Communicating in Three Dimensions: Questions of Audience and Reuse in 3D Excavation Documentation Practice

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After excavating the Praedia of Iulia Felix at Pompeii in 1755, architect Karl Weber published the building with an axionometric illustration that showed the remains in three-dimensional perspective. In doing so, Weber communicated additional information about the form of the building in a manner that was both visually accessible to a lay audience and sufficiently "scientific" for a scholarly one. By contrast, digital 3D documentation methods in current archaeological practice can reinforce a division between "scientific" models intended for internal consumption by the project that produces them, and external communication in the form of lower-quality online digital displays. Using recent fieldwork at the Greek colonial site of Histria in Romania as a case-study, this paper explores the space between high-resolution contextualized 3D documentation used only by an internal audience and down-scaled, decontextualized 3D content designed for public consumption. In particular, it explores whether measurable 3D models derived from photogrammetric capture are useful in communicating excavation results to non-specialists – and if so, in what ways. It presents several scenarios for the role of high-quality 3D documentation in both formal and informal scholarly communication and discusses the potential for the reuse of such documentation to answer new research questions.

Key words:
Photogrammetry, Scholarly Communication, 3D Modeling, Digital Documentation.

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1. INTRODUCTION

Contrary to conventional wisdom, archaeological documentation is not primarily concerned with the preservation of the archaeological record. Rather, it is intended to communicate the nature of that record to some audience in as effective (and ideally as honest) a manner as possible. As a recent paper on drawing and digital documentation has emphasized [Morgan and Wright 2018], this does

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not necessarily entail the attempt to re-present the physical reality of a set of archaeological remains exactly as they were found. In many cases, it is more effective to filter that reality to present idealized information that is more readily understandable on a schematic level to someone who cannot examine the remains in person. This is precisely what Karl Weber was doing in the graphic documentation he produced at Pompeii in the 18th century: by creating his axonometric drawing of the Praedia of Julia Felix,[1] he sought to communicate to a knowledgeable audience the overall architectural form of the building, not the precise state of its individual elements [Parslow 1995]. The image is effective not because it is photorealistic (axonometric drawings lack true perspective, after all) but because it is immediately comprehensible on a visual level.

This article arises from an interest in the way we communicate archaeological information, and the way our communication is changing as digital recording techniques take center stage. It is particularly concerned with unintended audiences: that is, not the audiences the creators of the models imagined while making them (primarily other archaeologists, or in some cases architects), but audiences who are examining models that were not built specifically to respond to their needs or questions. The origins of this interest can be found in work the Institute of Classical Archaeology (ICA) of the University of Texas at Austin (UT Austin) carried out at Chersonesos in Crimea more than a decade ago [Rabinowitz et al. 2007], but the catalyst for the current investigation was the first field season of a joint project of UT Austin and the Institute of Archaeology "Vasile Pârvan" at the Greek colonial city of Histria on the Romanian Black Sea coast. In the course of this season, the UT team applied photogrammetrical techniques we first experimented with at Chersonesos to create 3D models of stratigraphic units uncovered during excavations in an Archaic to Hellenistic Greek urban sanctuary at the site. Photogrammetry was occasionally being used in stratigraphic recording even before ICA's work in the early 2000s [Pollefeys et al. 2001; Tschauner 2007], but since the release of Agisoft's powerful PhotoScan software in 2010, it has begun to emerge as a new disciplinary standard [de Reu 2013; Olson and Caraher 2015; Opitz and Limp 2015; Roosevelt et al. 2015; Olson 2016]. It offers a low-cost alternative to laser-scanning for the creation of 3D models, and since reliable results can be achieved with consumer-grade camera equipment and relatively little training, it can be routinely applied to individual stratigraphic deposits in the course of excavation, rather than concentrated exclusively on a few high-value objects or buildings. The effects of such techniques on archaeological practice are likely to be transformative over the next decade, perhaps even to the extent that longstanding systems like single-context recording are called into question [Jensen 2018b].

Photogrammetrical modeling had never before been applied at Histria, however, and there was some skepticism about it on the part of several participants who felt that laser-scanning provided a more accurate mathematical representation of the physical reality of the subject. Photogrammetry, in this view, was better suited to public presentation than to scientific documentation. This skepticism was coupled in some cases with a preference for analogue modes of documentation over 3D modeling, especially with respect to remains that would normally be represented by measured plans and sections. On the other hand, some participants were enthusiastic about the potential of lower-cost

[1] A digital version of this drawing can be found at http://www.pompeiiperspectives.org/index.php/excavation-history/1748-1799/11-research/excavation-history/113-ads73.

3D modeling for excavation documentation. The range of responses encouraged us to take a step back from our excitement about the tools themselves to consider the varied audiences for whose benefit we think we are using them. These divergent reactions strongly suggested that there is a gap in our understanding of the reception of 3D models in the space between online platforms like Sketchfab, where low-resolution models are presented for basic exploration to the general public, and the community of field archaeologists who have already committed to 3D recording and insist on very high-quality models to help reconstruct stratigraphic sequences and support interpretation at their own sites. It is precisely in this gap that the primary audience for the scholarly communication potential of 3D models is located. That audience consists neither of the general public, which is for the most part not interested in deriving scientific information from a model or in reusing it in new ways, nor of the original excavators themselves, who are primarily interested in the opportunity to explore their own stratigraphy. Instead, it consists of the specialists, scholars, and scholars-in-training who might use these models now or in the future to understand a site and ask new questions, as well as a growing public "maker" community that engages with digital information by remixing and adaptation [Di Giuseppantonio Di Franco et al. 2015; Compton et al. 2017].[2] It is therefore helpful to explore what this audience might need in order to do so, and how the models we make now might better facilitate the production of new knowledge by unknown future consumers of archival data.

2. THE CURRENT DISCUSSION

Most recent work on the reception of 3D models by scholarly audiences has been more concerned with tools and standards for model *producers* than with the needs and experiences of model *users*. Scholarship in this area has focused on innovation in the production, capture, or display of 3D information [Lieberwirth 2013; Forte 2014; Berggren et al. 2015; Galeazzi et al. 2016]; on new interpretations made possible by a researcher's collection of 3D data [Sapirstein 2016]; or more generally on the examination of digital documentation from the perspective of theory of practice [Huvila and Huggett 2018]. Following the efforts of the London Charter of 2009 and the Seville Principles of 2011 to establish standards for the documentation and presentation of digital archaeological information,[3] a substantial critique has emerged of 3D reconstructions that do not make their assumptions clear [Huvila 2013], and the lack of attention to authenticity, reproducibility, and "scientific rigour" in many online platforms for 3D presentation is a significant source of unease [Scopigno et al. 2017; Statham 2019]. As a result, a number of projects are now seeking to connect architectural reconstructions with both archival documentation and the logic, assumptions, and uncertainties behind the visual choices made in the model [Wendrich et al. 2014; Clarke 2016]. These developments are paired with an increasing emphasis on the collection and preservation of paradata, which is differentiated from the metadata that describes a digital object or its subject (file format, creator, title, spatial coverage, etc.). Paradata is instead, in the words of the London Charter,

[2] The intersection between the last two groups was recently demonstrated to me by one of the former students in the class discussed below, who in a subsequent class used a 3D model of a stratigraphic deposit we explored to create a 3D print of the burial it contained.

[3] http://www.londoncharter.org/index.html; http://sevilleprinciples.com/.

"[i]nformation about human processes of understanding and interpretation of data objects."[4] Other formulations focus on the "narrative of the maker" and the intellectual context of creation [Carter and Elendt 2017] or on the documentation of the technical process of modeling itself, for the purpose of scientific reproducibility and the assessment of accuracy [Bentkowska-Kafel et al. 2012; Mudge 2012; Münster et al. 2016]. All of these definitions, however, understand paradata on a basic level as a record of the decisions – small and large, human and machine – that contributed to the final form of a digital object and to its meaning.

This emphasis on the explicit recording of process and assumptions, however, has not been accompanied by a similar critical exploration of the engagement of academic end-users with 3D documentation, especially in relation to the presentation of excavation stratigraphy. Probably the most relevant is an as-yet-unpublished user-survey attached to the digital publication of a Middle Republican house from Gabii [Opitz et al. 2018], which seeks to capture the reactions of scholarly users of a born-digital archaeological publication with embedded 3D content including stratigraphic data.[5] Another user-survey is currently under way for the stratigraphic display of the ADS 3D viewer [Galeazzi 2016]. But even these admirable efforts are connected with finished products, interpreted and polished by the excavation team. Our focus here is on the way that 3D models function to transmit knowledge in their liminal stages before publication or as items in archaeological archives. The models ICA produced in Chersonesos are a case in point: they currently exist only as a series of ArcScene files available to those working on the publication and as a set of 3D PDFs derived from those ArcScene files to serve as archival records. In 2007, these models took months of manual labor to produce. We are no longer able to open the original models created with PhotoModeler Pro software, but the derivative files can fortunately still be viewed. Yet in the absence of a final publication to contextualize them or an integrated GIS platform for their display, what information do they convey to various audiences beyond the dig team – and were they worth the effort?

This paper presents a qualitative, impressionistic first step toward an answer to that question. It focuses on three distinct academic audiences for 3D archaeological documentation outside of publication contexts: specialists in archaeological subdisciplines who are tasked with the post-excavation study of particular material classes; conservators of both objects and structures; and undergraduate students who are learning how to interpret the stratigraphic record, and who will be expected to apply that general understanding in the context of particular sites. None of these audiences are foremost in the minds of the archaeologists who are producing 3D documentation in the field, but all of them are potential consumers of that data, and therefore it is useful to see how the assumptions of the producers align with their reactions to the models. More importantly, because they are approaching the documents without the preconceptions of the team that produced them and with different perspectives derived from the type or extent of their training, these audiences are

[4] http://www.londoncharter.org/glossary.html.

[5] Not only did this project carry out extensive user surveys at various stages of the development of the publication, it served as a case-study for the development of the Fulcrum publication platform produced by the University of Michigan Press, which includes built-in feedback tools: https://www.fulcrum.org/. The data about user interactions captured in this context will be invaluable for understanding how readers respond to 3D documentation. Interestingly, a recent review of the Gabii publication suggests that the absence of traditional measured plans is a significant deficit [Sapirstein 2017].

ideally suited to testing the affordances of the models. They are also among the most likely to use the models to produce new knowledge unanticipated by their creators.

3. METHODS

As a preliminary investigation, this study was carried out on a conversational rather than a statistical basis. It encompassed five different audiences, four of which were represented by individual experienced specialists. The fifth was represented by a group of 14 undergraduate students enrolled in the same introductory course on method and theory in Classical Archaeology at the University of Texas at Austin in the spring of 2018, together with one undergraduate student who had participated in the Histria excavation. The specialists included an archaeozoologist, an objects conservator, a historic preservationist with particular expertise in materials science, and a senior architect with a specialization in Classical architecture and a long history of work at Histria. Each of these specialists had some experience with the material culture of the ancient Mediterranean world, but only the architect focused exclusively or even primarily on Greek and Roman archaeology. All of them had several decades of experience working with a variety of teams at sites with a broad distribution across both the old and the new world. The students, on the other hand, included both Classics majors and students from other majors with little or no archaeological background, who were enrolled in the course primarily to satisfy distribution requirements. Ten of the respondents were majoring in Classical Languages or Classical Studies, which covers archaeology and history, while five were majoring in Natural Sciences, all of them, coincidentally, in fields with a computational focus (mostly Computer Science). There were seven women and eight men in the group, and all of them were registered as second-year students or above.

Because these audiences were quite different in both composition and background, I approached them from different angles, in keeping with the conversational and qualitative frame of this inquiry. For three of the four specialists, I gathered a set of digital documents from Histria that were particularly relevant to their disciplines, including both 2D photos and 3D models at several resolutions and in several different file formats (OBJ, PLY, and 3D PDF). The materials presented to the archaeozoologist represented the documentation of a cluster of animal bones found in an ritual deposit in the Sacred Area (Fig. 1); those prepared for the objects conservator focused on an iron spit uncovered in a pile of ashes in the same deposit; and those reviewed by the historic preservationist and the architect were a series of views of the molded base of the cella of a Hellenistic temple to Aphrodite that had recently been made visible by the removal of a covering placed over them in the early 1990s (Fig. 2).

The archaeozoologist and the objects conservator reviewed the materials online, on their own, while I met with the historic preservationist in the Visualization Laboratory of the Texas Advanced Computing Center (TACC) to introduce both photographs and models on large digital displays before the files were consulted. After reviewing the materials, the specialists responded to a short set of questions, either in writing (the archaeozoologist and the historic preservationist) or through a telephone interview (the objects conservator).

Figure 1. High-resolution digital model of a ritual deposit of animal bones, created from 59 photos taken with a Canon EOS Rebel SL1, processed in Agisoft Photoscan, and exported as an OBJ file.

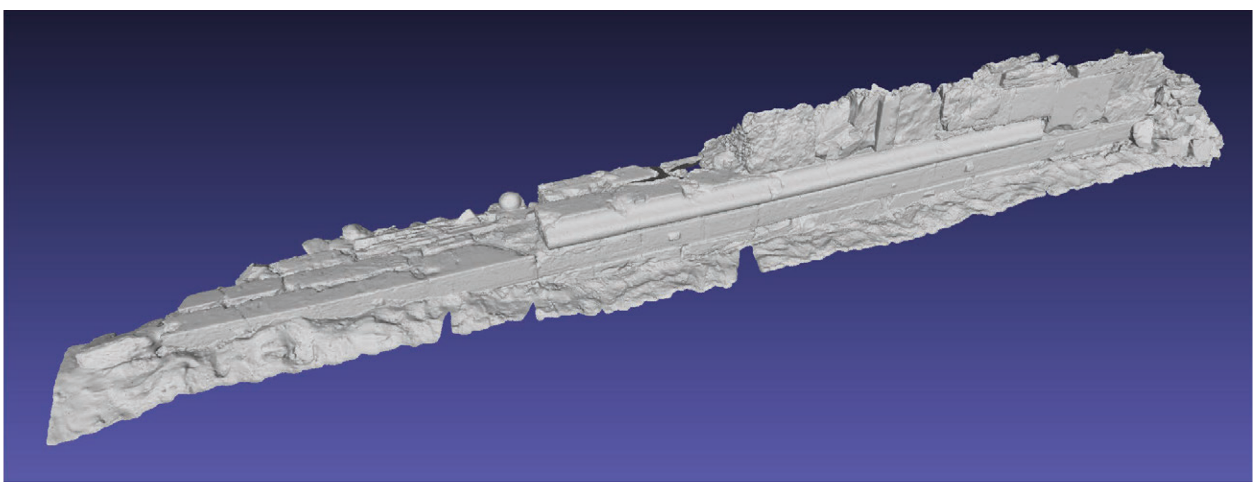

Figure 2. High-resolution digital model of a detail of the wall of the Hellenistic Temple of Aphrodite, created from 298 photos taken with a Canon EOS Rebel SL1, processed in Agisoft Photoscan, and exported by as an OBJ file. Untextured.

The format for the Bucharest-based architect was somewhat different: in that case, both the presentation of models of the temple of Aphrodite and the interview were conducted by Iulian Bîrzescu at the Institute of Archaeology "Vasile Pârvan" in the course of a normal working day, and the questions were fewer and more general, with a focus on whether 3D models were a useful or desirable addition to the current process of architectural documentation at Histria.

For the students, on the other hand, I introduced the 3D documentation in the context of the course, during a session on stratigraphy and stratigraphic recording in Classical Archaeology to which I also invited the student who had participated in the Histria project. The session came in late February, at a point when the class had already covered the history of the discipline and its larger goals, but when we were only beginning to discuss current practice. The students had been collaboratively annotating the Corinth Excavations Archaeological Manual [Sanders et al. 2017] using the Hypothes.is platform[6] since January, so I used notebooks and drawings from the Corinth excavation database to introduce Harris matrices and stratigraphic sequence before presenting graphic documentation of stratigraphy from Histria. This session also took advantage of the large displays available in the TACC Visualization Laboratory (the Stallion multi-screen display and the Lasso touch-screen), so that it was possible to present at the same time enlarged representations of stratigraphic section drawings, 2D photographs of stratigraphic profiles, and 3D models of both profiles and individual layers (Fig. 3).

Figure 3. Different graphic representations of the stratigraphy of the Sacred Area at Histria displayed on the "Stallion" multi-screen display in the Visualization Laboratory of the Texas Advanced Computing Center.

After our session in the Visualization Laboratory, the students were given access to the same set of materials, including 3D models in both OBJ and PDF formats, to explore them on their own time, and were asked to complete a brief survey delivered through the Qualtrics platform. This survey was

[6] https://web.hypothes.is/.

designed both to help them think about the purpose of stratigraphic documentation and to understand how they approached different forms of graphic representation, including the 3D models. I used a survey instrument not to attempt a quantitative analysis (the sample size is too small for any meaningful statistical results), but to offer the students an anonymous forum for their frank reactions to the different media, and to ensure a consistent framework for their responses. Two students did not respond to all the questions, leaving 13 complete surveys.

4. RESULTS

The questions I put to the specialists were intended to elicit an impression of the features and information that would make models of material and deposits *in situ* useful to them in the course of their work. I focused on certain aspects that I assumed would be of importance for the scientific reuse of 3D documentation: specifically, the ability to measure distances within the model and the paradata related to capture and processing that can allow the user to assess the precision and accuracy of the model. The questionnaire was tailored to the specialist's individual discipline in each case, but some broader patterns emerged across the responses.

The archaeozoologist and the objects conservator were both familiar with 3D media in general, and both had been asked on various occasions to identify or consult on material from previous excavations on the basis of documentation, but in all of those cases the documentation presented had been in the form of 2D photos (in the case of the archaeozoologist), or a combination of photos, plans, and textual information like database records (in the case of the objects conservator). Neither had ever been sent 3D files for consultation purposes. Both of them, however, saw the potential for richer information in this format, especially in the contextual information that could be gained from a rendering of the objects in their original position.[7] Specialists in these disciplines often receive material for analysis or conservation only after excavation, and they are rarely provided with detailed contextual records. The objects conservator mentioned a case in which an interpretation was changed on the basis of conservation observations, but only after a long series of discussions with the excavators to reconstruct the original context. A 3D model of the objects *in situ* would have made reinterpretation much easier. For both specialists, the opportunity to look at the objects from different angles was the main benefit. The faunal specialist suggested that models of bones in context might become even more useful, at least for remote consultation, if they were accompanied by 3D models of the individual bones.

Both of these specialists also expressed a desire to be able to move between different levels of detail. The archaeozoologist preferred to begin with photographs for quick visual assessment, and then move on to high-resolution models of bones both in context and as individual objects (the low-resolution models I shared were much less useful for confident identification of species or anatomical part than the high-resolution models). The objects conservator was more interested in

[7] This intuition was confirmed by another archaeozoologist working with the Histria project in the summer of 2018, as he studied the individual bones from the same ritual deposit shared in the course of this survey. He noticed that all the bones but one were from the same anatomical parts, and speculated that the outlier might have been accidentally added to the assemblage after excavation; the model, however, shows that bone in the same layer as the others, but at a short distance away from them and partially embedded in the use surface on which the others rested.

the ability to compare photos, which provide important information about color but can also produce visual patterns that falsely suggest certain features like textile pseudomorphs, with high-resolution 3D meshes *without* photographic textures, since these reveal the actual underlying geometry of the object. Even in this case, however, the conservator preferred to begin with low-resolution, easy-to-view and easy-to-load files like 3D PDFs, and only to move on to larger, higher-resolution models when it became necessary for specific issues of interpretation. Photos were considered to be especially useful for the purpose of annotation, which the conservator found more difficult to perform on 3D models.

In these conversations, it also became apparent that measurement was important for both specialists, but problematic in practice. All of the models I shared had been produced using a processing workflow for Agisoft Photoscan developed by Neffra Matthews and Tom Noble of the Bureau of Land Management [Matthews 2008] and refined by Cultural Heritage Imaging,[8] and thus were scaled, measurable in both OBJ and PDF form, and highly accurate. The archaeozoologist, however, was unaware of the measurement tools – which are, in fact, somewhat difficult to find in the Adobe PDF viewer – and would have preferred to see visible scale bars, although even these are sometimes hard to understand in photos. Since the scale of the model of the bone deposit was not immediately clear from the 3D representation, it was impossible to attribute the bones represented to a large animal or a small one. The objects conservator was more used to working with 3D files and so had less trouble with measurements but noted that the use of in-viewer measurement tools had not come naturally at the beginning.

Finally, both of these specialists also indicated that they had no interest in the process documentation – that is, the technical paradata – produced in the course of model capture and creation, either in the form of the Photoscan job logs or in the form of other textual documentation. Both of them preferred to trust the stated accuracy assessment of the archaeologist sharing the model, though the archaeozoologist thought that in the future, as 3D models become more common as a mode of scholarly communication, this situation might change. The objects conservator, on the other hand, indicated that the additional technical information was probably never going to be useful in this field, and suggested that asking the archaeologist "how accurate is this model?" would continue to suffice for conservation questions.

The reaction of the architect and the historic preservationist were more divergent. The architect, who had worked at Histria for several decades and who had done a large number of measured drawings of both buildings and architectural elements at the site, was largely uninterested in the 3D model of the temple of Aphrodite. In the architect's opinion, only first-hand observation and high-quality plans and elevations offered the level of visual understanding necessary for the scientific study of monuments. The historic preservationist, by contrast, had only seen features at Histria represented in photographs and 3D models, and was much more excited about the potential of photogrammetrical models of archaeology for off-site preservation and conservation analysis. In a list of areas where such models could be helpful, the preservationist mentioned the diagnosis of deterioration mechanisms, the triage of elements needing immediate stabilization, and the assessment of the state of the same monument across time through the comparison of models, as

[8] http://culturalheritageimaging.org/Technologies/Photogrammetry/.

well as the development of proposals, the creation of work time and cost estimates, and the selection of sample locations. The preservationist wanted accurate information about both color and geometry, ideally in the form of high-resolution models of individual elements of a monument (rather than models of an entire building). During the in-person session in the Visualization Laboratory, the preservationist noted that the 3D model had produced a visual, intuitive understanding of a section of molding that was not plain from the photo. While browsing the model, however, the preservationist did not use the measuring tools, and in response to a question about process documentation indicated that this information was of no particular interest.

The responses of the students, who had been asked to consider a wider range of graphic media with respect to their capacity to convey information about stratigraphic sequence, were also fairly consistent. In the following discussion, I quantify the student responses to Likert scale, ranking, or selection matrix questions only to provide a general impression of the class's collective reaction to the materials, not to make statistical claims (percentages would be more misleading with this small sample); the raw results of the survey are provided in the supplementary material. In the classroom setting, 12 of 15 felt that schematic drawings of stratigraphic sections made the most immediate visual sense (two others preferred a series of 3D models of layers, and one more preferred a photograph of a section). A majority preference for a stratigraphic section drawing is still clear in responses to a question about which sorts of material they would like access to in order to study a stratigraphic situation (13 of them included a profile drawing among their choices), but here the value of 3D models appears much higher (included by 11, and thus the next most popular after the drawing). Despite the apparent visual comprehensibility of the section drawings, however, only four of the respondents considered this representation to be the single richest source of stratigraphic documentation, while 10 ascribed that quality to the 3D model.

Responses to a series of questions about the students' feelings about these models indicated a similar disjunction. Few of them found scale and measurement within the models to be intuitive. At the same time, the vast majority wanted more access to 3D information: 11 strongly or somewhat agreed that they were interested in using 3D models in their research, and 12 strongly or somewhat agreed that they wanted to see more 3D models in scholarly publications or online presentations. Yet 11 of 13 were neutral toward or disagreed with the idea that 3D documentation should replace 2D graphic forms. In their written comments, many of them mentioned that they found it difficult to understand the scale or size of the things being represented. In some cases, this was because the measurement tools were hard to use or the units in the 3D PDFs that most of them consulted were not clearly designated, but in other cases it seemed to be due to the detachment of these objects from the visual cues that help us to understand scale in the real world.

The students' ranking of 17 types of documentation by their importance to the students' own understanding of the archaeological record underscores the tension between their interest in 3D documentation and their greater familiarity with 2D graphic media, especially maps and plans. When the rankings of the 13 students who completed this section were averaged, variants of 2D graphic documentation were two of the three most highly-ranked types (traditional printed maps and plans were first, and digital representations of spatial data such as GIS or webmaps were third), while 3D representations of stratigraphy were in second place. 3D representations of objects came next, followed by photographs of objects and photographs of stratigraphic contexts. On the other hand, some representations that professional archaeologists find important ranked at the bottom of the students' scale. Harris matrices, for example, came in 17th out of 17 in the average of the students' assessment of their importance for their own understanding of the archaeological record. Interestingly, the other forms of documentation ranked lowest in importance for student understanding included what we might think of as contextual paradata: the textual record of the tools and methods used in a project, and photographs showing people engaged in the process of archaeology. Archaeologists who use excavation archives for projects conducted fifty or a hundred years ago often find such documents to be of particular importance in the reconstruction of the history of research at a site, but the survey results suggest that they may be of little interest to student users of online datasets.

The short-answer responses of the students to a question about what might be lost in a general shift from 2D to 3D documentation strategies were especially telling. Across their comments ran a clear perception of 3D models as less filtered and less interpreted than traditional graphic documentation. One student commented that "If we solely rely on 3D models over 2D documentation, then we lose the thoughts and inferences the archaeologist would have made as they were digging up the site, as well as any events that happened while digging up an area but were not made into a model because it was mid-dig". Another pointed out that 3D models contain a level of detail that may not be relevant for the understanding of a particular feature, while 2D representations can schematize and highlight important information. In response to a question on the value of 3D documentation, on the other hand, their focus was on the realism of the representations, and on the way they enable the user to experience shape, texture, and "what archaeologists in the field see".

5. CONCLUSIONS

Several common themes emerge from the responses of this small but diverse set of respondents. The first is a clear recognition that 3D models and 2D documentation serve different purposes. Both specialists and students felt that 2D representations offered a faster path to understanding and initial assessment of archaeological information, while 3D models presented opportunities for richer exploration. The students felt that schematic graphic documentation provided a better reflection of the interpretive process of the archaeologists than the 3D models, while the specialists preferred to begin an assessment process with photographs before moving on to models. In general, most of the respondents expressed an interest in beginning with more filtered information before moving on to greater detail. The specialists, who were given models with multiple resolutions, also wanted to begin with smaller, lower-resolution models to orient themselves before exploring higher-resolution versions. Orientation also emerged as a significant concern for the navigation of the models themselves, especially in terms of scale. Lacking points of reference, a number of the respondents had difficulties understanding the relation of the models to the real world, at least with respect to size. External confirmation of the importance of these issues is provided by Sapirstein's review of the Gabii publication, in which he specifically cites "the lack of spatial referencing" as a "surprising deficiency" in the work, adding that "(a)rchaeologists have become accustomed to 2-D plans, elevations, and sections as analytical tools that can simplify and make sense of the often bewildering complexity present in an excavation" [Sapirstein 2017].

Some of the respondents were particularly interested in high-resolution models, while others preferred lower-resolution models that were easier to manipulate. Some wanted more photorealistic models, while others – especially those concerned with conservation – cared equally about the quality of the untextured mesh. None of the respondents, however, wanted the technical paradata that described the process by which the models were generated, despite the importance of paradata like processing logs and creation conditions for the assessment of the accuracy of the results [Schroer and Mudge 2017]. This disinterest was mirrored by the low ranking of process documentation, both visual and textual, in the student responses. In essence, these audiences seem to be willing to trust the model-makers about the level of precision and accuracy of the models. This is a potentially dangerous situation, and perhaps we should start thinking about ways in which we can communicate these technical details in a manner that is as easy for a user to process as the models themselves.

Such strategies will be especially important as the field itself begins to explore the mediating role of the process of creation on the resulting archaeological representations, moving on from an initial preoccupation with 3D documentation as a more precise, accurate, and objective replacement for traditional 2D recording methods [Carter 2017; Gant and Reilly 2018]. At the same time, broader concerns for authenticity in the face of photorealistic representations have encouraged some archaeological projects to develop visual documentation strategies that explicitly differentiate between what is observed and what is interpreted: at the Skelhøj barrow in Denmark, for example, photographs of sections were taken before and after the archaeologists incised their stratigraphic interpretation into the section itself, and orthorectified versions of the "after" photographs were used to create profile drawings [Jensen 2018a:61–62]. In the same article, Jensen argues that only rich paradata recording the decisions and assumptions that go into 3D models can create "authentic", transparent documentation [Jensen 2018a:64]. If models can only be fully understood in the context of their paradata, a greater effort should be made to ensure that paradata is both routinely collected and easily accessible for model users.

In fact, this preliminary investigation suggests several areas in which the archaeological community might approach the communicative potential of 3D models more creatively, especially in the development of archaeological archives. Rather than thinking in binary terms about scaled-down "public" presentation models and high-resolution, processor-intensive professional "archival" models, we might consider offering a continuous path from simplicity and low resolution to complexity and higher resolution in both public and professional or archival settings. It may be best to introduce the user first not to the models themselves, but to high-resolution 2D photographs or drawings of the material in question: these familiar formats can offer a more intuitive entry-point for complex documentation [De Felice 2016], even if they are not necessarily the richest end-point [Galeazzi et al. 2015]. The 2D representations could then direct the user along a path toward 3D models of increasing resolution. The anecdotal evidence presented in this article suggests that many users would benefit from engaging first with easy formats like 3D PDFs or 3D objects with relatively coarse meshes, while being offered access to more complex and detailed objects with the understanding that these require more specialized tools and more powerful processors to manipulate. With clear signposting, a user could proceed as far along the path from lesser to greater detail (and back again) as necessary, without being forced to choose between too little or too much. At the same time, models integrated with 2D graphic documentation could provide the interpretive filter necessary to orient the viewer to the context of the 3D information. This was suggested by one student in the survey and brought up again independently by another student in a more recent iteration of the class, who imagined a 2D stratigraphic section drawing superimposed on a 3D model of that profile. A similar idea has actually been put into practice in the Archaeo interface developed by Jensen for the Alken Enge excavations [Jensen 2018b:537–542]. Other intermediary modes might also contribute to this orientation: animated GIFs, for example, are a lightweight format in which sequence can be quickly and intuitively communicated [Morgan and Scholma-Mason 2017] (Fig. 4). Finally – at least until scale and measurement tools become more intuitive – we might consider the archaeological heresy of placing a small, easily recognizable extraneous object in our models, in order to provide a more immediately legible indicator of scale (Fig. 5). While this runs counter to the longstanding visual narrative of order, objectivity, and impersonalization in archaeological photography, it may be more effective than scale bars in helping users to understand a model quickly in its real-world context, which may in turn encourage greater scientific engagement.

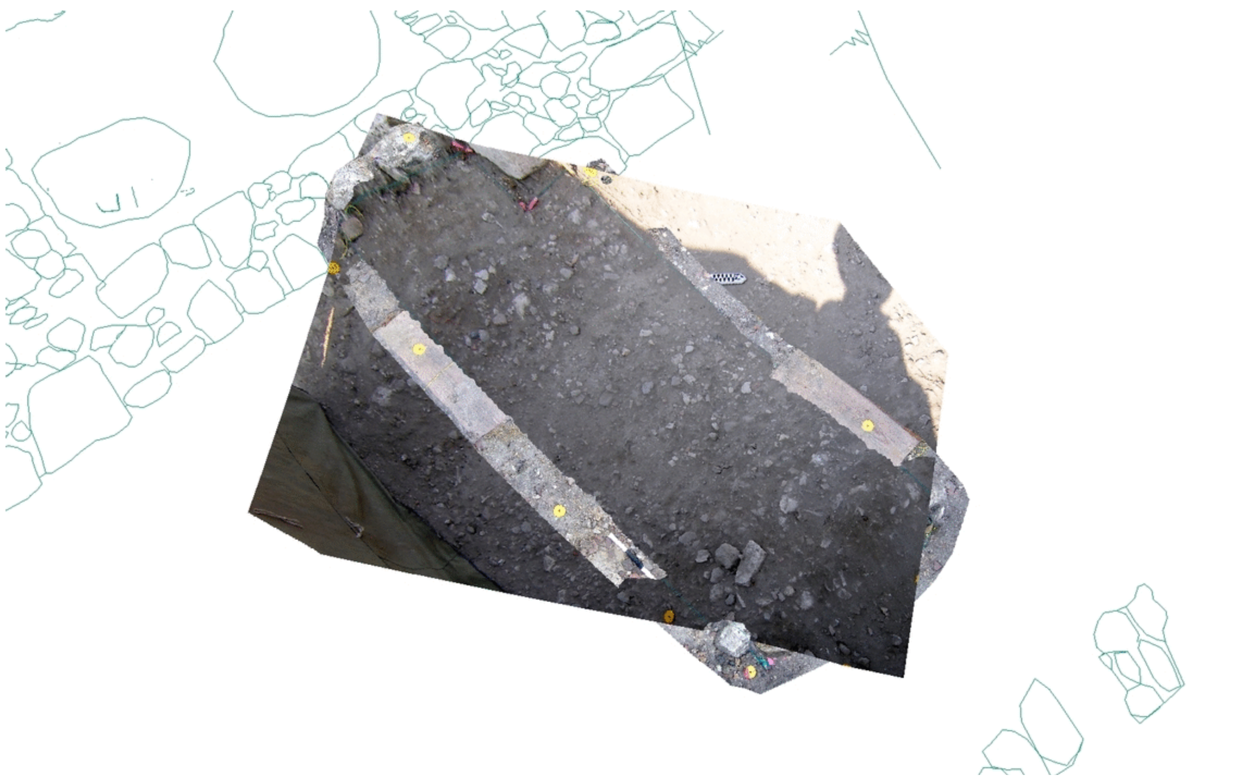

Figure 4. Animated GIF of a series of 3D representations of layers from a drain in a street at the site of Chersonesos in Crimea. Original models created in 2007 using Photomodeler Pro and exported to ArcScene, which was used to make the GIF.

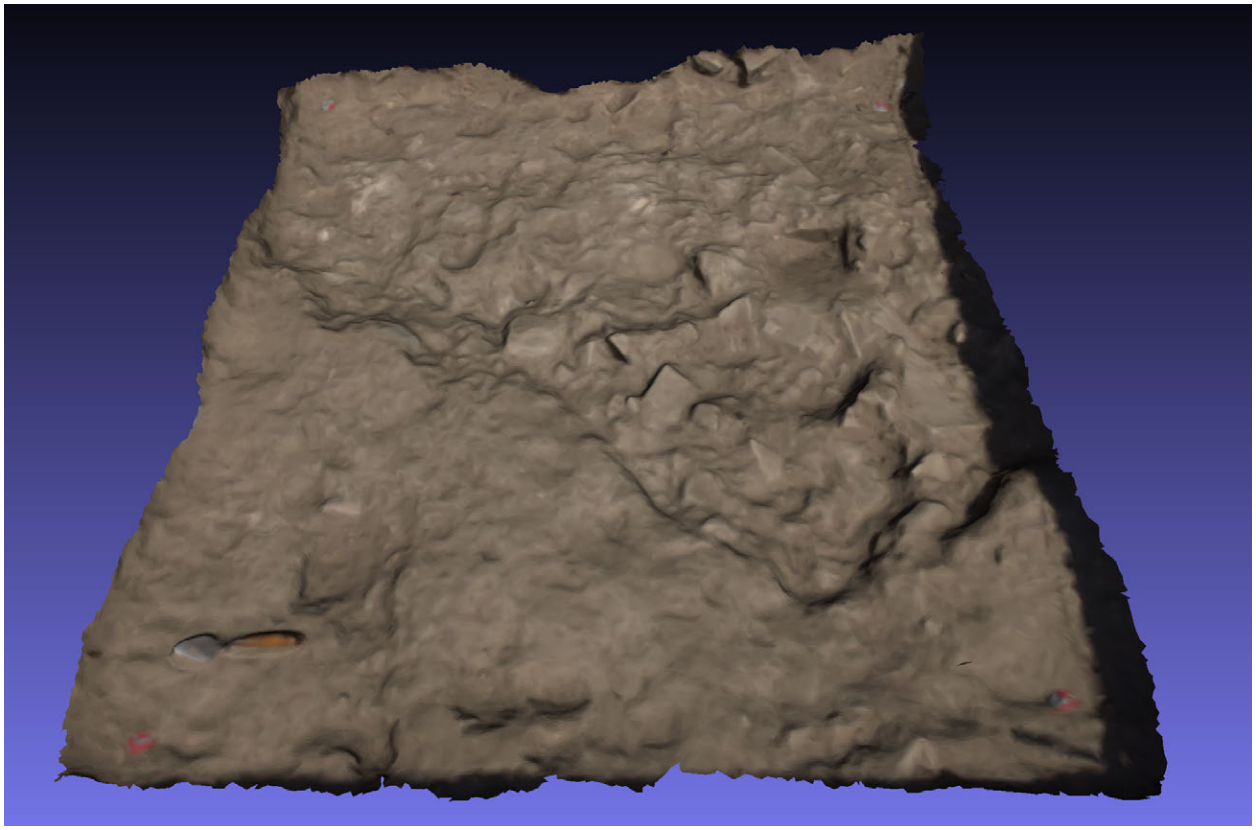

Figure 5. Medium-resolution digital model of a stratum of fill in a 2m x 2m test trench at Histria, 2018 season, with a trowel included for visual scale. Created from 141 photos taken with a Canon EOS Rebel SL1, processed in Agisoft Photoscan, and exported by as an OBJ file.

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