansen and Nyköbing Falster, "Experimental Reconstruction of Medieval Trebuchet," *Acta Archaeologica* 63 (1992): 189-208, especially 191.

13. Kelly Devries, *Medieval Military Technology* (Orchard Park, NY: Broadview Press Ltd., 1992), 137. Although in this situation, he refers to traction trebuchets (which involve people pulling instead of a counterweight), it can easily apply to an inexperienced crew that does not know how to properly load and adjust the sling and pin angles or load the projectiles.

14. Despite the use of volunteers as well as found and donated materials, the experiment was expensive. The final cost funded by the university was greater than $2,000, but does not include all the purchases common to any such undertaking.

Appendix

Student-built trebuchet in its first generation, undergoing initial testing.

A successful conclusion of undergraduate research; a positive test of the student-built trebuchet in its second generation.